REPORT

OF THE

GEOLOGICAL SURVEY OF OHIO.

VOLUME III.

GEOLOGY AND PALÆONTOLOGY.

PART I. GEOLOGY.

Part. II never published.

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PREFACE.

The volume which follows is the third and last of those which constitute the purely geological portion of the report required of the Geological Corps by the organic law of the Survey. Material sufficient to form a volume equal in size to the two before published was prepared, and its publication was authorized more than three years since, but its appearance has been delayed by various causes, chief among which was the rapid development of the coal and iron industries in the southeastern portion of the State, and the important discoveries made during the progress of the extensive explorations undertaken in this region. The credit of the Survey, and the interests of all those who were taking part in the development of the resources of this section, seemed to require that a new and thorough survey of at least the Hocking Valley Coal Field should be undertaken. This has been done with much care, and with very gratifying and satisfactory results, and the pages which follow give ample evidence of the importance and even necessity of this re-survey.

Much work has also been done during the interval in other parts of the State, correcting errors that have been made, or adding to the facts before gathered. In this way the dimensions of the volume now published have been considerably augmented, and its value greatly enhanced. It should also be said that the new material added to the volume has been acquired at very small cost to the State, as since 1874 no regular salaries have been paid to the members of the Geological Corps, and the small sum appropriated since the above date has been no more than sufficient to pay the actual expenses incurred in field and office work. Hence the delay has been a gain rather than a loss to the people of Ohio.

Part II of this volume, constituting the third and last contribution to the Palæontology of the State, is in the course of preparation, and will be ready for presentation to the next Legislature.

Vol. IV, Zoölogy and Botany, is now in the printer's hands. The Geological Map of the State will be ready for distribution this year. Vol. V, Economic Geology, is more than half done, and it is expected that the material necessary to complete it will be added during the coming year. It will be impossible for the public to justly estimate the value of the results of the Survey until all this matter shall have been submitted to them in printed form; but the degree of favor with which the reports already published have been received, will perhaps be accepted as proof that the work of the Survey has been, and is being satisfactorily done, and that when finished it will not be discreditable to those engaged in it or to the State. It is but just, however, to the members of the Geological Corps, to state that they do not regard their work as in any sense exhaustive and complete, but as at least a fair return for the time it has occupied, and the money expended upon it. To make a minute and thorough survey of a great and rich state like ours, would require a very large sum and many years of time, but the present survey was begun with a guaranty of only three years' continuance. Although subsequently extended by act of Legislature, no provision was made for its support in vigor and activity for more than five years; and whatever has been done since the expiration of that period has been largely as a gratuity on the part of those who accomplished it. When the materials collected by the Survey shall all have been worked up, the total expenses of field and office work will amount to about $100,000, a sum which will not appear extravagant when it is known that for the field and office work of the Second Geological Survey of our neighboring State, Pennsylvania, $350,000 have already been appropriated.

The cost of the publication of the reports of the Ohio Survey has been large, because they have been issued in editions of 20,000 copies; but for that expenditure the Geological Corps is not responsible, since it was made by independent and unsolicited action of the Legislature.

In the preface to Vol. II, Geology, an explanation has been given of the differences of the volumes of the report in size and in the quality paper used. For these differences and for the fact that the typographical execution in style and accuracy leaves much to be desired, the Geological Corps is not accountable. The errors in typography are such as are incident to the wholesale and hurried manner in which our public documents are printed.

The proof reading and also a measure of editorial supervision of the present volume have been turned over to Prof. Edward Orton, but in justice to him it must be stated that it has occasionally been found necessary to print one or more forms during his absence from home. For the errors occurring in such forms he is not responsible. It has not been possible, in any case, to send away proofs of the reports to their several authors for revision.

J. S. N.

CHAPTER LV.

REVIEW OF THE GEOLOGICAL STRUCTURE OF OHIO.

BY J. S. NEWBERRY.

LOWER SILURIAN SYSTEM.

THE CINCINNATI ARCH.

During the first two years of the existence of the Geological Survey, much attention was given to the Cincinnati arch, and its structure and age were then, for the first time, accurately determined. These are discussed at some length in the first volume of this report, and it is there stated that this arch is a great fold of the strata raised at the close of the Lower Silurian age, when it formed two islands, one in Tennessee, the other in Kentucky and Ohio, around which the more recent rocks were deposited on a sloping shore. It was also shown that no evidence exists that these islands have ever been completely submerged since the close of the Lower Silurian age, and it was suggested that the broad, depressed areas of Silurian rocks, which now mark their sites, were produced by the solution and removal by atmospheric water of the limestones of which they were composed.

Some doubt has been expressed by Prof. E. T. Cox, the able State Geologist of Indiana, whether the theory of the history and structure of the Cincinnati arch, given in our report, is the true one, and he advances the view that it should be rather regarded as a mass of the Lower Silurian limestones which formed a highland of the ancient continent, subsequently submerged, and receiving on its top and sides the sediments that compose the more recent groups of rocks. In answer to this theory, it may be said that, whatever it may seem to be in Indiana, the Cincinnati axis in Ohio is unmistakably an anticlinal ridge, of which the arched strata of the Cincinnati group form the core, the more recent formations resting on these, and dipping away on either side.

That the Cincinnati arch formed an elevated ridge, which separated depressed areas through the Upper Silurian, Devonian, and Carboniferous ages, is demonstrated by the thinning out on its flanks of the Clinton Group, the Corniferous Limestone, the Waverly, and the Coal Measures.

This is also proven by the Conglomerate of the Clinton, formed of pebbles and rolled fossils of the Cincinnati Group, and the Conglomerate at the base of the Corniferous, composed largely of pebbles of the Waterlime.

To the sketch of the structure and history of the Cincinnati arch, given in our first volume, we may add that there is apparently good evidence that during the Palæozoic ages the different portions of this arch were unequally elevated and depressed. In Southern Kentucky and Tennessee the Upper Silurian and Devonian rocks run out to featheredges on its sides, while they cover its summit in Logan county, Ohio, at an altitude now more than a thousand feet higher. This proves that during the Upper Silurian and Devonian ages, the southern portion of the arch was much higher than the northern. This condition of things was, however, reversed in the Carboniferous age, for in Southern Kentucky the Carboniferous Sea swept entirely over the arch, and the Lower Carboniferous limestone and Waverly rocks accumulated on it to the depth of more than five hundred feet, while in Ohio the Lower Carboniferous limestone scarcely reached its base, and the Waverly rocks did not cover its summit.

In the Coal Measure epoch, the Cincinnati arch was apparently a land area throughout its entire length, its northern end being then, as now, its highest portion, and connected with the highlands of Canada. This is conclusively proven by the manner in which the Coal Measure strata terminate on the western margin of the basin in Knox and Richland counties, where the coal-beds abut against pre-existent Waverly hills.

THE CINCINNATI GROUP.

In Chapter IV of Volume I of this report, the relations of the Cincinnati Group are discussed at some length, and it is there shown by conclusive evidence that the Lower Silurian limestones exposed at Cincinnati are *not*, as has been claimed, the equivalents of the Hudson River Group of New York, but that they represent the entire Trenton limestone series.

In the chapter referred to, a partial list was given of the Lower Silurian fossils which are found in Ohio, Canada, New York, and Tennessee, and it was shown from this list that the Cincinnati Group contains not only the characteristic fossils of the Hudson River Group, but a still larger number of those which occur in the Trenton limestone in New York and Canada, and even some of those of the Black River and Birdseye limestone; and these are all so intermingled as to make it impossible to identify any one of the subdivisions of the Cincinnati Group with either of the Lower Silurian limestones of the east.

The name Cincinnati Group is retained for the rocks under consideration in our report, since they are *not* the exact equivalents of any strata described under other names elsewhere, and *are* the typical series to which this name was first applied by Messrs. Meek and Worthen; but it should be distinctly understood that the term is not, as is represented by these authors and others, synonymous with the "Hudson River Group."

If it were so, it would have been much better to retain the older name, as the argument advanced for the change, viz.: "that as the 'Hudson River Group' does not reach the Hudson River, it was, therefore, a misnomer"—has no foundation in fact. As it is, the law of priority, as well as the interests of science, require the retention of the name Hudson River Group, for the rocks to which it was applied, but it should not be confounded with the Cincinnati Group.

In the State of New York, the differences between the Trenton and Hudson Groups are chiefly local and lithological; nearly all the fossils of the Hudson being found in the Trenton. The only fossils characteristic of the Utica shale, are graptolites which seem to have grown in great profusion in certain shallow and quiet parts of the Lower Silurian Sea. Subsequently, with the progressive shallowing of the portions of this sea adjacent to the shores of the Adirondack and Canadian highlands, the sediments deposited became more purely mechanical and coarser, and the Oswego sandstone, the Lorraine and Pulaski shales were laid down. These changing local conditions produced different groupings of molluscous life in the subdivisions of the Trenton group; but further south and west, where an open sea prevailed, the physical conditions were much more constant, and there were few changes in the fauna throughout the entire period of the deposition of the Lower Silurian limestones.

With all the facts brought out by a careful study of the Cincinnati Group and its fossils, we were compelled to qualify, in our first volume, as has been specified, the definition before given to it. Subsequent observations have strengthened the arguments then used, and no conflicting evidence has been advanced by others. Hence, we protest against the course pursued by those who represent the Cincinnati Group of Ohio as the equivalent of the Hudson River Group of New York, and call it by the latter name; and that of those others who, committing the same error of identification, employ the name Cincinnati Group, and represent it to be only the upper portion of the Lower Silurian system, and as overlying all the Trenton series of New York. In the light of all the facts cited in our reports, we cannot but regard adherence to these errors as a willful perversion of the truth.

Since the publication of the description of the Cincinnati Group, in the first volume of the Geology of Ohio, great additions have been made to our knowledge of the forms of life contained in these rocks, through the contributions of Messrs. Meek, Hall, Whitfield, and Nicholson. These are contained in Vols. I and II of the Palæontology of Ohio, in which the descriptions of species occupy 382 pages, and are illustrated by twenty plates. For the means of making this important contribution to palæontological science, the Survey is greatly indebted to Messrs. C. B. Dyer, U. P. James, S. A. Miller, D. H. Shaffer, and Drs. Miller, Hill, and Byrnes, all of whom generously placed their splendid collections of fossils in the hands of the palæontologists mentioned, for description. More new material is constantly being obtained from this vast storehouse of ancient life, and it is hoped that some of the species discovered since the publication of the second volume on Palæontology, will be described in the third and last volume, which is now in preparation.

Perhaps the most interesting fossils recently discovered in the Cincinnati group, are numbers of minute dental organs, collected about Cincinnati, by Professor Wetherby and Mr. E. O. Ulrich. Their zoölogical relations have not yet been accurately determined: they have much resemblance to the jaws and teeth of fishes, but are perhaps still more like, in form and microscopic structure, the teeth of annelids. Although at first supposed to be fish-teeth, it is much more probable that they formed the dentition of mollusks or articulates; at least, much stronger proof than they afford will be required, before the existence of vertebrates in the Lower Silurian Sea can be conceded.

UPPER SILURIAN SYSTEM.

THE MEDINA GROUP.

Nothing new has been learned since the publication of our first volume, in regard to the existence, in Ohio, of representatives of the Medina sandstone. Deep borings in the northern and central parts of the State indicate the presence there of a stratum of red, mechanical sediment between the limestones of the Cincinnati group and those of the Upper Silurian, and there is little doubt that this represents the Medina sandstone of New York. In south-western Ohio, a sheet of calcareous, colored clays occupies the same position. Professor F. H. Bradley reports that in Indiana the fossils of the Cincinnati Group extend up through this band to the base of the Clinton. We have, however, found this not to be the case in Ohio, nor has any evidence been gathered here which is inconsistent with the supposition that these clays form the extreme edge of the Medina. This is rendered the more probable by the great development of the Medina Group in Pennsylvania and West Virginia, at points not more than two hundred miles directly east from the eastern base of the Cincinnati arch.

THE CLINTON GROUP.

A large number of fossils, new to science, have been collected from the Clinton Group since the publication of our first volume of Geology, and most of these have been described in the volumes on Palæontology, but nothing has been discovered that requires any modification of the full and accurate description of the character and extent of the Clinton limestone given by Professor Orton.

It will be remembered that the stratum of beautiful building stone known as the Dayton stone, is made in our reports to form the base of the Niagara Group. It has been suggested that it should rather be regarded as the cap-stone of the Clinton, but no proof has been adduced which would justify the change; indeed, any line separating the Clinton and the Niagara formations in Ohio, must be very faintly drawn, as they form subordinate parts of one whole. Even in New York the ties that bind the Clinton and Niagara are much more numerous than would be inferred from their distinctness in the tables of geological classification. A large part of the fossils of the Clinton run up into the Niagara, and, while there are certain lithological distinctions there, as well as a few fossils that serve to separate them, they are plainly portions of one great formation. In Ohio, where shores that afforded silicious sediments were remote, the physical conditions were more uniform throughout the Upper Silurian age, and the Clinton and Niagara rocks are more alike, both in lithological character and fossils, than in New York.

To any one who will even briefly review the facts presented by the Clinton and Niagara Groups as they are shown in New York and Ohio, the history of their deposition, and consequently their relations, will be easily understood.

In Ohio the disturbances which resulted in the elevation of the Cincinnati arch, not only produced a great fold in the sediments which had been deposited in the Lower Silurian Sea, but caused a withdrawal of this sea, leaving its bed nearly bare throughout the interior of the continent, and forming a broad plain traversed by a low mountain chain. After remaining in this condition for an indefinite period, the eastern half of the continent was again invaded by the advancing sea. This flowed up between the Cincinnati arch and the old land of the Allegheny belt, producing the Medina as its first sediment, then the Clinton and then the Niagara, as the depth and spread of the water became greater.

The waves of the Upper Silurian Sea washed against the base of the Cincinnati arch, as upon the sloping shores of the Canadian and New York highlands, in all localities producing their legitimate and characteristic effects, viz.: grinding up and spreading as mechanical sediments the rocks which formed the barriers against which they dashed. The colored calcareous clays, to which allusion has been made, are the probable representatives of the Medina, deposited here at a period anterior to the deposition of the Clinton limestone when the water was shallow, and rendered turbid by a fine mechanical sediment washed down from the land on the north and east. Passing eastward from Ohio, the material of the Medina becomes progressively coarser, until in the Shawangunk Mountains it is represented by the Oneida conglomerate—the gravel formed by the dashing of the waves of the Upper Silurian Sea against bold shores composed largely of silicious rocks.

As the submergence progressed the water-line rose on the flanks of the Cincinnati arch, and in the Clinton conglomerate, composed of rolled fragments and fossils of the Cincinnati Group, we have the record of the mechanical action of the Clinton Sea. The materials composing the Cincinnati arch were all calcareous, although hardened into solid limestone, so that no quartzose gravel and sand, or shale, constituted the wash from the land, and hence no beds of quartz-conglomerate, sandstone, or shale are found here. In New York the Clinton Group is mostly shale, an off-shore deposit laid down in the deepening sea over the coarser material of the Medina, the product, as has been stated, of shore action.

The oolitic iron ore so characteristic of the Clinton, and found throughout the line of outcrop of this formation, from Dodge county, Wisconsin, east to Clinton, New York, and thence south to Rome, Georgia, is represented in Ohio sometimes by a band of iron ore from two to three feet in thickness, and sometimes by merely a red ferruginous stain imparted to the limestone. No satisfactory explanation of the formation of this iron ore has ever been published Professor Dana, in the last edition of his *Manual*, p. 231, speaking of the Clinton Group, says: "The beds of argillaceous iron ore which spread so widely through New York and some of the other States, west and south, could not have been formed in an open sea, for clayey iron ore deposits do not accumulate under such circumstances; they are proofs of extensive marshes, and therefore of land near the sea level." This paragraph could only have been written with an imperfect knowledge of the remarkable deposit to which it refers. The Clinton ore is not, in any sense, a clay iron-stone, and has nothing in common with the clay iron-stones o the Coal Measures, except that it contains iron, and of this it holds nearly twice as much. It is a red hematite or anhydrous sesquioxyd of iron, containing lime and phosphorus, but generally little silica or alumina. In Tennessee, where it is called the dye-stone ore, much of it is quite earthy and silicious, but there it was deposited near the shore and is mingled with a large amount of sand, washed down and deposited with it. In its most characteristic form the Clinton ore is granular or oolitic; consisting of flattened concretions of hematite mingled with innumerable fragments of shells and joints of crinoids. In places, too, it contains numbers of well marked fossils, and it is everywhere a marine and not a marsh deposit. It was probably formed by the precipitation of the iron of the drainage waters of the land which bordered the shallow Clinton Sea on the north and east. This land contained an unusual quantity of iron, and any one who would traverse the margin of the basin where it was deposited, beginning at Marquette and following the line of the Canadian highlands, the Adirondacks, and the Allegheny belt, would pass over the most important iron deposit on this continent. The chalybeate waters flowing from this shore apparently deposited the iron they carried in the form of minute concretions, of hydrated sesquioxyd, just as the "mustard seed ore"—granular or oolitic limonite—is now being deposited in some of the Swedish lakes, which receive the drainage from ferruginous districts. While in the process of transportation the iron was a soluble protoxide, but by oxidation was rendered insoluble and precipitated. In the ages that have since passed these limonite granules have lost their water of combination, as all the older limonites have done, and have been converted into red hematite or the anhydrous sesquioxyd. They also became somewhat flattened by pressure, so as to take the form of flax-seed rather than mustard seed, producing what is sometimes known as flax-seed ore.

THE NIAGARA GROUP.

This is the deposit from the Upper Silurian Sea at the period of its greatest depth and breadth. In Ohio it attains a thickness of about three hundred feet,* and consists of several distinct members which show that considerable oscillations of level occurred in the Niagara Sea during the long period of its continuance. The Niagara shales mark an interval of comparatively shallow and turbid water; the nearly pure dolomites—the Springfield and Cedarville limestones—were deposited from deeper and purer water; while the Hillsboro sandstone, which caps the

*Dana (Manual, page 221) says: "The Niagara is in Ohio the lower part of the Cliff limestone, and is eighty feet thick." The term Cliff limestone was vaguely used many years since to designate the Corniferous and Upper Silurian limestones, sometimes one or the other, sometimes both; it is now entirely obsolete. The thickness of the Niagara Group in Ohio, as given by Dana, is, without doubt, an accidental error.

series, seems to be a local accumulation of mechanical material, that must have been brought from the land at the east, during a period of shallow water, by the action of some local agent, such as a narrow tide-way or river current.

Unfortunately the Niagara Group dips rapidly eastward, and is, for two hundred miles, buried under the Allegheny coal-fields, so that we are unable to trace this mechanical material to its source. That it came from the east or south-east is indicated by the fact that the Cincinnati arch could furnish no sand, and in Northern Ohio, Canada, and New York, no sandstone is contained in the Niagara Group.

THE SALINA GROUP.

The Salina Group makes little show in Ohio, and the phenomena which it presents here have been already described. Additional light has, however, been thrown upon its general character and history by observations made in Canada and New York. These confirm the views advanced in our first volume that this formation was deposited in a local basin left on the withdrawal of the Upper Silurian Sea; a body of salt water to be compared with the Caspian or Great Salt Lake. The limits of this basin are in a general way marked out by the thinning away and termination in different directions of the peculiar sediments that accumulated in it. It extended from Central or Eastern New York to the base of the Cincinnati axis, and from the foot of the Laurentian highlands, on the north, to Virginia. It was filled with material washed in from the surrounding lands mingled with salt and gypsum, precipitated from the water which occupied it. These latter now form extensive beds many feet in thickness—of salt in Canada—of gypsum in Ohio and New York. Whether they were precipitated from the water of rivers which flowed into the Salina basin, and was there evaporated so as to deposit its saline matter, or were derived from influxes of the sea, cannot now be determined. Either cause would be adequate to produce the result.

In the former notice of the Salina Group exception was taken to the theory advocated by high authority that the gypsum it contained was formed by the action of acid waters on limestone; and it was argued that this—like all other great deposits of gypsum—was a true sediment precipitated by evaporation from saline water. Since the publication of our first volume facts have been observed which prove conclusively that the gypsum of the Salina Group in Ohio, at least, was deposited as a sediment or precipitate, and is not a secondary product, for in the quarries near Sandusky the strata of snowy gypsum are not only too extensive and regular to have been formed in this way, but *they are separated by persist-*

ent bands of limestone, which would certainly have shared any change produced by acid water in the beds above and below them.

THE WATER-LIME GROUP.

Professor James Hall has recently made the suggestion that the Water-lime Group should rather be united with the Salina than with the Helderberg Group, with which it has been heretofore associated. There is, perhaps, no good reason why this formation should ever have been united with the Helderberg, as they have almost no fossils in common, and they occupy for the most part different areas, still there is apparently no better reason for grouping it with the Salina. It is the product of an epoch of submergence which followed the Salina period when the Salina lake was replaced by, or expanded, to form a water basin of much greater area, and in which the water, although still impure, both from excess of saline matter and of clay, was such as to permit its being inhabited by great numbers of a few kinds of mollusks and crustaceans.

DEVONIAN SYSTEM.

THE ORISKANY SANDSTONE.

In New York the Oriskany varies from less than one foot to thirty feet in thickness; and is a white, or yellowish, rather coarse sandstone, traceable along a narrow line of outcrop from the Hudson to Lake Erie. It is succeeded above in Eastern New York by the Cauda Galli grit, an arenaceous shale full of the fucoid *Spirophyton*, from which it takes its name. A thin layer of calcareous sandstone about four feet in thickness rests on this in Albany county, to which the name Schoharie Grit has been given. On the eastern margin of the continent, as well as in the south and west, all this sheet of mechanical sediments is generally represented by limestones. In Canada the Oriskany Group consists of much the same materials as in New York, but is more cherty.

In New York the fossils of the Oriskany are distinct from those of the Helderberg rocks below, as well as from those of Cauda Galli and the Schoharie grits above, but in Canada West the most characteristic Oriskany species, such as *Spirifera arenosa*, *S. arrecta*, *Rensselæria ovoides* and *Avicula arenosa*, are found mingled with *Favosites Gothlandica*, *Zaphrentis prolifica*, *Conocardium trigonale*, *Platyceras nodosum*, and many other well known Corniferous fossils. These facts, joined to the entire absence of Upper Silurian species, seem to prove the Oriskany to be much more closely allied to the Devonian than to the Silurian system.

It is evident that the Oriskany sandstone is the record of a marked change in the physical condition of the region where it occurs, viz.: the shallowing and locally complete withdrawal of the Silurian Sea. Such material as composes the Oriskany might possibly be spread some distance from the shore over the bed of that sea in its retreat, but the very decided contrast which the Oriskany presents, both in lithological character and in fossils, to the underlying Helderberg limestones, indicates that it marks the dawning of a new era rather than the close of an old one, and that it was the first product of an incoming sea—the Devonian—rather than the last of the retreating Silurian.

The Cauda Galli and Schoharie grits are universally regarded as Devonian, since they contain many of the fossils of the Corniferous limestone; they are, in part, the shore equivalents of the open sea Corniferous. In the judgment of the writer, the Oriskany is the product of the earlier and wider spread of conditions similar to those in which the Cauda Galli and Schoharie beds accumulated; and that it is the true base of the Devonian system, corresponding in character and relative position to the Medina and Potsdam sandstones below.

THE CORNIFEROUS LIMESTONE.

This has proved to be one of the most interesting of all the rocks of Ohio, since it is a vast store-house of fossils, and these—especially the fishes and land-plants—hold a prominent place among the objects described in our volumes on palæontology. The Corniferous corresponds in general character with the Niagara and Cincinnati limestones below; that is, it is the organic sediment formed from the débris of animal life which thronged the sea in the age of its deposition, and which slowly accumulated, by the processes of growth and decay, over all the area where deep and clear water prevailed in the submergence that occurred in this age.

Many new species of fossils have been found in the Corniferous limestone since it was described in our first volume, but no facts have been observed which require any important modification of the view presented in that volume in regard to its distribution, history, and the life of the period in which it was deposited. Some interesting additions have been made by Professor Nelson to the collection of land-plants found in the Corniferous limestone at Delaware and Sandusky, and which we have conjectured once formed part of a luxuriant vegetation that covered the Cincinnati island in the Devonian Age, the first land flora of which we have any traces in the United States. These will be described more fully in our third volume of Palæontology.

It will be remembered that the Corniferous limestone in Ohio consists of two divisions: a whiter and more massive member below, which we have called the *Columbus limestone*, a bluish gray and thin-bedded stratum above, opened in the quarries at Sandusky and Delaware, and designated in Volume I of this report, the *Sandusky limestone.* Professor N. H. Winchell, who made the surveys of a number of counties in the central and northwestern portions of the State, in his reports on Delaware and Paulding counties (Geol., Vol. II, pp. 272, 335), proposes to place the Sandusky limestone in the Hamilton Group, and divide the Corniferous into two members, which he identifies with the Onondaga and Corniferous limestones of New York. There seems, however, to be no good ground for this classification. The distinction between the Onondaga and Corniferous limestones of New York is not marked nor constant there, and the whole formation is now generally regarded by geologists as one, and to this the term Corniferous is applied. It is quite certain that no evidence has yet been obtained which can be relied upon for identifying the Onondaga limestone in Ohio.

In regard to the position of the Sandusky limestone, it must be said that the weight of evidence is in favor of retaining it in the Corniferous. It is true that the Hamilton period is but a continuation of the Corniferous; the Hamilton strata being deposited in the same basin, and from the same sea, but at a time when this had become somewhat shallowed, and its sediments were more earthy and carbonaceous. There is even in New York much in common between the fossils of the two groups, and all the fossils which Professor Winchell relies upon as criteria for distinguishing the Hamilton from the Corniferous, are found in both; hence, their presence in the Sandusky limestone is no proof of its Hamilton age. It should also be said that quite a number of fossils are found in the Sandusky limestone which are regarded as characteristic of the Corniferous, such as: *Spirifera acuminata*, *S. gregaria*, *Strophodonta hemispherica*, *Pentamerus aratus*, *Tentaculites scalaris*, as well as the fishes, *Onychodus sigmoides*, *Macropetalichthys Sullivanti*, *Rhynchodus secans*, *Machæracanthus major*, etc.

THE HAMILTON GROUP.

As originally defined by the New York geologists, the Hamilton group of New York consisted chiefly of blue calcareous shales traversed by a thin band of impure limestone—the Encrinal limestone—and capped by another, the last of the calcareous sediments of the Devonian sea, called the Tully limestone. This group rests on a black shale—the Marcellus—and is overlain by a similar carbonaceous deposit, to which the name Genesee slate was given. These strata are highly fossiliferous, containing many species which are peculiar to the group, with also a considerable number that pass up from the Corniferous. The most characteristic fossils of the Hamilton are *Heliophyllum Halli*, a coral, the brachiopods *Tropidoleptus carinatus*, *Spirifera mucronata*, *S. granulifera*, and *Athyris spiriferoides*; the conchifers *Orthonata undulata*, *Microdon bellastriata*, *Pterinea flabella*, *Modiola concentrica*, and *Nyassa arguta*; the gasteropods *Bellerophon patulus*, *Pleurotomaria sulcomarginata*, and *Loxonema delphicola*; and the trilobites *Homalonotus Dekayi*, *Phacops rana*, and *Dalmanites Boothii*.

Prof. Dana wisely includes in the Hamilton group the Marcellus shale below and the Genesee shale above, for it is evident that they are the products of the same general order of causes as the intervening strata. The lower portion of the Portage Group—the Cashaqua and Gardeau shales of Prof. Hall—should be added to the list, since they are conformable to the beds below, and consist of similar materials. The great mass of the Hamilton series in western New York—including under this name all the beds lying between the Corniferous limestone and the base of the Portage sandstones—is composed of alternations of argillaceous and carbonaceous shales, evidently the finely levigated mud deposited in a shallow and quiet water basin from the wash of the surrounding land. The two thin beds of limestone which occur in the series are the record of the temporary and local prevalence of deeper and clearer water, and these, with the shales, prove that during the continuation of the Hamilton period there were frequent changes in the physical condition of this portion of the continent. These changes were, however, progressive, and indicate the gradual shallowing and final withdrawal of the waters of the Devonian sea. That the bottom of the sea was ultimately exposed is demonstrated by the facts that when the next succeeding formation, the Erie (Upper Portage and Chemung) rocks were laid down, these were shore deposits, and were ripple-marked, and sun-cracked.

In coming west from New York we find the changes in the Hamilton group to be precisely what our knowledge of the physical geography of the continent in this age would lead us to expect, namely, the thinning out of all the earthy strata, and thus a great diminution of the volume of the group, and a relative increase of limestones in the direction of the open sea. The aggregate thickness of the Hamilton beds of New York is about one thousand feet, while in Michigan and Illinois the limestones which represent it are only from fifty to one hundred feet in thickness. In Ohio the Hamilton limestones have but a very meagre representation, in no locality showing a thickness of more than fifteen to twenty feet, and in many places being absent from the horizon where they belong. They seem, indeed, to run out in a feather edge along the eastern base of the Cincinnati, and afford conclusive evidence of the truth of the statement made in our first volume, that in the Hamilton period the level of the Devonian sea was much depressed. The shallowing of the Corniferous sea is shown too, in the difference in lithological character between the lower or Columbus and the upper or Sandusky members of the formation, the first being a nearly pure calcareo-magnesian sediment, while the latter is largely mixed with earthy matter.

The only representatives of the Hamilton limestones seen on the eastern side of the Cincinnati arch are the cherty and marly limestones lying between the Huron shale and the Sandusky limestone, at Prout's Station, Erie county, in Tully township, Marion county, etc. These are sometimes without fossils, but in the two localities named they abound in fossils, which are recognized as characteristic of the Hamilton group, such as *Heliophyllum Halli*, *Tropidoleptus carinatus*, *Athyris spiriferoides*, *Strophodonta demissa* (the small Hamilton form), *Nyassa arguta*, *Spirifera mucronata*, *Phacops rana*, etc.

As has been before stated, the changes which are noticed in passing from the Lower Corniferous to the Hamilton—both in the mineral character of the deposits and in their fossils—are changes of degree rather than kind, and are so gradual that it is impossible to draw any line which will sharply separate the strata into two formations.

On the west side of the Cincinnati axis, in Paulding, Defiance, and Henry counties, the Hamilton limestones are thicker, and resemble more, in lithological character and fossils, the Hamilton rocks of Michigan.

THE HURON SHALE.

This remarkable and interesting formation is so fully described in Volume I, that it may be thought to be unnecessary that anything more should be said about it; but there is still so much difference of opinion among geologists in regard to its positions and relations, that a brief recapitulation of some of the more important facts brought out in the careful study we have made of it, seems called for here.

The Huron shale, along its belt of outcrop through the central portion of Ohio, is a nearly homogeneous bituminous shale, attaining a maximum thickness of 350 feet, and containing, everywhere, at least ten per cent. of combustible matter. It has been traced continuously from the Ohio River southward through Kentucky and Tennessee, diminishing in thickness to forty or fifty feet in this direction, but becoming more homogeneous and bituminous. On the west side of the Cincinnati arch, a similar stratum is found holding the same position as in Ohio, but thinner. Throughout the western States, this formation has been generally known as the *Black shale or Black slate.* In Michigan, it was studied by

Professor Alexander Winchell, and was by him associated with some overlying greenish sandstones and shales, to form what he called the *Huron Group.* The upper portion of that group has, however, since been proved oy its fossils to belong to a more recent formation, and is said by Professor Rominger to be Lower Carboniferous, and to represent a portion of our Waverly group. In these circumstances, it was thought best to retain Professor Winchell's name, but to limit it to its most important representative in Michigan—the Black shale, which, although widely and well known, had before received no distinctive geological appellation. Hence it has been designated in all our reports as the *Huron shale.* By different writers on the geology of the western States, it has been referred to, sometimes, as the western extension of the Marcellus or the Genesee, or a union of both.* Professor Dana, in the last edition of his "Manual," page 268, refers to it as "the *Black shale* or Genesee shale;" Professor E. T. Cox, in his report on the Geological Survey of Indiana, 1875, page 169, speaks of it as the "New Albany black shale, equivalent of the Genesee shale of New York, and reports it to contain *Leiorhynchus quadricostata*, *Lingula spatulata*, *Tentaculites fissurella*, and *Chonetes lepida*, all of which are fossils of the Genesee.

In the discussion of the age of the ~~Hudson~~ shale, contained in Volume I, page 152, it is shown that it is not the equivalent of the Marcellus shale, since in Ohio it overlies unmistakable Hamilton limestones; and it is argued that it cannot be the representative of the Genesee exclusively, as where last observed by Professor Hall, in Western New York, the "Genesee slate" is only twenty-two feet in thickness, and is thinning westward; and because we have found in our *Black shale* characteristic Portage fossils—*Clymenia complanata*, *Avicula speciosa*, and *Orthoceras aciculum*

The conclusion reached in the discussion referred to, was *that the Huron shale of Ohio is made up of the black shales of the Lower Portage and the Genesee.*

Subsequent examination has fully confirmed this view, and has furnished what may be accepted as demonstrative evidence of its truth.

In the central and southern part of the State, the Huron shale is a nearly homogeneous mass, containing no argillaceous shales or sandstones. Recently, a number of borings have been made along the lake shore, at Norwalk, mouth of Black River. Berea, Brighton, Cleveland,

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* Professor Lesley, in his appendix to Mr. Carll's report, calls the Huron shale Hamilton; but, as will be seen further on, although forming a natural continuation of the Hamilton Group upward, and, therefore, belonging to the Hamilton chapter in Geological history, it is not the equivalent of any portion of the Hamilton Group of the New York geologists.

Painesville, Ashtabula, and Erie, which have entered or passed through the Huron shale, and have shown that in going eastward from its line of outcrop on Huron River, it becomes much thickened by the introduction of wedges of argillaceous shale. Passing into the western counties of New York, the rocks rise easterly, and all the strata between the Chemung and the Corniferous are exposed to view. We there find the Genesee less than twenty-five feet in thickness, the "Cashaqua shale" —a clay shale—resting on it and having dwindled from a thickness of 110 feet on the Genesee river, to thirty-three feet at Eighteen Mile Creek. (Hall.) Further west, the Cashaqua is still thinner and apparently runs out altogether, letting the overlying Gardeau shale directly down on the Genesee. Of the Gardeau shale in this region, Professor Hall speaks as follows: "At the western limit of the State, along the shores of Lake Erie, the Cashaqua shale is succeeded above by a thick mass of black shale, and this is again succeeded by alternations of green and black shale, for several hundred feet upward." As we have proved by tracing it westward, this group supplies most of the material for our Huron shale, the sandy and argillaceous layers following the general law and thinning out towards the west, finally disappearing altogether, and leaving the black shales in a nearly homogeneous mass. With these facts in view, it is easy to see that the Huron shale of Ohio is composed of the Genesee and Gardeau shales, and since the Gardeau shale is a portion of Professor Hall's Portage Group, the truth of the proposition advanced in our first volume, that the Huron shale is the equivalent of the Genesee and Lower Portage shales of New York, seems sufficiently established.

The great fossil fishes found in the Huron shale have been frequently referred to in the preceding volumes of this report. Two species of *Dinichthys*, the largest and most remarkable of all known ganoids, one of *Aspidichthys* and one of *Ctenacanthus*, are described and figured in the volumes on Palæontology.

Important additions have recently been made to the list of fossil fishes found in the Huron shale, chiefly through the unwearied efforts of Mr. Jay Terrell, of Sheffield, the discoverer of *Dinichthys Terrelli.* Among the most interesting of the things he has found lately, is the jaw of a large Placoderm allied to, but very distinct from *Dinichthys*, to which the name *Diplognathus* has been given. Mr. Terrell has also obtained the jaw and dorsal plate of a new species of *Dinichthys* (*D. corrugatus N.*) much smaller than those before known; a new *Ctenacanthus* (*Ct. compressus N.*); and several new species of *Cladodus;* all from the upper portion of the Huron at the mouth of Black River. Fragments of the dermal plates of two other large and hitherto unknown Placoderms have been procured from the Huron shale within the last year. These are too imperfect for description, but they indicate the existence of a varied ichthyic fauna in the Huron epoch, and afford reason for expecting that the Huron shale will yet contribute largely to our knowledge of the life of the Devonian age.

It will be remembered by those who have read the first volume of this report, that the Huron shale is regarded by the writer as the most important source of supply of petroleum in this country, and also that the greater part of the gas-wells of Ohio and Pennsylvania derive their flow of carburetted hydrogen from this formation. The arguments in favor of this view are briefly stated in Volume I, Geology, (page 158, *et seq.*,) and most geologists have accepted them as affording a rational and satisfactory explanation of the problem of the origin of petroleum. There are some, however, who still cling to the theory that the petroleum and gas which fill the cavities and interstices of the sandstones and conglomerates in the Oil Creek region, are indigenous in these rocks. This hypothesis is certainly untenable. Sandstones and conglomerates are made up almost altogether of comminuted quartz, which could contribute nothing to the formation of hydrocarbons. All chemists agree that these are of organic origin, and must have emanated from some source foreign to the sandstones, and that these latter can only act as reservoirs to hold them, or as channels through which they flow.

That the hydrocarbons have not *descended* to saturate the sandstones is certain, as they are always thrown *upward* by hydrostatic pressure, and are, in fact, found working to the surface everywhere. They must, therefore, have risen from some source beneath to fill the reservoirs that hold them. The organic sediments which underlie the oil-bearing sandstones in Ohio and Pennsylvania are bituminous shales and limestones. In making a choice between these, as the possible source of oil and gas, the following facts deserve consideration, some of which have been already noticed:

1. No rock can furnish that which it does not contain, and none of the limestones that underlie the oil regions of Ohio and Pennsylvania hold more than one or two per cent. of organic matter. They are, therefore, entirely inadequate to supply the enormous flow of hydrocarbons which has continued through ages past and will continue through ages to come. In the argillaceous shales, sandstones, and conglomerates, the amount of organic matter is even less than in the limestones; hence the theory that they can furnish petroleum or carburetted hydrogen in any quantity is untenable.

2. The bituminous shales which underlie the oil reservoirs contain from ten to twenty per cent. of combustible matter, and they are therefore the greatest repositories of the materials out of which petroleum can be manufactured. They have already been successfully employed for the production of oil and gas by artificial means, and they constitute the source from which we must derive our illuminating oil whenever the supply of natural oil shall fail.

3. The organic matter of the bituminous shales is an unstable compound, which is constantly undergoing spontaneous decomposition. This results in the formation of water, carbonic acid, and the liquid and gaseous hydrocarbons. Whenever exposed to the air, the bituminous shales soon lose all their carbonaceous matter, and even when buried in the earth, especially where loosened and broken along lines of disturbance, they are undergoing spontaneous distillation.

4. Observation connects oil and gas springs directly with beds of bituminous shale. A line of gas and oil springs marks the outcrop of the Huron shale from New York to Tennessee, and the porous rocks overlying this formation, as well as the Waverly sandstones above the black Cleveland shale, are in thousands of localities charged with petroleum. The underlying rocks are not so saturated.

5. Wells bored through the strata overlying the black shales which have been mentioned, never obtain any considerable quantity of oil or gas below them. If, as has been claimed, limestones lying still lower were the source of the oil and gas, the strata nearer them and below the black shales should be at least as highly charged as those nearer the surface. As a matter of fact, no porous strata lying above limestones like the Corniferous are ever reservoirs of oil, while there are almost no porous strata immediately overlying black shales that are not more or less impregnated.

Prof. Dana says (Manual, page 268): "The oil obtained from this rock (the Huron shale) is not present in it as oil, for no solvents will separate it; it is produced by the heat of distillation out of carbonaceous matter present." This statement requires qualification, as the Huron shale is sometimes found charged not only with carbonaceous matter, but with oil. In these circumstances, when broken, the stone emits a strong odor of petroleum, and fragments thrown into water diffuse an oily scum over the surface.

In the remarks on petroleum on pages 70 and 160 of Volume I, Geology, it is suggested that the difference in productiveness between the oil wells of Pennsylvania and Ohio, located at the same geological horizon, is largely due to the facts that the strata overlying the Huron shale in Ohio are much finer and more impervious than in Pennsylvania, and are without the layers of sandstone and conglomerate which, on Oil Creek, serve as reservoirs for the oil, and also that the rocks of Pennsylvania are more disturbed than those of Ohio. This latter statement is denied by Prof. Lesley in his note to the report of Mr. F. A. Randall, *On the Geology of the Vicinity of Warren*, where he says: "The district of greatest oil production of Pennsylvania is precisely the district where there has never been any disturbance whatever. * * * In fact, had not Western Pennsylvania been lifted from the ocean bed into the air at the end of the coal era in a steady and gentle manner, *without disturbance*, the oil production would never have been a historical event." Such a statement, coming from such a source, is not a little surprising, for every geologist knows that the great disturbance which formed the folds of the Alleghany Mountains was felt throughout Western Pennsylvania, and we have conclusively proved that its influence extended even into Ohio. The series of basins which the Coal Measures exhibit in and immediately east of the oil region, are indisputable records of just such disturbance of their original horizontality as are indicated in the remarks referred to. That these disturbances were slight compared with those that affected the central portion of the Allegheny belt is evident; that they were sufficient to fracture and loosen rigid sandstones will hardly be denied by any one who knows any thing of the structure of the country under consideration and the condition in which the "oil sands" that underlie it are found.

The experience of all the well-borers has shown that these are cracked and fissured in every direction, and their capacity as reservoirs is thereby greatly increased. As they were once unbroken sheets of sand and gravel, their present shattered condition must have resulted from mechanical violence. That *no* disturbance could occur in the oil region without breaking up the strata and permitting the oil to escape, is a gratuitous and groundless assumption, for it is well known that a disturbance which would fracture and open the rigid sandstones, might leave the plastic clay shales still impervious.

CARBONIFEROUS SYSTEM.

THE ERIE SHALE.

As stated in the description of this formation contained in our first volume—the name Erie shale was applied to the great mass of argillaceous shale which forms the shore of Lake Erie from the Pennsylvania line to Avon Point. This was shown by the investigations made in the first year of the existence of the Geological Survey to be the western extension of the upper half of the Portage Group—the Portage sandstones of New York, and the overlying Chemung Group. These become finer and rapidly diminish in thickness westward, and finally run out to a feather-edge in the central part of the State. On the Pennsylvania line they have a thickness of at least twelve hundred feet. With the commencement of the deposition of these strata a new round of physical changes began in this part of the continent. The Devonian Sea had, up to this time, been gradually shallowed and diminished until its bottom formed land, which came west to the border of Ohio. After a longer or shorter period this land began to sink with an influx of water which received the wash from the continent on the east and spread it in the form of shales, sandstones, and conglomerates, that in their accumulation kept pace with the subsidence, so that Northeastern Ohio was maintained in either a shore or an off-shore condition until all the Erie and succeeding Waverly series had been deposited. The open and clear water of the new sea that spread these sediments reached no further than the central line of the State, there leaving its record in the thin edge of the Lower Carboniferous Limestone. Then the process of retreat began again and the whole eastern half of the continent was slowly raised out of the ocean, with many oscillations and local subsidences. In this latter period of continental elevation and local subsidence, the Conglomerate and Coal Measures were formed, and finally the elevation of the Allegheny Mountain belt took place, and this portion of our country was lifted above the ocean level, so to remain until the present day. If such was the progress of events in geological history—and abundant proof can be furnished for each of the steps reported—it is evident that the Erie Group is the record of the introduction of a new geological age; and that there are, therefore, reasons for removing it from the Devonian system, where it has hitherto been placed and attaching it to the Carboniferous. This change of classification is also favored by the character of the fossils of the Erie, which are generally different from those of the Hamilton, and resemble and probably shade into those of the Carboniferous system. Hence, it seems that the geological record would be best interpreted by considering the Erie Group as the base of the Carboniferous.

THE WAVERLY GROUP.

The phenomena presented by the Waverly Group in different parts of Ohio are so fully described in the volumes of our report already published, that no further reference to it would be needed here, but that Professor J. P. Lesley, Director of the Geological Survey of Pennsylvania, has advanced views in regard to the relations of the formation which seem to require a few words of comment. On page 97, note of Mr. Carll's report, on the Venango county oil district, Professor Lesley says:

"We have not used the general term Waverly sandstone formation of the Ohio geologists because of the controversies to which it has given rise, and because its subdivisions correspond to our Pennsylvania formations."

These considerations seem to us insufficient, since the controversies alluded to resulted in demonstrating that the Waverly was a distinct and important formation in Ohio and other Western States, and in the accurate determination of its place and age; also, because its subdivisions *do not* correspond to the Pennsylvania formations, and it was named before they were. Hence the law of priority, the truth of science, and a proper regard for the courtesies of life, require the Waverly to be recognized as such by any one who writes about the geology of Ohio. On page sixty-seven of the report referred to, he says:

"Dr. Newberry makes the Cuyahoga shale to be the uppermost member of the *Waverly Group* (his sub-Carboniferous system consisting of Cuyahoga shale, Berea grit, Bedford shale, and Cleveland shale—that is, all from the Conglomerate down to the Erie shale.) The geology of Pennsylvania opposes the adoption of this name, for resaons already alluded to and to be fully stated hereafter. The imperfect series of rocks at Cleveland afford no opportunity for so important a classification; but the name Cuyahoga shale will stand, for it designates a formation extending eastward with an ever growing thickness, until on the Schuylkill River it becomes 3,000 feet thick."

In answer to this paragraph, it may be said:

1. That the term Waverly Group was not coined by Dr. Newberry, but was conferred by the first Geological Corps of Ohio on the Waverly sandstone series, as exposed about Waverly, in southern Ohio.

2. The subdivisions of the Waverly Group established by Dr. Newberry, were not founded on the exposures of the Waverly rocks at Cleveland, but were proposed after a careful study of the formation throughout northern Ohio, where these subdivisions were found to prevail over twelve counties and along a line of outcrop of more than 150 miles.

3. The section of the Waverly Group at Cleveland, is one of the most complete in Ohio, and if the classification adopted had been copied from this section, it would have fairly represented all the different elements which compose the Waverly throughout the Western Reserve.

4. It has nowhere been claimed in the reports of the Ohio Survey, that these subdivisions of the Waverly could be recognized in other States, or in other parts of Ohio than the district referred to; indeed, it was clearly shown in the description of the Waverly already published, that in central and southern Ohio the lithological characters of the group

were quite different from what they are along the northern line of outcrop.*

But any description of the Waverly group, as it appears on the Western Reserve, would be very incomplete and inaccurate that did not specify and define the marked subdivisions which it shows, and it has greatly facilitated both the communication and the acquisition of a knowledge of the formation to give to these subdivisions distinct names. The custom of attaching local names to well marked subdivisions of geological formations, has been followed since men began to write on geology, and it will unquestionably continue to be followed as long as geological surveys and explorations shall be made. Beyond the region where the local subdivisions of a formation are distinguishable, the local classification will not hold, but in the district where the Berea grit is well defined, and where, as on the Reserve, it is literally a mine of wealth to the citizens—furnishing building stones, grindstones, etc., to the amount of a million of dollars annually—it is a matter of great practical consequence that it should be carefully described and its place in the series be accurately defined. To do this, it was indispensable that it should receive a distinct name.

5. The Cuyahoga shale, stated in the above paragraph to be identical with the umbral of Rogers, and to reach in Pennsylvania a thickness of 3,000 feet, is simply one of the local subdivisions of the Waverly in northern Ohio, and is not recognized in the central and southern parts of the State. Its identification with the umbral of Rogers, is not supported by any satisfactory evidence.

6. The Berea grit is supposed, by Professor Lesley, to split into two parts in passing into Pennsylvania, the upper one to become the "Vespertine" or "First Mountain Sand," the lower to descend and form the Chemung Conglomerate at Chautauqua Lake and Olean, New York. It is scarcely necessary to say that this view is entirely untenable The

* On page 97, note, Professor Lesley says: "Dr. Newberry, in his Report of Progress of the Ohio Survey, for 1870, page 59, divides it (the Waverly) into three members—upper, middle, and lower—the Middle Waverly being a Conglomerate. This is the Berea grit and the New York 'Conglomerate;' our Venango Second Mountain sand. But in the report of 1873, the Ohio geologists divide the Waverly group into four formations—Cuyahoga, Berea, Bedford, and Cleveland." This paragraph contains three errors, which require correction. (1) It was Professor Andrews who divided the Waverly into three members in southern Ohio, Dr. Newberry into four in northern Ohio; (2) there is no evidence that the Middle Conglomerate of Fairfield county is identical with the Berea, and it is quite certain that neither are the equivalents of the 'Conglomerate' of New York, for they are Waverly and that is Chemung; and (3) the "New York Conglomerate" is not the equivalent of the "Second Mountain sand" of Pennsylvania.

Berea, of Ohio, is essentially one formation, and is generally a single stratum of sandstone, although sometimes, as has been stated, having a parting of shale. It is here underlain by one hundred feet or more of strata, which contain large numbers of well known Carboniferous fossils, while the Panama Conglomerate, on Chautauqua Lake, is covered by more than a hundred and fifty feet of Chemung shales, full of fossils. If palæontological evidence is worth anything, anywhere—and every day adds to the proof that it is a safe and sure guide—it is impossible that any part of the Berea grit can be represented by the Panama Conglomerate. This latter rock is, in fact, one of the several conglomerates of the Chemung, which are known in Pennsylvania as the "Oil Sands." Their true position in Ohio is far below the base of the Cleveland shale, and, at Cleveland, below the lake level. The reason why they have not been reached in the wells bored in Ohio, is that, following the general law, they become thinner and finer going west, and run out altogether, or are represented by the flags of fine-grained sandstone found in the Erie shales.

That the Berea grit is the equivalent of the Second Mountain sand of Venango county, is possible, but by no means certain. All deposits of this kind, produced by mechanical agents, are far more variable in thickness and local in development than limestones, which are laid down continuously, over hill and dale, on the sea bottom. All identifications of sandstones and conglomerates at distant points, are, therefore, to be regarded with suspicion until confirmed by unquestionable evidence.

The Bedford shale, which immediately underlies the Berea, and is locally partly or wholly red, is regarded by Prof. Lesley as the equivalent of the Catskill of New York and Pennsylvania, but with no other evidence than such as is afforded by its local red color. In the first year of the organization of the Ohio survey the writer, with several assistants, went forward and backward over all the interval between the Ohio line and the outcrops of the Catskill in Tioga county, Pennsylvania. The result of this examination was to show that the Catskill could not be identified west of McKean county, Pennsylvania. In the neighborhood of Warren, Pennsylvania, every inch of the strata between the coal and the Chemung has been carefully examined, and in that section there is nothing which corresponds to the Catskill in lithological character or fossils. The same is true of the valley of Oil Creek. The interval here between the Chemung and the coal is less than four hundred feet, and through this interval must pass the Catskill, Vespertine, and Umbral—strata which in the east have an aggregate thickness of five thousand feet—if there is any connection between the supra-Chemung rocks of north-eastern Pennsylvania and Ohio. That the Vespertine connects through this gap with the Waverly of Ohio is indicated by the Waverly fossils found continuously from McKean county to the Ohio line, but that the Umbral and Catskill do not reach Ohio seems demonstrable.

The local red color of the Bedford shale is certainly insufficient proof of relationship with the Catskill, while the palæontological evidence is incompatible with the theory of their identity. The Bedford shale contains in some places great numbers of fossils, among which may be mentioned *Syringothyris typa*, *Spiriferina solidirostris*, *Orthis Michelini*, *Rhynchonella Sagerana*, *Chonetes Logani*, etc., all Lower Carboniferous species, while not a trace of the Catskill fishes has yet been found in Ohio.

The truth in regard to the Catskill formation probably is that it was formed in an enclosed—perhaps fresh water—basin which had its centre in south-eastern New York and eastern Pennsylvania, and that it shoaled away to a Chemung shore in western Pennsylvania, beyond which its deposits did not extend.

The Cleveland Shale is considered by Prof. Lesley to be of Chemung age, but this was necessitated by his identification of the Bedford shale with the Catskill, and the arguments against one are as cogent against the other. As has been already stated, the fossils found at and even under the base of the Cleveland shale are identical with those of the Bedford.

It may be thought that the preceding remarks are inconsistent with the view before presented, that the Chemung and Catskill as well as the Waverly group should be included in the Carboniferous system, for if all are parts of one formation why insist upon their distinctness? It is true, however, that the well-marked subdivisions of each formation hold invariable positions in regard to each other, and are characterized by differences in lithological characters and fossils, although some species are usually common to all the members of the group. We may hereafter find in Pennsylvania such a blending of Chemung and Waverly fossils as shall unite them more closely than heretofore, but such blending would in no wise affect the question of the identification of the subdivisions of the Carboniferous system in Pennsylvania with those of Ohio.

THE LOWER CARBONIFEROUS LIMESTONE.

In the discussion of the phenomena presented by the Carboniferous system in Ohio, published in Vol. I, Geology, of this Report, mention is made of the discovery by Prof. Andrews of a thin bed of limestone in the southern part of the State, proved by its fossils to be the representative of the Chester limestone of Illinois, the upper member of the great Carboniferous limestone series. Facts are also stated there which prove the submergence that resulted in the formation of the Carboniferous limestone to have been progressive from the south and west, and the Waverly group of Ohio to be in a large part the shore equivalents of the open-sea limestone sediments of Kentucky, Indiana, and Illinois.

The limestone of southern Ohio was called the *Maxville limestone* by Prof. Andrews, from one of the localities where it is exposed. Its occurrence there and at Newtonville, Muskingum county, within the area of the Coal Measures, created considerable surprise, and caused its identification with the Carboniferous limestone of Kentucky to be questioned, but the long list of fossils collected from it seem to leave no room for doubt on this subject.

Prof. Edward Orton, who has been engaged during the past summer in a careful review of the geology of the Hocking valley region, has brought out some new facts in regard to the Maxville limestone which will give it fresh interest to geologists, while at the same time they explain in an unexpected way all the mysteries that have hung around it. These facts are briefly as follows: 1. That the Maxville limestone can be followed by numerous outcrops—as a distinct geological horizon, from Perry county to the Ohio River, and that it does not lie in patches alternating with others of Conglomerate as has been represented. 2. That one, sometimes two, limestones or flints are found within a hundred feet below it which share in a degree its lithological character and fossils. 3. That the Wellston and Jackson coals, well known and important seams in southern Ohio, are both beneath the Maxville limestone.

A recent visit to the Hocking valley, in company with Prof. Orton, has resulted in the verification of all his observations, and the collection of fossils from the Maxville limestone and Waverly shales, which prove beyond question that the lower coals—two or three in number—of Southern Ohio are of Lower Carboniferous age.

Another important result of the recent observations of Prof. Orton is to demonstrate that all the conglomerate of Southern Ohio lies below the Maxville limestone, and is, therefore, distinct from, and older than, the conglomerate of Northern Ohio. The latter conclusion, which will, perhaps, be questioned, is established by the facts that the conglomerate of Southern Ohio is overlain by shales, which contain the fossils characteristic of the Upper Waverly in Holmes, Summit, Mahoning, etc.; while the conglomerate of Northern Ohio—which, apparently, extends no further south than Licking county, and thence thickens greatly northward—lies upon the Upper Waverly, and has no Waverly fossils in or above it; also, that it contains, in Holmes county, numerous imperfectly rounded fragments of cherty limestone, of which the lithological characters and fossils are identical with those of the Maxville and Logan limestones, such as have apparently resulted from the destruction of these limestones by the forces which, at a later date, spread the Conglomerate. Hence, we must conclude that the Conglomerate of Northern Ohio is more recent than that of the Hocking Valley, and that Coal No. 1 of Mahoning county is not, as formerly supposed, identical with the Jackson shaft coal.

In the Sub-Carboniferous coals of Southern Ohio, we have additional evidence that the submergence which resulted in the formation of the Lower Carboniferous limestone was progressive from the south toward the north. They show that the Waverly shore of the Carboniferous sea was for a time marshy, and sustained a luxuriant vegetation that produced the accumulation of peat, and that, by subsequent subsidence, the sea water flowed in over this shore, covering the peat beds with thin sheets of organic sediment derived from the hard parts of the mollusks which inhabited the Carboniferous ocean. At a later date continued sinking of the surface resulted in the formation of other peat beds, limestones, etc., but the water which buried or deposited these was not that which formed the Maxville limestone, but came from a different source, and was, perhaps, fresh.

THE CONGLOMERATE.

In the description of the development of the Conglomerate in Ohio contained in the first and second volumes of this report, nearly all we have learned about it is told. It seems necessary, however, to refer to one or two errors which have become current in regard to this rock, and which require correction.

First. It is believed by some that the Conglomerate nowhere extends under the Coal Measures, but forms a bank or rim around the margin of the basin.

Abundant evidence of the falsity of this theory is, however, furnished in the reports and maps descriptive of the geology of Mahoning, Trumbull, Portage, Summit, Medina, Wayne, Holmes, and Licking counties, contained in this or the preceding volumes of our report. In all these the Conglomerate is shown to pass under Coal No. 1. It is true that the greatest development of the Conglomerate is north of the coal field, and that it is rarely struck in borings made towards the central portion of the basin. It is reported, however, in a number of localities, and has been missed in many others, simply because it was not reached. There are sometimes forty or fifty feet of light shales interposed between the Conglomerate and Coal No. 1, and as these have been considered "bottom rock," the borings have not been carried deeper. The Conglomerate is frequently seen occupying a higher level than the coal, but that is also sometimes true of the Waverly. Along the margins of the old coal marshes there were hummocks, hills, and highlands which rose above it, and over these the peat, which has since become Coal No. 1, was not deposited. Sometimes the peat partly filled valleys and narrow channels produced by surface erosion in the Waverly or Conglomerate, so that we now find the coal perhaps a hundred feet below the *level* of the Waverly, or base of the Conglomerate, but never *beneath* the true Conglomerate, or any part of the Waverly. Good examples of this peculiar relation in position between the Waverly, Conglomerate, and coal may be seen in Mahoning, Holmes, and Richland counties; and they are described in Vol. I, page 128, and in the Third Annual Report of Mr. Andrew Roy, State Inspector of Mines, page 129.

Second. The error of confounding the Conglomerate below the coal with that which sometimes occurs above.

In Ohio it can hardly be said that a conglomerate anywhere immediately overlies Coal No. 1, but patches of pebbles are sometimes found in the sandstone over the coal in Medina, Trumbull, and Mahoning counties. These are referred to in the sketch of the Carboniferous System in Vol. I, Geology, and are supposed to be portions of the gravel-hills, now the Conglomerate—which bordered the coal basin on the north, washed down by local streams into the coal marsh, sometimes on to the coal; but in Western Pennsylvania several of the sandstones of the Coal Measures become conglomerates.

THE COAL MEASURES.

So much space was given to a discussion of the Coal Measures of Ohio in Volume I, that it will be only necessary here to review briefly the facts of importance that have been learned since the publication of that volume.

During the last two years, such developments of the richness of the Hocking Valley coal field have taken place as seemed to require that a more careful study of and report on this field should be made. This work has been done by Mr. M. C. Read, and the results are given in his report which forms part of this volume. From this it will be seen that the Coal Measure iron ores have been found to exhibit an unexpected, and it may be said an almost unequalled development there. The iron lies at several horizons, the most important seam being about a hundred feet above the Great Vein Coal, and therefore on the same level with the Blackband and Mountain ore deposits of Tuscarawas county. In the Hocking Valley the iron ores are chiefly earthy carbonates, frequently in the form of continuous strata from one to four feet in thickness. The discovery of these beds of iron ore adds greatly to the value of the mineral lands of Perry and Hocking counties, and has induced the erection of many new furnaces there. These are now manufacturing iron at a cost of not more than $12 to $15 per ton—a less price than it costs in any other part of the country. The excellence and abundance of the coal of this region had before been sufficiently proven, and it is now stated by Mr. Read that the iron ores associated with it exist in such quantity that they are not likely to be first exhausted.

A re-examination of the Coal Measures of the region lying south of the Hocking Valley coal field, in the counties of Jackson, Vinton, Gallia, and Meigs, has been undertaken by Prof. Edward Orton, and his report, now published, will be found to contain much interesting and valuable information in regard to the coal and iron mines of this rich district.

The reports on the geology of a number of the coal-bearing counties north of the National road are contained in the present volume, and the reader is referred to them for details illustrating the general description of the Coal Measures given in Volume I.

SURFACE GEOLOGY.

In Vol. II of this Report, a chapter of eighty pages is devoted to Surface Geology, and a somewhat detailed description is given of the Drift phenomena which had been observed in Ohio, with a sketch of the history they seemed to teach. Since the publication of that volume a large number of papers on the Drift have been issued in this country and in Europe, and new editions of Croll's "Climate and Time," and Geikie's "Great Ice Age" have appeared. In some of these the facts and conclusions of Chapter XXX have been made the subject of comment in such a way as to show that they have not always been understood. A few additional notes on our Surface Geology are therefore required to explain more fully the facts reported or views advanced, or to correct some mistakes and misstatements which have been made in regard to them.

BURIED CHANNELS.

In the earlier notices of the system of deeply excavated, and now buried drainage lines, which are found beneath the superficial deposits of Ohio, and many other parts of North America, published by the writer, * they were referred to the glacial epoch, but in a subsequent paper † they are

* Proceedings Bost. Soc. Nat. Hist., Vol. X, 1862.

† Surface Geology of the Basin of the Great Lakes. Annals Lyc. Nat. Hist., N. Y., Vol. IX, 1869.

stated to have been formed "during the ice period, or at an earlier date." On page 12, of Chapter XXX, it is said, "Some of the channels were in part formed long anterior to the ice period, as all of the area of the Eastern, Middle, and North-western States has been a land surface traversed by drainage lines since the close of the Carboniferous period. We may, therefore, conclude that many of our great arteries of aqueous circulation have been in action all through the Mesozoic and Tertiary Ages. The continued study of these interesting features in our Surface Geology, has led to the conclusion that most of these buried *river* channels are pre-glacial, and that they form, as suggested in the quotation above, a portion of the surface erosion, suffered by this part of the continent during several geological ages. The facts upon which this conclusion is based are—

1st. Many of these channels are deep and narrow gorges, such as are produced by running streams, and not by glaciers, and these bear no evidence of ice action.

2d. They are found south of the line to which the glaciers reached, and in that region ice could have taken no part in their formation.

3d. Some of them have been filled and obliterated by the bowlder clay, showing that these were river channels which antedate the ice period.

Many of these old channels have, however, been filled with and modified by ice, as the valley of the Cuyahoga, the bottom of which is glaciated at Boston, twenty miles from its mouth. In this instance the direction of the valley accorded with the line of motion of the great glacier which passed *across* the lake basin, and it is probable that all the old channels within the glacial area that had a north southerly direction, have been occupied and modified, like the valley of the Cuyahoga, by some portion of the ice being pressed into and moving through them. It is probable, also, that the lines of these old channels were frequently followed by local glaciers, as they would then as before be channels of drainage, and the consolidated water would naturally move along the lines of lowest levels, as fluid water had done. As was suggested in the second volume, it is even probable that the basins of Lake Erie and Lake Huron were formed by local glaciers, which followed and enlarged pre existing river valleys.

Prof. E. B. Andrews prefaces his report in Vol. II with some pages devoted to surface geology, in which he alludes to these buried channels. On page 45, after referring to the facts cited by the writer, he says:

The larger streams in the Second District, (south-eastern quarter of Ohio) had, at some time antecedent to the Drift era, large portions of their beds deeper than now, as shown by wells and borings. They had at no time beds of uniform depth and slope, the softer rock strata over which they flowed being more readily eroded than the harder. From this cause there would be pools separated by ripples or water-falls. * * * The harder rocks were where the ancient rapids or falls are now sometimes seen, and constitute the present bed rock of the streams.

He then cites a number of instances where the Ohio River shows a rock bed apparently extending quite across the present stream, and quotes from E W. Sprague, Esq., the following facts in regard to the construction of the dams on the Muskingum:

At Marietta, at the east end of the dam, the solid rock was found twenty-four feet below the low-water mark, but no rock at all was found under the western two-thirds of the dam. At Devol's the dam is built on "red soapstone," no harder rock appearing except near the lock at the east end. * * * At Lowell the dam is on rock, but when we go above or below, the rock disappears on one side of the river or the other. At Beverly the dam at the east end is built on rock, but at the west end no rock is found to a depth of eighty feet. At Windsor the dam is built on soapstone bottom, no rock, *i. e*, hard rock, appearing except near the lock. At McConnelsville the dam is built upon a soft, shelly rock. At Rokeby no rock was found, and the dam is built upon a sand foundation. At Taylorsville the dam is built upon the bed rock of the river. At Zanesville the dam is upon bed rock. At Symmes Creek the dam and lock are upon soapstone at the east end, but no rock was found at the west end within a depth of sixty feet.

These facts would, at first sight, seem to refute the theory that the Muskingum and Ohio at one time flowed in continuous channels at a much lower level than now. They will be seen to be in entire harmony with it, however, when it is explained that the present streams do not follow the exact lines of the old filled up channels, but in many places cross spurs or shoulders which projected into the old valleys, as the Ohio does at Louisville, (as described on p. 14 of Vol. II, Geology of Ohio). By reference to Mr. Sprague's notes, it will be seen that some of the Muskingum dams were built on the solid rock which formed the side of the channel, in others the dams were built partly on the rock and partly over the old channel, where the rock was not reached at the depth of sixty or eighty feet. In one instance, at Rokeby, the dam was constructed directly over the old channel and no rock was found.

The valleys of the Ohio and all its principal tributaries, after being deeply excavated, were filled with gravel and sand—by the setting back of water into them, and the checking of their currents—to a much higher evel than that of the present streams. This old filling has now been partially and irregularly removed, leaving terraces and broad bottom lands, under which the old channels are frequently concealed. An immense number of facts gathered by the writer—chiefly from the borings for oil in the valleys of our western rivers—prove that the buried channels are continuous, and, though not necessarily of uniform depth, show no such succession of deep pools and rocky barriers as are imagined by Professor Andrews to exist. Indeed, it is inconceivable that any such alteration of transverse rocky barriers and pits, one hundred feet or more in depth, could be formed in a country where the rocks are so nearly horizontal as they are in south-eastern Ohio.

It is true that every water-fall formed by a harder stratum overlying a softer one scoops out the latter to a considerable depth, but the fall constantly recedes by the wearing away of the shelf over which the river pours, and the excavation below, as above, is nearly horizontal. If the channel of any stream in which there is a succession of falls formed by horizontal hard layers be carefully examined, the rock bottom will be found to form a series of steps, and not of ridges and pits. The *water* may be of very unequal depth, because loose material accumulates unequally in the channel, but the fall recedes horizontally, and cuts, as it goes, to a nearly uniform depth. It will be remembered that the excavations of the rock bottom of the Muskingum, brought to light in building the dams, were longitudinal and not transverse, and that some of the dams were built over channels of unknown depth, *cut up and down the river through layers of hard rock.* There is scarce the shadow of a doubt that if a series of transverse sections were made of the valley of the Muskingum, that there, as elsewhere, the old deep channels would be found to be continuous.

GLACIAL EROSION.

In Chapter XXX of this Report the evidences of glacial action in Ohio, and the country north and east of it, are very fully described, and it was there shown: First—That the planing and grooving of the surface rocks, so frequently seen north of the Ohio river, were produced by ice, since they are precise copies of the inscriptions made by this agent in different parts of the world, and such as are not made by any other cause. Second—That these marks were produced by glacier-ice, and not icebergs, was also proved by their identity with the peculiar inscriptions made by glaciers, and by cases where the glaciation is visible on vertical and overhanging surfaces, where it could only have been produced by some moving mass which moulded itself to the form of the object against which it pressed. To those who have seen the *roches moutonnées*—the planed, grooved, and striated surfaces produced by recent glaciers, and who have examined the markings on the surface rocks of the region about the great lakes, no argument is necessary to prove that both sets of phenomena were produced by the same cause, and yet there are some, who have not had the opportunity of making the comparison, who still cling to the theory that the distribution of the Drift, as well as the glaciation of the surface rocks, were produced by icebergs, which floated over the continent during a period of submergence, grounding, dragging, and grinding as they progressed.

Principal J. W. Dawson, of Montreal, is generally credited with the authorship of the iceberg theory of the Drift, but he is too good an observer, and too well-read a geologist to exclude glaciers from participation in the great mechanical effects produced during the ice period. That he differs from the writer in the reading of the history of the Drift phenomena in the basin of the great lakes, is simply due to the fact that he has not had the opportunity of studying on the spot the inscriptions upon which our conclusions have been based. If he could come to Ohio, and examine our Drift deposits, and the peculiar and characteristic glacial markings on the rock surfaces, he would find here the same unmistakable evidences of glacial action that he has seen in those portions of the country where he concedes that glaciers did exist. It is also probable that, if he had examined the Till or Bowlder clay which so generally covers the glaciated surface in the lake basin and Upper Mississippi Valley, in which there are no marine fossils and no eastern Canadian or Adirondack bowlders, he would abandon the view which he once entertained that our glaciation was effected, and our Drift deposits were distributed, by icebergs floating from the north-east through the submerged lake basin and down the Mississippi Valley.

The arguments against the glacial, and in favor of the iceberg hypothesis, advanced by Professor E. B. Andrews, in his report contained in Volume I (page 447, *et seq.*), would hardly have been written if his district had not been outside of the Drift area. These arguments are:

First. That an ice sheet could not cover a large part of Ohio without there being local glaciers in the Alleghanies.

Second. That grounding icebergs could produce the planing, grooving, and striation of the rocks.

Third. That the clays, gravels, and sands of the Drift bear evidence that they were deposited and arranged in water.

Fourth. That the Canadian highlands were not high enough to afford sufficient fall to carry glaciers by gravity through the basin of the lakes, and over the surface of Ohio. The conclusion is that, in a general submergence, ice rafts and water currents produced all the Drift phenomena.

To which, it may be answered:

First. The traces of local glaciers have been observed by the writer in the Alleghenies of West Virginia, and by Professor Safford in the Unaka range of Tennessee. (Geol. of Tenn., p. 438.)

Second. That the grooving, polishing, fluting, and carving of the rocks is precisely that done by glaciers, and such as could not be produced by floating ice.

Third. The bowlder clay which covers so much of the glaciated surface is generally *unstratified*, and hence could not have been deposited from water, and it everywhere contains angular or imperfectly rounded fragments of rocks, frequently brought from neighboring localities and lower levels, planed and striated, as glacier-worn pebbles always, and as water-worn pebbles never, are.

Fourth. The objection that there was no declivity down which glaciers could descend on to Ohio, has been considered by Dana,* by the writer,† and others; and it has been shown that from the practical plasticity of ice, if it were to accumulate to the thickness of several thousand feet on the Canadian highlands, and was prevented from moving northward by an unyielding ice barrier, it would flow off to the south, over any minor topographical irregularities, until it reached a point where it was melted by a warmer climate. It may also be said that even if it were impossible to explain *how* glaciers could have reached Ohio, the fact that they have been here is attested by the deeply graven and unmistakable record they have left.

THE ERIE CLAY.

This, the first and lowest member of our Drift series, is fully described in the second volume of this report, but its nature and origin do not seem to have been clearly understood by all those who have since referred to it. The name Erie clay was first used by Sir Wm. Logan, and applied to the lowest Drift clay, on the north side of Lake Erie, the exact equivalent of the clay which holds the same position in Ohio. It corresponds to the Till or Bowlder clay, which covers so much of the rock surface glaciated in the ice period in the British Islands, and to the *grunde-moräne* and *moraine profonde* of the geologists of Germany, France, and Switzerland.

In the description of the Erie clay contained in Chapter XXX, the laminated clay which locally overlies the true Bowlder clay, was united with it, on the supposition that this was deposited in local water basins synchronously with some portion of the sheet which it formed, but in view of facts which have been more recently brought to light, it has seemed best to distinguish the two clays by different names; the laminated clay having been proved to be fossiliferous, the product of a slow

* Manual, Second Edition, page 536.

† Geology of Ohio, Volume I, page 69.

process of deposition at a time and under circumstances quite different from those in which the Bowlder clay was formed.

The Erie clay in Ohio is essentially an unstratified formation. It is true that in certain localities it is divided into thick layers or beds, separated by sheets of sand and gravel, as will be seen by the interesting section given on page 24 of Vol. II, but these subdivisions are quite local, and, as a whole, the Erie clay shows as little evidence of aqueous stratification as does the Till of England and Scotland.

No unquestionable case of the occurrence of fossils in the Erie clay—except as transported pebbles—has yet come to our knowledge. A piece of wood was found by Mr. M. C. Read, in Lake county, in what he supposed to be the Erie clay, and it is probable that he is correct in that supposition, but there is room for doubt in regard to this case, from the difficulty of distinguishing, on the Lake shore, where the clay beds are constantly slipping, between the true Bowlder clay and the more recent laminated clay which overlies it. The latter contains many fragments of floated wood, and these are sometimes brought down by slips below the surface of the Erie clay, and where they would very naturally be supposed to have been derived from it.*

Over nearly all the counties of Ohio that lie within the lake basin the Bowlder clay forms a continuous sheet from ten to a hundred feet in thickness. It has every where the same general character, although toward the north-west corner of the State the stones it contains are larger, and it is underlain by a water-bearing sheet of gravel and sand. The pebbles contained in the Bowlder clay are generally small, sub-angular, scratched and planed fragments either of indigenous or of exotic rocks, the former largely preponderating. It is usually yellow or brown at the surface and blue below. In our former notices of the Erie clay this difference of color was represented as due to the oxidation of iron at the surface. Prof. Otto Torell, who examined, with the writer, some of the exposures of the Bowlder clay in northern Ohio, was inclined to regard the upper and yellow portion as a distinct formation, and as corresponding with a yellow Till found overlying the blue Bowlder clay in Scandinavia and Germany, reported to be separated from it by a well-defined line of demarkation, and to contain different pebbles. A careful

* It is by no means impossible that sticks and logs should be found in the Erie clay, although it is purely morainic material, for when the ice period began, all the country between Lake Erie and the Arctic Sea was covered with a luxuriant forest, and in the advance of the glacier which removed the soil and all other superficial material some of the tree trunks may have been so buried and lodged as to escape complete attrition, and leave rolled fragments in the terminal moraine.

examination since made of many exposures of the Bowlder clay in northern Ohio has failed to show any constant difference, except in color, between the yellow and blue portions. So far as observed the pebbles are the same in both, and there is no distinct line of separation between them. In some places the yellow color is seen to penetrate the blue irregularly, to affect the sides of fissures to a considerable depth, and to pervade the exterior of blocks of clay of which the central portions remain blue. Mr. M. C. Read, whose attention was called to the question, and who has had good opportunities for observing, reports that he also has been unable to find any constant difference, except in color, between the two phases of the Bowlder clay. Hence, until facts shall be observed which invalidate the conclusion stated in our former article—that the yellow is the leached and oxidized portion of the blue clay—this will remain unqualified.

In the examination made with Prof. Torell beautiful exhibitions of "contorted drift" were found on the shore of Lake Erie, just west of the mouth of Rocky River. Here the upper portion of the Bowlder clay has evidently been thrust forward and much folded and twisted by a powerful lateral pressure. So far as observed, this appeared to be simply a change in the physical condition of the Till. The character of the material and the enclosed pebbles seemed to be the same here as below.

Such examples are not uncommon, and they appear to illustrate the manner in which the Bowlder clay was formed; portions of the mass which had before accumulated having been impinged upon and crowded forward by a temporary advance of the glacier. In such advances the edge of the ice sheet over-rode a part of the Bowlder clay, but crushed and contorted another part by vertical and lateral pressure.*

In the description of the Erie clay given in Vol. I. it is said to be the material ground up and transported by the great glacial sheet in its passage from the Canadian highlands to southern Ohio, and that it was moraine matter unwashed and unassorted, thrust out and left behind by the retreating glacier. It was also said that it did not accumulate *beneath* the glacier, because the rock surface on which it rests is planed down,

* Mr. Searles V. Wood, Jr. (Geol. Mag., Sept., 1871, p. 3), attributes the contorted drift of Cromer. to the bumping and dragging of icebergs on submerged Bowlder clay, and Prof. Geikie (Great Ice Age, pp. 122, 258) gives examples of what he considers both glacier and iceberg contortions of the Drift clays. Of these the first are more regular and general, and the foldings of the clay are in the direction of the glacial scratches: the second local and irregular. Most of our contorted Drift has probably been produced by glaciers, but some folding of the stratified Till which has been noticed can hardly be due to any other cause than icebergs. Doubtless the Bowlder clay was also sometimes crushed and folded by the grounding of icebergs.

grooved, and carved, as it could only be where the ice fitted closely to it, and since two solid bodies can not occupy the same space at the same time, the clay could only have accumulated in the places where it is found, after, or as, they were abandoned by the ice. The facts which sustain this view of the origin of the Bowlder clay are so numerous and significant that it is difficult to imagine that any one carefully reviewing them should not be convinced of its truth, and yet, as there is perhaps no subject on which all men think alike, there are differences of opinion here. Prof. Jas. Geikie, speaking of the North American glacial deposits, in the last edition of his "Great Ice Age," p. 461, says:

> "Dr. J. S. Newberry maintains that the deposit in question (the Bowlder clay) must have accumulated at the margin of the glacier. This is the same view as that held by Mr. S. V. Wood and some other geologists in our own country. It fails, however, to account for many of the facts. The Bowlder clay has evidently been subjected to great pressure, and has been pushed and rolled forward under the ice."

And in a note he says farther:

> "I have often tried to conceive how one hundred feet of tough Till could have been slowly excluded in the form of loose clay and stones from the foot of an ice sheet so as to cover a wide, flat country, but I have never been able to realize the process. Let me ask those geologists who hold the opinion that the Bowlder clay has really been deposited in this way, why it is that along the limit of the 'Northern Drift' that formation consists almost exclusively of more or less loose accumulations of bowlders, gravel, and sand, while to the north, Bowlder clay is present as the basement Drift, with bowlders, gravel, and sand lying upon it."

That the Bowlder clay should exhibit marks of great pressure is inevitable from the fact that it *has* been thrust out at the margin of the glacier, and crushed against itself or any barrier behind it, with a force almost inconceivably great. It should be remembered that the broad, flat, almost continental glacier which formed it, must have been affected by the seasons of the year and alternations of warmer and colder years, just as modern glaciers are, and that in its great retreat there were thousands of temporary advances, and thus the materials which it ground up and slowly excluded was from time to time pressed up into a ridge or heap against which every advance of the glacier impinged. In the gradual withdrawal of the glacier, these terminal moraine clay ridges coalesced to form a plateau or sheet, such as we find it. It is also probable that the comparatively thin terminal edge of the glacier in its temporary advances in some degree over-rode the great moraine sheet it had thrust out. Indeed, this was inevitable, for the excluded clay would form a slope which would receive the pressure of the advancing ice-sheet, and thus it might with its diminished weight shoot far up on and over the mass of clay it had before deposited.

Many instances are reported of pavements of stones embedded in the Bowlder clay which are striated in a common direction, but which, when lifted from their beds, are found to be worn or scratched perhaps on several sides, showing that they have been previously transported in the Till. These do not necessarily mean a second ice period, but are probably the result of the temporary advance of the glacier when the edge over-rode the embankment which had been piled up before it, and wearing away the softer portion above, formed a bed for itself on the tougher mass below and the stones impacted in it. The evidence that these pavements do not mean a second ice period seems to be furnished by their being so local and by the homogeneity of the mass of Till above and below them.

Those who can not accept the view presented in our former article—that the Bowlder clay accumulated along the margin of the glacier—are offered the choice of two other theories, one of which they must accept: first, that the Bowlder clay formed under the glacier; second, that it was formed on the glacier, and by its melting was let down into its present position.

The considerations which oppose the acceptance of the first of these theories have been already alluded to. The peculiar character of the erosion produced by the glacier proves that it was accurately moulded to the surface over which it moved, and that the grinding it effected was done by sand and stones impacted in it; that it was, in fact, a sort of great emery wheel. We sometimes see acres of rock surface not only ground to a plane but polished, and sections containing fossils as nicely cut as they could be done by hand. That there could have been any considerable thickness of clay under the ice when this process was going on is simply impossible.

The theory proposed by Prof. N. H. Winchell was referred to in Volume I. He describes very graphically the manner in which the Bowlder clay accumulated *on the surface of the glacier*, increasing in thickness towards its edge and finally, by its melting, let down quietly on the bed rock. However complete the picture Prof. Winchell has presented of the formation of the Bowlder clay, it is necessary to say that it is impossible that in the basin of the lakes or the Valley of the Mississippi it could have had any counterpart in nature. No accumulations of stones and earth take place on the top of glaciers except where peaks and cliffs of rock overtop them. In all the country north of Ohio there are no such peaks or cliffs, and this country during the glacial period was covered with a continuous sheet of ice several thousand feet in thickness.* This was growing at the surface by continual accessions of snow, while it wore away and melted below. Even at its edge, no considerable accumulation of clay could take place, for this would be continually washed by the water supplied from its melting, and we have no warrant for supposing that earth and stones would work up from below far into it. The present glaciers of the Alps, Himalayas, Greenland, Terra del Fuego, and Alaska are all witnesses against this theory. The testimony of the ancient glaciers is still stronger in the same direction. The only recent glaciers which in their breadth and thickness are to be compared with those of the ice period, are those of Greenland and the Antarctic continent, and all observers agree that they are composed mainly of pure crystalline ice, and that their surfaces are entirely free from earth or stones. The reason why no Bowlder clay is found in the terminal moraines of modern Alpine glaciers, is that these moraines are thoroughly washed and the fine flour ground by the glacier is carried away in the draining streams and forms the milkiness which is a marked characteristic of these streams and the lakes into which they flow. The highlands of Canada and New England show thousands of glacial deposits of the character of the Alpine moraines, and the Champlain clay along the Atlantic coast represents the finer material ground up by the glaciers which covered the highlands at the time of its deposition. In Ohio, the moraine material was never levigated except on the divide between the basin of Lake Erie and the Ohio River—where it now forms Kames—and along certain drainage lines where the water from the melting glaciers flowed away.

Hence, the Bowlder clay of Ohio, Indiana, Illinois, etc., may be said to be the entire grist ground by the glacier, which never having been screened or sorted, contains both the bran and the flour—and since most of the rock ground up was limestone or shale, most of the grist is flour or clay. In Canada and New England where the surface was higher and better drained, the flour was, for the most part, washed out, and re-deposited where the flow of the draining streams was stopped, as Champlain clay; the bran was left behind as sand, gravel, and bowlders.

The answer to the inquiry made by Professor Geikie in regard to the

* Prof. Dana says, on page 537 of his *Manual:* "The surface of the glacier in North America must have been of unblemished whiteness, for from New England to the Rocky Mountains there was not a peak above the surface except the White Mountains, and these probably had their cap of snow." This might have been made still stronger by omitting the exception, for Prof. C. H. Hitchcock reports having found glacial mark and transported Drift on the summit of Mt. Washington.

stoniness of the surface and margin of the northern drift of the British Islands can, of course, only with propriety, be given by those who have studied the phenomena on the spot, but we may offer the conjecture that the clay has been most thoroughly washed out of these portions.

THE FOREST BED.

The above name was given in our second volume to a sheet of soil with fallen, and sometimes standing tree trunks, beds of peat, etc., which, in Southern Ohio, rests upon the Erie or Bowlder clay; and it was shown to be the product of a growth of vegetation which, after the retreat of the glacier, covered much of the nearly continuous, but, uneven sheet of morainic material left behind it. This was for ages a land surface which sustained a forest of arborescent and herbaceous plants, the home of the mammoth, mastodon, giant beaver, and doubtless, many other animals. Numerous instances of the occurrence of vegetable matter in the Drift of other portions of the Mississippi Valley were cited in connection with the description of the Ohio Forest bed; but it was not asserted, nor can it now be, that these were continuous or synchronous with it. The facts reported proved conclusively that the southern half of the State was covered with an inter-glacial forest, the first indication found on this continent of an interval of mild climate in the ice period.

The remarkable facts reported by Mr. George Jennings Hinde, of Toronto, in his very interesting paper, "*On the Inter-Glacial Strata of Scarboro Heights*,"* are not only confirmatory of the views advanced in our first volume, but seem to indicate a second inter-glacial mild period; inasmuch as he finds three beds of Till or Bowlder clay, with stratified and fossiliferous sands and clays between them.

Professors Croll and Geikie, in their "Climate and Time," and "Great Ice Age," present what seem to be conclusive proofs of one or more inter-glacial, warm, or less cold intervals in Europe during the ic period, and they are generally accepted as such by geologists. These changes may have been in part local, but the evidence that the ic period of Europe was synchronous with that in North America, is very strong, and it is now generally believed that the causes which produced the excessive cold, affected the whole northern hemisphere. Our Forest bed is confirmatory of this theory—as any great changes of temperature recorded in the European superficial deposits should also be indicated here, and it constitutes another marked correspondence between the autographic records of the Ice Age in the old and new worlds. Further investigation will be required, both here and abroad, before it can be de termined whether the parallelism is exact. The subject is one of great

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* Canadian Journal, April, 1877.

interest and scientific importance, and it is hoped that it will receive special attention from those who are making our Surface Geology a matter of study.

THE UPPER TILL OF SOUTHERN OHIO.

It will be remembered by those who have read the description of the Drift of Southern Ohio, contained in Chapter XXX, or the report of Professor Orton on Clermont county, that the Forest bed is overlain by one or two beds of clay, the upper being white or nearly so, stratified and without pebbles; the lower, yellow, unstratified, and containing striated pebbles and bowlders. Both of these are quite thin; the upper from one to eight feet; the lower not exceeding ten feet in thickness. The latter has all the essential characteristics of a Till or Bowlder clay, and resembles the lower Till, except that it is yellow from oxidation of contained iron; is of less thickness, and is much more local. Whether there are any differences in the character and derivation of the stones contained in the two Tills, has not been accurately determined, from want of systematic observation, but none have been noticed.

In the references formerly made to the upper Till, doubt was expressed of its being a true glacial deposit, as it is laid down on the Forest bed with no evidence of violence or erosion, such as a glacier moving over the surface would be likelv to produce. Facts cited by Mr. Hinde, in the paper referred to above, and others reported by Professor Geikie, show, however, the possibility of a true glacial Drift being spread over stratified sands and clays without disturbing them. We must imagine, however, that such phenomena are local, and are confined to places where the clays and sands below the Till occupied some basin over which the ice-sheet passed without great pressure. No facts have been observed since the publication of our second volume which decide the question of the mode of formation of the upper Till of Southern Ohio; but, in the light of the remarkable sections of Scarboro Cliff, figured and described by Mr. Hinde, it seems likely to prove a true glacial deposit. The coöperation of those who are favorably situated for studying this member of our Drift series, is invoked for the solution of the problem.

LOESS, LACUSTRINE CLAYS, AND TERRACES.

The superficial deposits, which accumulated in the lake basin, and the valleys of the Ohio and Mississippi after the complete withdrawal of the glaciers, are so fully described in Chapter XXX, that they need not be reviewed here. In this category we have the Lacustrine clays of the Lake Erie basin, and the Cuyahoga Valley, the "Valley Drift" of the Ohio and tributaries, and the Loess of the Mississippi Valley. These are referred to the Terrace epoch, and if that has any place in geological history, it should include them, as this was a period of submergence of the Mississippi and Ohio Valleys, and the time when the lake basin was filled with water to the brim; the time when the sediments brought down by the rivers were deposited in sheets, out of which the streams, with greater descent and more rapid flow, have cut the terraces that border them. Professor Dana, in his papers on the Drift of the Connecticut Valley, questions Hitchcock's conclusion that the terraces found there are records of submergence, and were produced in the dead water of an arm of the sea, and he attributes them to the great volume of the rivers flowing from the melting glaciers. There can be no question, however, that the terraces of the Ohio Valley were formed in quiet water. This we learn from the accurate stratification of the materials composing them. The section of the Valley Drift in Mill Creek Valley, at Cumminsville, given by Professor Orton (Vol. I, p. 433), is demonstrative of this, for it is impossible that these stratified materials could have accumulated here simply by current action. It may be further said that the natural and inevitable effect of an immense increase in the drainage flowing through the trough of the Ohio from the melting of the glaciers without dead water to check it, would have been to sweep it clean throughout its entire length.

KAMES.

The gravel hills which cover the summit of the divide between the waters of the lake and the Ohio, present the most difficult problem of our surface geology. Their affinity with some of the *Kames* and *Eskers* of the British Islands, and the *Asar* of Scandanavia, is unmistakable; and if a satisfactory explanation of the origin of such of the Kames as resemble ours, had been offered by the European geologists, it would be equally applicable here; but no theory yet proposed fully satisfies the conditions of the problem. The fact seems to be that the collections of gravel and sand, which have been called Kames, are not all alike in structure or history. Some of them are long and narrow ridges, located in valleys or on comparatively low ground, and evidently mark the lines of ancient sub-glacial rivers. The general character of these is well shown in the map of the *Asar*, in the basin of Malar Lake, copied from Tornebohm, on page 408 of Geikie's "Great Ice Age." Similar ridges, in the valleys of the Connecticut and Merrimac, have been studied with much care by Mr. Warren Upham, of the Geological Survey of New Hampshire. He attributes these linear Kames, as do Tornebohm and Hummel, in Sweden, to the action of sub-glacial rivers. By Professor Dana, they are called sub-glacial moraines. Quite another kind of Kames, although possibly produced by some modification of the same cause, are the hills of sand and gravel which frequently occupy broad and high surfaces, presenting a billowy outline to the eye, and frequently holding lakelets in the depressions which separate them. The Kames of Ohio, are generally of this kind, although some of them are elongated ridges. They occupy, however, here, a topographical position which makes it impossible that they should ever have been the beds of rivers, for they form a belt along the summit of the divide between the lake-basin and the Ohio Valley, all the way across the State. Their altitude is from 400 to 600 feet above the lake, *i. e.*, 1,000 to 1,200 feet above the ocean, and some of them rise nearly 100 feet above their bases. They are composed of gravel and sand, sometimes horizontally stratified, more generally as interlocking wedges. They contain but few large bowlders, and the gravel of which they are composed is well rounded; it is derived from both indigenous and exotic rocks. The Bowlder clay is usually absent where the Kames are found, and they rest on the underlying rock; but they are occasionally seen to spread over the Till, and are evidently of more recent date.

In the notice of the Kames given in Chapter XXX, it was suggested that they may have been formed by the action of shore-waves, when the lake-basin was filled to the brim and they were islands or shoals. This view is not sustained by any conclusive evidence, but was offered as a possible and even probable explanation of a problem of difficult solution. That they are not moraines, properly speaking, is certain, as they have not the form, composition, nor structure of moraines. They occupy the summit of the water-shed, and in their stratification and the rounding of their pebbles, distinctly show *water* action; therefore, although composed of material which may be morainic, it has been all rolled and re-assorted. The pebbles and bowlders contained in the Kames, are such as are found in the bowlder-clay, but rounded and worn so that scratches and angles have been removed. Everything indicates that they are composed of the coarser material of the Till, triturated and rounded by water, which washed out the clay.

Professor Geikie, in the second edition of his "Great Ice Age," page 469, suggests that the Kames of the summit of our water-shed are formed by sub-glacial rivers and the great quantity of water pouring from the glacier when it filled the lake-basin. This is an explanation that would satisfy some of the conditions of the problem, but, unless we imagine the glacier to have remained for a very long period precisely at this stage, it is difficult to see why the washing effect of the water draining from it should be so localized. It will be remembered that this belt of Kames, along the highlands, divides two areas of Bowlder clay, where no gravel-beds, just like these, are found. In the lake-basin there is nothing at all like them, and in southern Ohio, the only hills of gravel which resemble them are in the lines of the old waste-weirs, through which the surplus water flowed from the lake-basin to the Ohio. In the Miami Valley are hills of well-rounded gravel, not unlike the Kames in general character, but they are mostly composed of limestone pebbles derived from the upper portion of the valley, and are remnants of sheets of valley-drift, eroded by the present streams.

That the kames of the water-shed have been formed by the action of *water* on the morainic material of the Erie clay, seems certain, but how the necessary floods of water could be produced there, is a difficult problem. Up to the present time no more plausible explanatory hypotheses than those mentioned have suggested themselves.

ICEBERG DRIFT.

Most recent writers on the surface geology of North America, have given to icebergs a more or less prominent part in the distribution of the Drift material. By some they are made the chief agent, both in the scoring of the rocks and in the transportation of clay, sand, gravel, and bowlders, but we have shown that both the erosion and transportation were chiefly affected by glaciers. Another party has denied altogether the agency of icebergs in producing the phenomena of the Drift. Prominent among the latter is Prof. N. H. Winchell, who has written voluminously on the Drift deposits, particularly those of the north-west. He attributes all the phenomena of the Drift to glaciers, denies the littoral origin of the so-called beaches of the lake basin, considering them moraines, and intimates that the four hundred feet beach, near Montreal, may come into the same category.* Every unprejudiced person must, however, admit, from the facts given in our second volume, that icebergs did at one time float over the waters that filled the lake basin, transporting and depositing more or less of the material now found on the surface of Ohio. Several instances of the occurrence of large striated bowlders, buried in laminated clays, where they must have been floated and dropped from an ice-raft, are referred to in Chapter XXX. Another instance which has recently come under the observation of the writer, is equally conclusive of the presence of icebergs in the lake basin. In cutting down the cliff of clay on the lake shore, near the Union Depot, at Cleveland, in 1876, a large striated bowlder of gneiss was found bedded in the finely laminated clay, (the upper and stratified portion of the Erie clay), some twenty feet below its surface and forty feet above the lake. That this stone had come from the Canadian highlands, had once been imbedded in an ice-raft, and was dropped into the clay that was being deposited at the bottom of the lake, when its surface was very much higher than now

* *Drift Deposits of the North-west*, Popular Science Monthly, July, 1873, p. 219.

is capable of demonstration. One such case proves the presence of one iceberg, and the many others which have been observed prove many icebergs.

Equally conclusive arguments to the same end are the thousands of bowlders which lie *upon* the laminated clays; for no glacier or water current could have transported them to their present positions, without cutting away the delicate layers of impalpably fine clay on which they rest, and without leaving Bowlder clay or some other material beside these large, solitary erratics as tokens of their presence.

Another fact confirmatory of the view that icebergs took part in the transportation of the Drift, is that the bowlders found resting on stratified sand and clay—often the most recent of our Drift deposits—are uniformly masses of crystalline rocks, granite, greenstone, slate, etc., which have been brought from the Canadian highlands, while the bowlders of the Bowlder clay are in Ohio oftener than otherwise derived from indigenous rocks.

Prof. Jas. Hall reports the same thing in regard to the bowlders which are scattered over the surface about Albany, and which rest upon sand or laminated clays. In the Natural History of New York, part IV, p. 319, he says:

> In the vicinity of Albany and Troy I have searched in vain for a bowlder or pebble of granite or any other rock older than the Potsdam sandstone in the deposits below the clay, while in a period subsequent to the deposits of the sands and clays, bowlders of granite are by no means rare.

Mr. Thos. Belt, who has carefully studied the Drift deposits of many countries, speaking of the erratics of our northern States (Quarterly Journal of Science, April, 1875), says:

> Only one satisfactory explanation has been given of the presence of these far-traveled blocks on the surface of the undisturbed loose beds of sand and clay, namely: that they have been dropped from floating ice.

The evidence that the waters of Lake Erie once stood two hundred or three hundred feet higher than now is indisputable, and given this great body of water filling the lake basin, and a retreating glacier resting on the flanks of the Canadian highlands, icebergs are a necessary consequence. Whether the *continent* was depressed at the time the lake basin was filled is altogether another question, with which this has no logical connection. The fact of the filling of the basin is recorded in the old beach lines and Lacustrine clays, and the discussion of the causes, consequences, or concomitants of this submergence, can not affect the validity of that record. We may say, however, in passing, that the proofs of alternations of elevation and depression, either of the land or ocean surface, during the Quarternary age, are unmistakable and striking. It has been shown conclusively, that since the deposition of the Champlain clay, all the Atlantic coast north of New York has been raised, although very unequally; the elevation increasing northward from fifty to sixty feet in southern New England, to one thousand eight hundred feet at Polaris Bay, Greenland.

Professor E. W. Hilgard has shown that the country about the mouth of the Mississippi, during the Quarternary Age, changed its level a thousand feet or more, and the facts which he reports are altogether in keeping with those observed higher up the valley. The manner in which the Loess is spread demonstrates that the region where it occurs was covered with water at the time of its deposition, and we know that it was mainly the silt transported by the Missouri, arrested in its passage to the Gulf—where it is now deposited—and diffused through quiet water, which, at one time, apparently, occupied the whole valley as far north as the Great Lakes. With these submergences, the filling of the lake-basin had, perhaps, nothing to do, for, as we have shown, the water it contained was fresh, and was, doubtless, derived from the melting of the glaciers and snow fields of the north.

LAKE RIDGES.

The old beaches which encircle the lakes have been fully described in our second volume, and the proof that they are what they are commonly called has been given at length. The mistaken notion that they are moraines is, however, still entertained by some persons who have not carefully studied them, so that it is, perhaps, desirable to recapitulate very briefly here the proofs that they are "raised beaches."

First. The true lake ridges, three or four in number, are found marking the south shore of Lake Erie, up to the height of two hundred and fifty feet above its present surface, in horizontal lines, that conform to all the topography, precisely like the "Parallel roads of Glenroy." They are, in fact, contour lines on the surface, and hence water-lines. No glacier would give such uniformity of height and dimension, such horizontality and parallelism to the terminal or lateral moraines, which it left as it shrunk in volume.

Second. The lake ridges are composed of beach and not moraine material; that is, they consist of gravel and sand, the former water-worn and rounded, with sometimes sticks, leaves, and, it is said, fresh water shells.

Third. Where the line of an old beach passes round a headland, or along a steep declivity, it becomes a terrace—as at Berlin Heights, Cleveland, etc. This would be necessarily true of a shore line, but never of a moraine.

Fourth. The ridges sometimes rest on stratified sands and clays—as on the old Cuyahoga delta at Cleveland—where no moraine could be produced by an ice sheet without, more or less, disturbing the beds below.

Fifth. Precisely similar ridges are now being formed in many places along the shores of the present lakes: wherever, indeed, the shore is sloping and composed of loose material. Excellent examples of these surround the head of Lake Michigan, where the higher and older beaches may be directly compared with the lower one, and shown to have the same character and history.

ORIGIN OF THE BASINS OF THE LAKES.

The subject of the origin of the basin of Lake Erie, and, as illustrative of that, the origin of all our great lakes, was discussed at some length in the chapter on Surface Geology of Volume I. After a review of the facts presented by the present condition of the lake-basins, it was shown that the history of the formation of the lakes was briefly as follows:

First. That all the lake region has been above the sea level since the close of the Carboniferous age; no great disturbance has affected it, but its topography has been greatly modified by surface erosion, and hence its system of drainage has suffered important changes, such as the transfer of the drainage of some portions of the lake region—first, from the Mississippi to the Hudson, and then from the Hudson to the St. Lawrence.

Second. That, previous to the ice period, the eastern half of the continent was higher above the ocean than now, and the rivers of this region had so long flowed in their channels as to cut them much below the beds of the present streams; that at this time the area occupied by Lake Erie was traversed by a river which had cut its bed more than two hundred feet below the present surface of the lake; and that Grand River, the Cuyahoga, the Maumee, and other streams were tributaries of this river, flowing through gorges of nearly equal depth with its own.

Third. That the excavation of all the lake-basins was chiefly accomcomplished by local glaciers descending from the Canadian highlands, either in the advance or the retreat of the great glacier, or both—following and greatly broadening and deepening the old drainage channels, or both.

Fourth. That the local glaciers which formed the lake basins moved along the lines of their major axes; those which formed Lake Ontario and Lake Erie moving from the north-east, the Lake Huron glacier from the north, the glaciers of Lake Michigan and Lake Superior moving towards the south, south-east, and south-west.

The arguments advanced to support these views were—

First. That the lake basins are boat-shaped cavities, deeply excavated, in nearly horizontal strata, by some eroding agent.

Second. That this agent must have been either water or ice.

Third. That it was ice, because rivers never excavate such basins. In a plateau country, as this was, rivers could only produce narrow gorges, like the cañons of the Colorado, or shallower and broader valleys, widening towards their mouths, and with bottoms forming more or less regular slopes.

Fourth. That the ice was in the form of glaciers, and not icebergs, because the lake basins, wherever they can be examined, are found to bear conspicuous marks of *glacial* action; the furrows and scratches having the bearing of the long diameter of each, and flint nodules, with ridges in their lea, and other signs, proving conclusively that the motion in Lake Erie was from Buffalo toward Toledo.

Since the publication of our second volume, the subject of the origin of the great lakes has been discussed in a paper read by Prof. E. W. Claypole before the Natural History Society at Cincinnati, and published in the Canadian Naturalist, of April 6th, 1877. The theory advanced by the author of this paper is, that the chain of great lakes are only portions of the valley of the pre-glacial river, to which reference has been made, blocked up in the ice period by beds of Drift.

The considerations which oppose this theory are so apparent and formidable, that it never could have been proposed or accepted by any one who had carefully studied the problem. In addition to those already suggested, they are—

First. That the lakes occupy a series of boat-shaped *rock* basins, which have almost nothing in common with river valleys. The notion that the valley of a river could be beaded in this way by the broad excavation of such portions as lay in soft rock, and the formation of cañons through hard strata, has no warrant in any facts yet observed on the earth's surface.

Second. The great and unequal depth of the lake basins renders it impossible that they could have been excavated by a continuous flowing stream. Lake Michigan is nine hundred feet deep to the silt which covers its bottom; it is excavated in rocks that are not softer than those of the adjacent country; is surrounded by a rocky rim, from which, it is true, a narrow, buried channel leads, but that has, so far as known, no greater depth than two hundred feet—the depth of the pre-glacial river which drained this region before the formation of the lake.

Lake Huron is eight hundred feet in depth, while the buried channel, which connects it with Lake Erie, is not more than two hundred feet deep.

Lake Erie is generally very shallow, and while its bed is no doubt traversed by an old river channel, which is very much deeper than most of the lake itself, it is incomprehensible that it should not have been cut as deeply by the old river as Lake Huron was, since the rocks to be removed were the same.

Lake Ontario is again a deep basin, being 450 feet deep with a surface level of only 234 feet above the ocean.* Every thing indicates that the basin of Lake Ontario is connected by a buried channel with the Hudson, but we have no proof that this pre-glacial channel is cut as low as the rock bottom of the lake basin.

Third. The bottoms of some of the great lakes are now several hundred feet below the ocean level. Just how deep they are is not known, because they have been for ages receiving the silt washed from their sides, and their rock-bottoms may be covered with a great depth of mud. Enough is known, however, to prove that they could not have been drained into the ocean, when it stood at its present level. It is true that the continent was 500 or 600 feet higher than now at the time the old buried channels were cut out, but even this does not afford sufficient fall for a stream which should wear the rock basins of Lake Michigan and Lake Huron to their bottoms. These are undoubtedly 1,000 to 1,200 feet below the water surface and *reach nearly to the old ocean level*, a relative depth far too great for rivers to excavate rock a thousand miles from their mouths.

In the important paper published by Mr. George J. Hinde, some interesting facts are stated in regard to Lake Ontario, which confirm not only the views advanced in Chapter XXX as to the glacial origin of our lake basins, but also the statement made on page 79 of Volume I, that Lake Ontario was formed by a glacier moving westward from the Adirondacks and Laurentian hills. They are contained in the paragraph given below, taken from page 11 of the paper before quoted:

"I will give a very striking instance of glacial action on the shores of Lake Ontario, which seems to me to furnish strong proof of the basin of this lake at least having been scooped out by the ice. At its easterly end, where the channel of the St. Lawrence commences, I have traced the deep glacial striæ and furrows on one of the islands of Potsdam sandstone from one hundred feet above the water's level down to the water's edge, until they disappeared beneath the lake. These striæ, like the generality of those abundantly seen in this district, run towards the south-west. From thence I have crossed the lake to its south-western shores, about one hundred and eighty miles distant from the place where

* By a typographical error stated in Volume I, page 13, to be 274 feet, but correctly stated in Report of Progress, 1869, page 25, where the same paragraph appears.

the striæ entered the water. The rocks immediately next to the lake here are too soft to retain striæ, but in going back two or three miles to the elevated escarpment of limestone four hundred feet above the lake, the rock surface is seen to be covered with striæ, running in nearly the same directi‹n as at the easterly end, or S. 35° W. Standing on the edge of this escarpment and looking towards the north-east, whence the ice came, it can be seen at a glance that it must have crossed the basin of the lake; and still further to complete the proof, in the bed of Till on the summit of the escarpment there are plenty of striated fragments of the Cambro-Silurian strata, (Hudson River) which, from the course of the striæ, must have been brought from the outcrop of these beds in the bottom of the lake. When the path of the glacier can be thus traced following the axis of the lake from the north-east to south-west, and masses of Till which have been eroded from the rocks outcropping in the area of the lake are met with, heaped up on its banks at the south-westerly end, the only conclusion which can be drawn is that the lake basin is due to the powerful eroding influence of a glacier."

Dr. Edmund Andrews, of Chicago, who has studied with much care and success the surface geology of the country bordering Lake Michigan, in his paper on *The North American Lakes considered as Chronometers of Post-Glacial Time* (Trans. Chicago Acad. Sci., Vol. I), attempts to estimate the time which has passed since the close of the Drift period, by measuring the erosion of the Drift clays by the shore waves, and the accumulation of sand—the result of such erosion—about the head of Lake Michigan. This paper is an interesting one, and is the product of much careful and conscientious study, but it can only be considered as furnishing data for measuring approximately the time during which the lake has stood at its present level. This is, however, only the last chapter in the history of Post-Glacial events, and it may represent but a fraction of the time which has elapsed since the glaciers retired from the lake basin. Of all the earlier period, when the water of the lakes stood several hundred feet higher than now, and when the upper beaches of Lake Superior, Lake Huron, Lake Erie, and Lake Ontario were formed, no record remains in the vicinity of Chicago, as the shores of Lake Michigan are so low that when the waters of the lakes was highest, they were deeply submerged.

Prof. James Geikie devotes a chapter in his "Great Ice Age" to the Drift Deposits of North America. In this he labors under the serious disadvantage of never having seen with his own eyes the phenomena he describes. He is compelled, therefore, to trust to the testimony of widely separated observers, studying different phenomena, and very unequally fitted by experience and sagacity for giving a full and accurate reading of the facts before them. Naturally, this testimony is often discordant, and not being able to discriminate between the true and the false, the local and the general, he has been led by it into some errors, which are the more to be regretted since they are endorsed by his high authority, and are published in by far the best history of the Drift period yet written. For the errors into which he has fallen in regard to the Surface Geology of Ohio, he is mainly indebted to Prof. N. H. Winchell, who has observed the Drift phenomena in the north-western portion of the State only, and there his observations are not fully in accord with those made by others.

On page 462, Professor Geikie says: "The succession of changes in Ohio during the Drift period were, according to Professor Newberry, as follows:

First. A period of a great continental glacier or ice sheet.

Second. The retreat of the ice and the appearance of a vast fresh water lake, covering a large part of Ohio, in which were deposited the finely laminated Erie clays, etc.

Third. The silting up of the lake, and the advent of a luxuriant forest growth.

Fourth. The submergence of the land below a great inland sea of fresh water, and the deposition from floating ice of blocks and bowlders.

Those who have read the transcript of Drift history, given in our Chapter XXX, will see that this is not accurately epitomised in the paragraphs above quoted; inasmuch as it has been nowhere stated by the writer that the lake basin was ever silted up so as to become a land surface, covered with forest, nor that there was any second submergence of the lake basin. The true order of succession of events in the history of the lake basin, as believed and represented by the writer is, very briefly, as follows:

First. A pre-glacial continent, several hundred feet higher than now, deeply scored by drainage lines, now the buried river channels.

Second. The advent of the ice period, producing, first, local, then general, and, again, local glaciers, which ground down, scratched, and grooved the surface rocks, filling and obliterating many of the old channels, and scooping out the lake basins.

Third. The retreat of the glaciers, leaving the Bowlder clay as a wide-spread sheet of unwashed morainic material, covering the glaciated surface; over this a body of fresh water, which formed a great inland sea, on which ice rafts floated from the north southerly, scattering bowlders broadcast over the bottom.

Fourth. The final retirement of the glaciers over the Canadian highlands; the gradual subsidence of the water in the lake basin until it reached its present level, and occupied only the deeper portions, forming our modern chain of lakes. In this descent, the shore line was marked at different intervals with terraces and beaches.

In *Southern* Ohio, the succession of events was somewhat different, inasmuch as the Forest bed, an old soil, with stumps, logs, and leaves, there rests on the Bowlder clay, and is covered locally by an upper stratum of Till, which is the product of glacier or iceberg action. No evidence of this has been found in the lake basin, where there is no forest bed—unless it be represented by the drifted vegetable matter which is sometimes found in the Erie clay, but which is not covered by a second bowlder clay. So far as yet observed, the facts seem to indicate that the basin of Lake Erie was filled with water or ice during all the time that the alternations of temperature recorded in Southern Ohio were taking place.

Professor Winchell is represented, by Professor Geikie (Great Ice Age, page 462), as claiming the existence of a forest bed, overlain by a second Bowlder clay, in north-western Ohio, but this is probably due to a misunderstanding of Professor Winchell's language, when he had reference to the north-western States. No forest bed has been seen or heard of by the writer in north-western *Ohio*, and nothing of the kind is reported by Mr. G. K. Gilbert, or Mr. J. H. Klippart, in their papers on the Drift of the Maumee Valley, nor by Professor Winchell, in his reports on the counties surveyed by him.

Prof. Winchell, in his "Drift Deposits of the North-west," attributes the excavation of the basins of the great lakes to the great continental glacier cutting locally deep into beds of soft rock. His language is as follows: "Southward, prolongations of the ice sheet follow the north-south outcropping edges of argillaceous formations. Lake Michigan lies in one of these troughs; Lake Huron lies in another. Lakes Erie and Ontario are only shallow basins dug out of soft rocks by ice that passed south-westwardly. The shale bed that gave rise to Lake Ontario als determined the location of Georgian Bay and Green Bay. The basin of Lake Erie is much shallower toward the west end than toward the east, and it finally runs out altogether by reason of the westward attenuation and finally entire disappearance of the *Salina* formation in which it is largely excavated. The ice was then thrust up on to harder rocks that form the basis of north-western Ohio and north-eastern Indiana. Lake Michigan was terminated southwardly by the eastern trend of the rocky outcrops at an angle that the ice could not follow."

Many difficulties stand in the way of the acceptance of this theory. The rocks cut away to form the basin of Lake Michigan are the Upper and Lower Silurian limestones, and are equal in hardness to the average of sedimentary strata. We have no proof that any considerable portion of the mass is "argillaceous shale," as reported by Prof. Winchell. The same may be said of the rocks cut away by the Lake Huron glacier. At the north end of the lake, and in Georgian Bay, the excavation was in Lower Silurian rocks; at the south end in Devonian and Upper Silurian limestones. In all this series there is no considerable mass of soft material. At Goderich, near the south end of the Lake, borings show that there are beds of rock-salt in the Salina Group below the lake bottom, but the rocks out of which the basin is cut are chiefly the Corniferous limestone and the Waterlime.

Lake Erie is not excavated, as Prof. Winchell says, mostly in the *Salina Group*, for that was not reached except just at the summit of the Cincinnati arch. All the eastern portion, and the deepest, of the lake is formed by the removal of the Upper Devonian shales, soft rocks it is true, but those which lie below and have resisted the action of the glacier, are precisely those which have been removed to form Lake Huron. A better explanation of the shallowness of Lake Erie is afforded by the suggestion that the glacier which excavated it was the most southerly of all the lake-producing local glaciers, and that it was the product of a climatic condition which did not continue nearly as long as the next one, when the ice sheet had retreated a step farther northward, and Lake Superior, Lake Michigan, Lake Huron, and Lake Ontario, were formed.

The basin of Lake Ontario, below the water-line four hundred and fifty feet deep, is mostly excavated in the Utica and Hudson shales, but the north shore of the lake is formed by the Trenton limestone, a hard and tough rock, and much of the northern and eastern portions of the basin are cut from this.

The bearings of the glacial furrows as well as the *drift* of the transported materials prove that the basins of Lake Erie and Lake Ontario were cut out by *local* glaciers moving from the north-west, and nearly at right angles to the line of motion of the *continental* glacier. This latter crossed the basins of the last mentioned lakes from north to south, and the whole tendency of its action must have been to obliterate any such troughs lying across its track. Besides this the local glaciers which formed these basins came after the general one, for where their tracks cross the lake, glaciers have obliterated, more or less completely, the traces of the great ice-sheet.

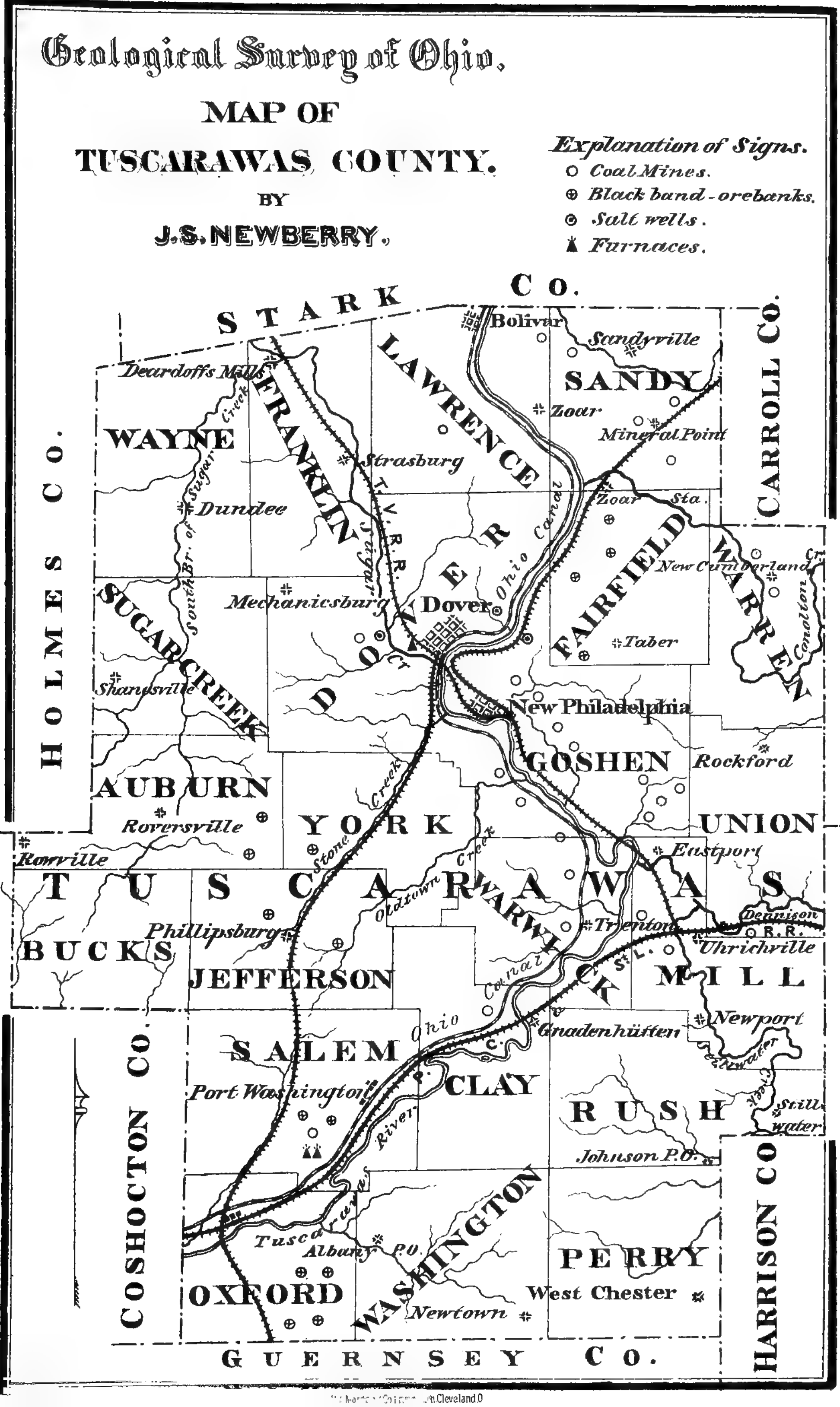
CHAPTER LVI.

REPORT ON THE GEOLOGY OF TUSCARAWAS COUNTY.

BY J. S. NEWBERRY.

SURFACE FEATURES AND DEPOSITS.

The topography of Tuscarawas county has been produced almost exclusively by erosion. From the study of its geology we learn that the surface originally formed a plain on the southern slope of the water-shed, having a gentle inclination toward the south. In the lapse of ages this plain has been deeply furrowed by the great line of drainage which traversed it, now known as the Tuscarawas River. The valley of this stream was originally cut to the depth of more than seven hundred feet below the highest lands of the county, and, though now partially filled, it still exists as a broad and deep trough more than three hundred feet below the adjacent highlands. This passes, by a somewhat circuitous route, from the middle portion of the northern border through its central part, making its exit near the south-western corner of the county. The tributaries of the Tuscarawas are quite numerous, and some of them are of considerable size, such as Sugar Creek, the Conotton, and the Stillwater, and all these having deeply excavated their channels, have formed a network of valleys which give great diversity to most of the surface. The relief, or relative elevation of some portions of the county, produced by the excavations of the valleys, may be plainly seen by any one who, starting from New Philadelphia, will pass to a distance of ten miles either east or west. The town of New Philadelphia is located on a terrace which reaches northward to Dover, and has an elevation of from forty to fifty feet above the bed of the Tuscarawas. This plateau is the old flood-plain of the river, formed when it ran at a higher level than now. It is composed of gravel, as we know by borings, and is the surface of the mass of Drift that occupies the bottom of the old excavated valley. At Dover the borings made for salt have shown that the rock bottom of the valley lies one hundred and seventy-five feet below the present surface of the Tuscarawas. Hence, we learn that the plains


Geological Survey of Ohio.
MAP OF
TUSCARAWAS COUNTY.
BY
J.S. NEWBERRY.
Explanation of Signs.
Coal Mines.
Black band-orebanks.
Salt wells.
Furnaces.
STARK CO.
HOLMES CO.
CARROLL CO.
COSHOCTON CO.
HARRISON CO.
GUERNSEY CO.
TUSCARAWAS
WAYNE
FRANKLIN
LAWRENCE
SANDY
SUGAR CREEK
DOVER
FAIRFIELD
WARREN
AUBURN
YORK
GOSHEN
UNION
BUCKS
JEFFERSON
WARWICK
MILL
SALEM
CLAY
RUSH
OXFORD
WASHINGTON
PERRY
Bolivar
Sandyville
Deardoffs Mills
Zoar
Mineral Point
Strasburg
Dundee
Zoar Sta.
New Cumberland
Taber
Mechanicsburg
Dover
Shanesville
New Philadelphia
Rockford
Roversville
Rowville
Eastport
Phillipsburg
Trenton
Dennison
Uhrichville
Newport
Gnadenhütten
Port Washington
Still water
Johnson P.O.
Albany P.O.
West Chester
Newtown
Ohio Canal
Sugar Creek
South Br. of Sugar Creek
Stone Creek
Oldtown Creek
Conotton Cr.
Stillwater
Tuscarawas River
T.V.R.R.
R.R.

between Dover and New Philadelphia are underlain by two hundred feet of sand, gravel, and bowlders, which have been filled into the old valley since the remote period when the continent stood higher; the drainage was freer than now, and the Tuscarawas flowed with a rapid stream far below its present bed.

The general topographical features of Tuscarawas county may be gathered from the series of altitudes given below:

ALTITUDES IN TUSCARAWAS COUNTY.

	Above Lake Erie, feet.
Bolivar	327
Zoar mills	313
Dover (canal)	300
Dover (railroad)	313
New Philadelphia (canal)	287
New Philadelphia (railroad depot)	331
Newcastle (canal)	279
Trenton (canal)	269
Gnadenhütten (canal)	251
Port Washington	244
Newcomerstown	220
Uhrichsville (railroad)	230
Uhrichsville (top of hill)	580
Mineral Point	387
Tunnel (C. & P. R. R.)	446
Zoar Station	314
Zoar Station (top of hills)	600
Mt. Tabor	775
Hill tops north of Port Washington	725

In the northern part of Tuscarawas county the rocky strata are somewhat covered with Drift, especially in the valleys, but in all the central and southern portions of the county, the highlands are without drift, the slopes of the hills, ravines, and roads showing the geological structure distinctly, and the soil is derived exclusively from the decomposition of the underlying rocks. This difference in the character of the surface deposits is also indicated by the material transported by the streams. Most of those which flow from the north bring down drift-gravel and bowlders, and have sandy or gravelly bottoms; while those which flow into the Tuscarawas from the south, south-east, and south-west, carry only the wash from the shales of the Coal Measures, and their valleys have clay bottoms.

The soil of Tuscarawas county, being for the most part of local origin, varies considerably in different localities, and in this respect wants the unity displayed by the soils overlying the Drift gravels of Stark county, and the drift clays of the Western Reserve; but the prevailing character of soil is that of the large territory lying within the coal basin, and beyond the reach of the Drift. The surface features of all this great district I have remarked upon elsewhere. It finds exemplification in Columbiana, Carroll, Harrison, and other counties south. The surface is rolling, with rouuded hills, separated by broad valleys from one hundred to three hundred feet lower than the hilltops. Though so much diversified, this surface is nowhere barren; the hills are frequently steep, but almost never broken, and are composed of sheets of sandstone, shale, limestone, fire-clay, coal, etc., which, furnishing material for the soil, impart fertility even to the highest summits. Hence, it is not uncommon to see luxuriant crops of corn growing on the most elevated surfaces, and to find a prevailing productiveness, which is quite independent of the topography, and which is sure to excite the wonder of those who have formed their ideas of agriculture in regions where the valleys are fertile and the hills are barren.

GEOLOGICAL STRUCTURE.

Tuscarawas county lies entirely in the coal area, and no rocks come to the surface within its limits except such as belong to the Coal Measures These include all the lower groups of coals, with the exception of the lowest, and there is, perhaps, in no other county of the State a better exhibition of the Lower Coal Measures. Many of the highest hills also include a portion of the Barren Measures, but none rise high enough to reach the Pittsburgh seam (Coal No. 8), the first in ascending order of the upper series of coals. The general geological structure of the county will be seen at a glance by referring to the engraved sections given in this report, as these were taken at points somewhat remote from each other, and where the greatest geological intervals are exhibited.

An analysis of these sections, with descriptions of the distribution, character, and local development of each of the useful minerals found in the series, are given below, to which are added some notes on the geology of the most important topographical subdivisions of the county, and tables of analyses of coals, iron ores, etc.

COAL NO. 1.

Coal No. 1—the Massillon seam—has nowhere been opened in Tuscarawas county, nor has it been found of workable thickness in any borings. It is known to all who have had much experience in coal-mining in the northern part of the State, and to those who have read our previously published reports, that this lower seam is very irregular in its distribution, and though of preëminent value when present in good thickness, even in the districts where it shows its best, comparatively little of the territory holds it. It every where lies in limited basins, separated by broad intervals of barren ground. Hence the explorations which have been carried deep enough to reach it in Tuscarawas county can not be said to have decided the question whether or not it should be reckoned as one of the possible sources of wealth. Only seven borings are known to me that have been sunk deep enough to reach the Lower Coal; these are, two at Uhrichsville, four near Dover, and one at Scott's Mill, below Mineral Point. Most of these borings were made for the purpose of obtaining petroleum, and such explorations have usually but little value for determining the presence or thickness of underlying coal seams. The borings made at Uhrichsville and Dover were, however, supervised with much more than ordinary care, and the registers of these wells seem to afford reliable information with regard to the strata underlying the localities where they were made. If these records are to be accepted as correct, it must be confessed that they do not give a very encouraging prospect for finding the Massillon coal of workable thickness; and yet such is the irregularity of this seam that if only seven wells had been sunk in the districts which are now producing such great quantity of this coal—about Massillon and in the Mahoning valley—the probabilities are that the enormous subterranean wealth of these districts would have been to the present time entirely undeveloped. I would suggest, therefore, to those who are favorably situated for such enterprises in Tuscarawas county, that it may be worth while to make further search for Coal No. 1, especially in districts remote from the wells that have been already sunk—for example, in the valley of the Conotton, near New Cumberland, above and below Deardoff's Mill, on Sugar Creek, at Trenton, and at Port Washington. In all these localities the place of the Massillon coal lies within two hundred feet of the surface, and where machinery is in action for other purposes, a drill may sometimes be attached and carried down two or three hundred feet at a trivial expense. Where this is not practicable, the services of experienced drillers can secured, and a hole bored to a depth of two hundred feet at a cost of about three hundred dollars. While not disposed to encourage too confident expectations of success in such an enterprise, the probabilities are so strong that some portions of Tuscarawas county are underlain by basins of this excellent coal, that I feel justified in recommending that those who have the means to do so will do well to pursue their explorations until this question shall be definitely settled.

I subjoin the following registers of borings for Coal No. 1:

DRILLING ONE MILE WEST OF SUGAR CREEK, CANAL DOVER.

		FT.	IN.
1.	Earth and loose clay	13	..
2.	Gray shale	8	6
3.	Loose sandstone	1	6
4.	Coal	..	6
5.	Fire-clay	8	..
6.	Sandstone, with iron ore	5	..
7.	Coal, slaty	1	..
8.	Fire-clay	5	..
9.	Blue shale	14	..
10.	Coal, slaty	..	6
11.	Fire-clay and blue shale	5	6
12.	Dark blue shale	7	6
13.	Soft sandstone	6	..
14.	Hard sandstone	34	..
15.	Gray shale	3	..
16.	Hard white sandstone	19	..
17.	Gray shale	2	..
18.	Sandy shale	2	..
19.	Gray shale	20	..
20.	Dark shale	11	6
21.	Black shale, with trace of coal	1	..
22.	Fire-clay	4	..
23.	Soft fire-clay	1	..
24.	Blue clay	6	..
25.	Soft brown sandstone	4	..
		183 to	6

(Bored 549 feet for coal, deepened to 894 feet for salt.)

		THICKNESS.		DEPTH.	
		FT.	IN.	FT.	IN.
1.	Gray sandrock	10	4	10	4
2.	Coal	2	..	12	4
3.	Fire-clay	16	6	28	10
4.	Soft black shale	5	..	33	10
5.	Gray sandrock	2	..	35	10
6.	Soft light shale	4	..	39	10
7.	Limestone	2	3	42	1
8.	Dark shale	29	9	71	10
9.	Sandstone, with thin seams of gray shale	36	5	108	3
10.	Coarse gray sandrock	2	..	110	3
11.	Rock iron ore	1	3	111	6
12.	Gray shale	20	..	131	6
13.	Fine white sandstone and dark shale	26	4	157	10
14.	Gray shale	12	..	169	10
15.	Gray sandstone, iron ore, trace of coal (No. 1 ?)	5	..	174	10
16.	Hard dark gray shale	8	..	182	10

			Thickness. Ft.	In.	Depth. Ft.	In.
17.	Hard white sandstone, conglomerate		9	4	192	2
18.	Gray shale		31	..	223	2
19.	Gray and white sandstone		147	6	370	8
20.	Quartz rock (pebbles)		21	..	391	8
21.	Crevices		2	..	393	8
22.	Quartz rock with mica		8	..	401	8
23.	Hard gray rock, with iron ore		21	4	423	..
24.	Gray and dark shale		405	..	828	..
25.	Oil-rock	6	25	..	853	..
26.	Hard sandrock	19			886	..
27.	White salt rock (porous sandstone?)		33	..	894	..
28.	Dark sandrock		8	..		

This well was commenced one hundred and twenty feet below Coal No. 5, which crops out and is worked in the hill above. Fifty feet below this, or seventy feet above the well-head, is the Putnam Hill limestone. The first seam of coal cut, is apparently No. 3; and the limestone reported below, is probably some other rock, as its distance—one hundred and forty feet—from the Putnam Hill, is almost too great to make it possible that it should be the limestone over Coal No. 3. Should it be a true limestone, however, and that which overlies No. 3, it would show a wider interval between the limestones than is known in the Tuscarawas valley, and very much greater than the distance which separates them at Zoar Station, where they are both visible. In any case, the place of Coal No. 1 should be within two hundred feet of the top of the well.

At Uhrichsville and Dennison, two wells were bored for oil, several years since—the first by E. S. Ferguson, the second by J. L. Morris. The registers of these wells, furnished me by the gentlemen named above, are given below.

Section of the Uhrichsville Well.

		Ft.	In.
1.	Fire-clay	6	6
2.	Coal (No. 5)	3	..
3.	Fire-clay	14	..
4.	Sandstone	26	6
5.	Black shale	52	6
6.	Flint rock (Putnam Hill limestone?)	1	..
7.	Coal	7	..
8.	Fire-clay	15	6
9.	Coal (No. 3*a*)	4	..
10.	Fire-clay	11	..
11.	Dark sandstone	16	..
12.	"Fossil rock" (Zoar limestone)	1	6
13.	Coal (No. 3)	1	6

		FT.	IN.
14.	Fire-clay	22	..
15.	White, flinty rock	1	..
16.	Black shale	4	6
17.	Sandstone	7	..
18.	Black shale	13	..
19.	Clay shale ("soapstone")	5	..
20.	Black shale	16	..
21.	Clay shale ("soapstone")	12	..
22.	Coal	1	6
23.	Sandstone	16	..
24.	Coal	1	..
25.	Dark sandstone, with coal	12	..
		280	..

SECTION AT THE DENNISON WELL.

		FT.	IN.
1.	Earth, stones, and iron ore	21	..
2.	Sandstone	1	..
3.	Coal (No. 5)	3	..
4.	Fire-clay	10	..
5.	Sandstone	18	..
6.	Blue shale	65	..
7.	Flint rock (Putnam Hill limestone)	2	..
8.	Coal No. 4)	5	6
9.	Fire-clay	12	..
10.	Cannel coal	2	..
11.	Shale	73	..
12.	Coal No. 3 ?)	4	6
13.	Shale	19	..
14.	White sandstone	20	..
15.	Black shale, and coal	3	6
16.	"Soapstone" (clay shale)	74	..
17.	Coarse sandstone	29	..
18.	Fine sandstone	20	..
19.	Black shale, and coal (No. 1)	8	..
20.	Black shale	30	..
21.	Fire-clay	20	..
22.	Sandstone	12	..
23.	Fire-clay	6	..
24.	Sandstone	1	6
		400	..

In the above section, the last four numbers are probably Waverly, and the strata named fire-clay are the fine light-colored shales of this series, which, when ground up, have much the appearance of the under-clays of the coal.

Subsequent to the boring of the Uhrichsville well, a shaft was sunk there, and carried down to the lower workable coal. This was found to be four and a half feet thick, the upper part cannel, and all containing much ash and sulphur. The enterprise was, therefore, abandoned.

I am informed by Mr. Watson, Secretary of the Glasgow-Port Washington Iron and Coal Company, that several holes will be bored on the property of this company, to determine the question of the presence or absence of the lower seam. Although the lower coal, along its western line of outcrop is decidedly inferior to what it is in the Tuscarawas and Mahoning valleys, and borings give but little encouragement that it will be found of workable thickness, still the breadth of unexplored territory surrounding Port Washington is so great that explorations there would be almost in a new field, and they may be attended with success. It should be said, however, that the facts before us seem to indicate that Coal No. 1 was deposited only along the margin of the basin, as in no case, up to the present time, has it been found of workable thickness far from its line of outcrop.

Coal No. 3.

There is little doubt that, if the base of the Coal Measures was fully exposed in Tuscarawas county, there would be found here, as in Stark and Holmes, a thin seam of coal, lying from fifty to one hundred feet above Coal No. 1. It is, however, rarely of workable thickness, and as almost nothing is known of its presence or importance in the county, it requires here no further notice.

The rocks associated with this coal are shales and sandstones, which vary much in their relative development, and in their mineral characters. There is frequently, however, a heavy bed of sandstone above the lower coal, and separated from it by a greater or less thickness of shale. This sandstone is best shown in the valley of the Tuscarawas, about Massillon, and we have, therefore, named it the Massillon sandstone. In Tuscarawas county, this everywhere lies below the surface, unless it may be on Sugar Creek, near Deardoff's mill.

At a distance of about one hundred and fifty feet above Coal No. 1, we find Coal No. 3, beneath the first of the two limestones which run almost continuously around the margin of the coal basin, from the Pennsylvania line to the Ohio. The distance between these limestones varies from thirty to one hundred feet. In Tuscarawas county, they are usually from fifty to eighty feet apart, and a bed of coal is generally found beneath each—sometimes immediately under it, sometimes separated from it by a few inches or feet of shale.

It is only in the northern part of the county that Coal No. 3, and the Zoar limestone, which overlies it, are exposed. In the valley of Sugar

Creek, at Deardoff's Mill, in the valleys of the Nimishillen and Sandy, near Sandyville, in the bed of the Tuscarawas, below Zoar, and at Zoar Station, the lower limestone may be distinctly seen. At Zoar Station, an arch in the strata raises this limestone higher than in any other locality in the county. It is visible just at the station, and at the point where the railroad strikes the river. In this section Coal No. 3 is not more than eighteen inches in thickness, and no where in the county, so far as I know, is it workable. At the Dover salt well the lower limestone was struck somewhat below the river, and at Trenton it is said to occur in the river bottom, with a thin seam of cannel beneath it.

Coal No. 3*a*.

At Zoar Station, where a rock cutting was made along the river side to form a track for the railroad, the upper, or Putnam Hill limestone, is seen just at the top of the cut, with a coal seam two feet in thickness below it. Beneath the fire clay of this seam lies a heavy bed of sandstone; under this, in some places, four or five feet of shale, then a coal seam three feet in thickness, fire-clay and shale to the lower, or Zoar limestone. The coal seam best exposed here is No. 3*a*. It lies just at the grade of the road, and was opened for a hundred yards in the excavation to which I have referred. Thence to Dover it runs nearly with the railroad level, and its outcrop may be seen at a number of localities. Its maximum thickness is about three feet; its quality poor, from its softness and the quantity of sulphur it contains. This is a local seam, not found much further north or west. It is, however, possibly the margin of a coal seam which has its greatest development south and east, where it is deeply buried beneath overlying rocks.

Coal No. 4.

This is the "upper limestone coal," and generally lies immediately beneath the Putnam Hill or gray limestone. In Tuscarawas county it is of comparatively little economic value, but it lies at such a level as to be of great importance as a guide in searching for the upper coals. As the dip of all the rocks in the county is southward, nearly with the draining streams, it happens that the gray limestone lies at about the same relative level, just above drainage, in the Tuscarawas valley, all the way from the north-eastern to the south-western corner of the county. Hence, in all the hills bordering the main valley or its tributaries, it is generally easy to fix the place in the series of any stratum of coal exposed by referring it to the Putnam Hill limestone, and to Coal No. 4, as a known base.

Coal No. 4 is the seam that was formerly worked by Mr. J. A. Saxton, near Sandyville, and this, with the overlying limestone, is traceable from that point northward up the valley of the Nimishillin to Canton and Greentown, and up the valley of the Sandy, as far as Oneida. Going south from Sandyville the limestone and Coal No. 4 are seen at Zoar, about fifty feet above the river, the coal thin, the limestone, as usual, from three to four feet thick.

At Mineral Point, Coal No. 4 lies below the railroad, and at Zoar Station about fifty feet above. At Canal Dover the limestone crops out on the hillside, between the Sugar Creek salt well and the mouth of the mine in Coal No. 5, which supplies the fuel for the salt works.

At New Philadelphia the limestone may be seen all along the base of the hills east of the valley, but the coal is either thin or absent. In the road from New Philadelphia to the Goshen salt well, it exhibits the phase which is seen at Newcastle, Coshocton county, and at Flint Ridge, Licking county—that is, it becomes much thicker than usual, and more shaly, breaking up into thin plates, which, by exposure, lose their blue color, and become brown or yellow. Here, as elsewhere, it contains many fossil shells, among which may be mentioned *Chonetes mesoloba*, *Spirifer cameratus*, *Productus semireticulatus*, *Athyris subtilita*, *Spirifer lineatus*, etc.

In the valley of the Conotton, Coal No. 4 is found outcropping at the base of the hills, all the way from Scott's Mills to New Cumberland

At Trenton it lies some twenty feet above the railroad, and at Patterson's ore-shoot, three miles below Port Washington, twenty feet above the canal. In tracing it further south, it is found continuously through Coshocton and Licking counties, overlying the cannel, near Warsaw, in Coshocton, and at Flint Ridge, in Licking. This is also the Putnam Hill limestone of Zanesville, and it reaches thence southward to the Ohio.

The coal beneath this limestone is exceedingly variable in thickness and quality. At Greentown, on the north line of Stark county, it is four to five feet thick, bituminous and good; at Canton four feet thick, of fair quality, but rather slaty, and contains considerable sulphur.

At Browning's Mills, six miles below, on the Nimishillen, it is six feet in thickness, very slaty, containing much sulphur, and is partly an impure cannel. At Sandyville, where mined by Mr. Saxton, it varies in thickness from two to four feet, and is of medium quality.

At Kelley's Point, on the Tuscarawas Branch Railroad, it is two and a half feet thick, a good cannel; near Mineral Point, one and a half to two feet thick, bituminous; in the valley of the Conotton, three miles above its mouth, five feet thick, slaty and worthless; at Lock 17, one foot in thickness. In the Dennison well it is reported to be five and a half feet thick; in the Urichsville well, seven feet. In the valley of the Killbuck

Holmes county, Coal No. 4 shows variations similar to those already described. As a whole, it exhibits a strong tendency to pass into cannel, and in Bedford and Jefferson townships, Coshocton county, it becomes an excellent cannel coal, from three to six feet in thickness. Near Flint Ridge, in Licking county, it exhibits the same character. It is plain, from the foregoing facts, that while Coal No. 4 is capable of assuming considerable local importance, and of adding much to the value of a single farm, it cannot be estimated as an important element in the resources of Tuscarawas county.

LIMESTONES AND CLAYS.

Limestones.—In the tables at the end of this chapter will be found analyses of specimens of the limestones which overlie Coals No. 3 and 4. These are, however, very variable in composition, and chemical analyses, unless in great number, would fail to indicate their economic value. Over the greater part of the county both limestones are fairly pure, and exhibit the normal character of similar strata elsewhere, interstratified with the other Coal Measure rocks. From the quantity of earthy matter and iron which they always contain, they produce a brown lime when burned. This is unfit for the finishing coat of plastered walls, but it makes a good and strong mortar, for which purpose it is largely used, the white limes of the lake region supplying the material for surface and finer work. The lime produced by the Putnam Hill and Zoar limestone is as valuable as any other for fertilizing, but it generally happens that in the region where this is most readily obtainable the soil is already well supplied with calcareous matter, and naturally fertilized from the decomposition of the limestone strata in place. Lands that are deficient in this important ingredient will derive as much benefit from a dressing with the brown lime as any other.

An important use of the limestone of both the strata which have been mentioned is for furnace flux, a purpose which it serves well, where the purer varieties are used.

Both limestones are prone to run into chert, and in some places consist largely of flinty matter. These are of course unfit to be used for either lime or flux, but they serve an excellent purpose for road-making, supplying, indeed, the very best material for macadamized turnpikes.

The question of the origin of the silica which so frequently impregnates, and sometimes replaces the lime of the Coal Measure limestones, will be found discussed in the chapter on the Carboniferous system, which forms the introduction to the geological portion of Vol. II.; and reasons are there given for supposing it to be derived from minute plants (diatoms), which secrete pure silica to form their frustules. These microscopic organisms inhabit nearly all lakes and ponds, and in some instances produce strata many feet in thickness of silicious earth ("tripoli," "infusorial earth," etc.). This is often found associated or alternating with shell-marl, precisely as the limestone and flint are mingled, the only marked difference between the marl and limestone, and the tripoli and flint, being in their degree of solidification. As the silica secreted by diatoms is very soluble in alkalies, we may infer that the older deposits of this kind have become infiltrated and solidified until they are converted into chert of flint, just as the soft marls have been hardened into limestones.

In certain localities both the Putnam Hill and Zoar limestones contain so much earthy matter as to be unfit for burning into quicklime. This is specially true of the Putnam Hill limestone, and one outcrop of this character, at New Philadelphia, has been already mentioned. Where this phase is assumed, and the quantity of silica and alumina is not too great, a hydraulic limestone or cement rock is found. No specimens of either limestone were found in Tuscarawas county which seem to promise to produce a cement of first quality, but not the hundredth or thousandth part of the outcrops of the strata could be examined, and since the limestones are very variable, there may be many deposits of the requisite character which are as yet unknown. It would be well, therefore, for the inhabitants of the county to have their attention drawn to the possibility of finding a good cement rock in some local phase of one or the other of the two limestones which underlie every township. The best cement rocks are usually fine-grained, with a smooth conchoidal fracture. In burning they do not swell much, and generate little or no heat on the application of water after calcination. When ground to powder, and made into a paste, however, they have the peculiar property of hardening under water.

Chemical analyses will generally not determine the value of the material supposed to possess hydraulic properties. The best test is actual experiment, which may be performed by any intelligent person. Small fragments of the stone to be tried should be calcined in a common crucible, samples being taken out and tested from time to time, until the pieces left in the crucible begin to vitrefy. When burnt to different degrees, the fragments should be separately pulverized in an iron mortar, wet up with water to the consistence of putty, and laid in water to harden or dissolve, according to their properties.

Iron Ore.—As has been mentioned in the general description of the Putnam Hill and Zoar limestones in Vol. II, the surface of each of these limestones almost always carries some iron ore; generally in flattened concretions or nodules, sometimes forming continuous sheets of plate or block ore. It is not now known that either of these ore-beds is of sufficient richness anywhere in Tuscarawas county to pay for drifting, but in many places on the slopes of the hills one or the other may be profitably stripped. It is possible, also, that in some localities the bedded ore may be of sufficient thickness to warrant systematic mining. As a guide to the judgment of those who may be hereafter interested in this question, it may be said that one foot of solid ore of average richness (33 per cent. metallic iron) will repay the expense of working by drift.

Fire-clay.—In Summit, Portage, and Columbiana counties the fire-clay which underlies Coal No. 3 is usually thick and of excellent quality, so that it forms the basis of a great industry in pottery, fire-brick, etc. Little is known of the character of this bed of clay in Tuscarawas county, since it is almost universally below drainage, and has been but rarely exposed to view. In the Uhrichsville boring, however, a remarkably thick bed of fire-clay is reported to have been passed through beneath Coal No. 3. It is, however, difficult to distinguish between fire clays and shales in boring, and thus the thickness of the stratum at Uhrichsville may have been over-estimated. Its quality also needs to be determined before it can be said to have any positive value. It would be well, however, for the inhabitants of the county to remember that a valuable deposit of fire-clay occurs locally under Coal No. 3, and should be looked for wherever an opportunity is offered for its examination.

Coal No. 5.

From fifty to eighty feet above the Putnam Hill limestone, we find, in most parts of Tuscarawas county, a coal seam which is of very considerable importance. This is extensively worked in the northern part of the county, especially at Mineral Point and at the tunnel of the Tuscarawas Branch Railroad. Its maximum thickness here is four feet, though more generally it is somewhat thinner. The quality of the coal is usually good; it is hard and bright, partially open-burning, contains a moderate quantity of sulphur, and about five per cent. of ash, kindles readily, and holds fire to a somewhat remarkable degree. Its normal composition is shown in the analysis given at the end of this chapter. Some varieties of this coal make an excellent coke, hard, bright, and silvery, containing ten per cent. of ash, and a little over one per cent. of sulphur. More generally, however, the quantity of sulphur is greater, and to make a first-class coke the coal should be washed. In some trials made at the Cleveland Gas Works of the coal from the south side of

Huff's Run, at Mineral Point, it yielded four and a half cubic feet of gas of high illuminating power. This gas, however, required considerable purification to free it from sulphur. The coke formed in the gas retorts was pronounced first-class.

Coal No. 5 is the seam worked for many years near Bolivar; it is there from three to three and a half feet in thickness. About Zoar it is found on both sides of the Tuscarawas, showing very much as at Bolivar, in the mines belonging to the Zoar Community, west of the river, worked for some years by Mr. Medill. This seam at one point was folded upon itself and thickened to thirteen feet. At Mineral Point it shows a similar disturbance in the mines of Mr. C. E. Holden. This peculiar phenomenon was occasioned by the forcing out of a belt of coal from its natural position over another part of the same seam. The force by which this displacement was produced seems to have acted laterally, and affected the coal in a belt of about one hundred feet wide. In driving one of the entries in the mines at Mineral Point, a "horseback" was encountered, formed by the descent of the roof shale, which had evidently been forced downward, and was very much broken up. After cutting through this, the coal was regained, but here refolded on itself. In some places a layer of shale was interposed between the two strata of coal, in others they were in immediate contact. After passing beyond the disturbed belt the coal seam resumed its normal position and thickness.

On the south side of Huff's Run, at Mineral Point, Coal No. 5 has a thickness of about four feet, and appears better than in any other locality where it has been opened in the county. Here it underlies a broad table land, and seems capable of supplying a very large amount of excellent coal.

At the old Fairfield Furnace, three miles below Mineral Point, Coal No. 5 is found to be two feet in thickness; at Dover it is the seam mined to supply fuel to the salt well, and has here a thickness of about three feet. From this point it runs through the hills on the west side of the Tuscarawas all the way to and below Port Washington; it is generally thinner, however, in this direction, rarely exceeding three feet in thickness. It is opened at the new furnaces below Port Washington, and shows here a thickness of two and a half feet—a moderately good coal. On the river bank, near Burton's ore-shoot, it was formerly worked, and is said to have been four feet in thickness.

At Lock 17, Coal No. 5 is two feet in thickness, about twenty feet below Coal No. 6, and seventy feet above the Putnam Hill limestone; the limestone is here one and a half feet thick, underlain by one foot of coal. At Trenton, Coal No. 5 is thirty feet below No. 6, and has been worked for many years. At Uhrichsville it is found in the valley of the Still-water from twenty-five to thirty feet below Coal No. 6, three feet in thickness; it is here and at Dennison, according to the borings, ninety feet above the limestone.

On the east side of the Tuscarawas valley, below New Philadelphia, Coal No. 5 seems to be thin, and is scarcely worked at all. The same is true of all the region lying between the valley of the Tuscarawas, and that of the Conotton, and it is doubtful whether this coal has much value south of Zoar Station and west of the Conotton. On the east side of the Conotton, over a large area, between Waynesburg, Mineral Point, and New Cumberland, it seems to be of good quality and thickness.

Fire-clay.—Beneath Coal No. 5 is the most valuable bed of fire-clay in the series, and one that now serves as a basis for an important branch of manufacture at Mineral Point and Dover. This fire-clay is always good, but it exhibits considerable diversity of character. In some localities it is quite plastic, while in others it is "non-plastic" or "flint" clay, is free from injurious ingredients, and has been found to form a very superior material for the manufacture of fire-brick. This hard clay may be recognized by its having somewhat the appearance of flint, and instead of softening down to a paste, like most fire-clays, it breaks into small angular fragments. In this respect it resembles the clay from which the famous Mt. Savage fire-brick is made, and it seems to be of equally good quality. When used for the manufacture of brick, it is coarsely ground, and the fragments are then mixed with from one-sixth to one-tenth of plastic clay, by which they are made to adhere and hold the form of the mold. Large fire-brick factories are now in operation at Dover and Mineral Point. The first is owned by Messrs. Barrett & Rhodes, and the second by Mr. C. E. Holden. From all the trials made of the fire-brick manufactured at these localities, they are now reckoned not inferior in quality to the Amboy or Mt. Savage brick. The clay used by Mr. Holden is mined on his own property, at Mineral Point; that used at Dover, is obtained from the land of Geo. Lechner, at Mineral Point, and on the Watman farm, between Dover and Zoar. The same stratum of hard clay is opened near Bolivar, and supplies the material from which the "Bolivar Star Brick" are made.

A considerable quantity of the hard or "flint" clay is shipped from Mineral Point, for manufacture in other counties. Much of it goes to Akron, where it is largely used by Mr. J. Parke Alexander, in one of the varieties of excellent fire-brick made by him.

Iron Ore.—Coal No. 5 is usually overlain by a black or gray shale, which contains a notable quantity of iron, and this horizon has furnished the greater part of the kidney ore that has been used in Tuscarawas county. No effort has been made to drift for it, and it is doubtful whether the quantity is sufficient to pay for the expense of drifting, but in the valleys, and on the slopes of the hills, it has been largely and profitably mined by stripping.

COAL No. *5a*.

About Mineral Point a thin seam of impure cannel is found, eighteen to twenty feet above Coal No. 5. It is of no economic value, but has been opened on the old furnace property at Zoar Station, at Mineral Point, and at the tunnel, where it is cut by the excavation. This is apparently a local seam, as I have found no traces of it north or south. It may, perhaps, be identical with some of the coal seams in the southern part of the State.

COAL No. 6.

At a variable distance—twenty to fifty feet—above Coal No. 5, lies one of the most important and widespread coals of the Ohio coal basin. This is the "Big Vein" of Columbiana county, the Osnaburg coal of Stark, the Steubenville and Rush Run coals of the Ohio valley, the main seam of Holmes county, and that chiefly mined in Coshocton. It is also identical with the "Great Vein" of Perry county, here assuming its most important development. In Tuscarawas county this coal seam is more extensively mined than any other, though in the northern townships it is less thick and valuable than in some of the neighboring counties.

At the tunnel on the Tuscarawas Branch of the C. and P. Railroad, Coal No. 6 is the "upper tunnel seam," here having a thickness of from three and a half to four feet; the coal is soft and of rather inferior quality.

At Mineral Point it has been opened in numerous places, but never worked, being less valuable than the underlying seam, No. 5. On the south side of Huff's Run it is the coal mined by John Black, three and a half feet thick, and of medium quality. On the old furnace property, in Fairfield, it is four feet thick and quite good. This seam furnished the fuel used for twenty years under the boilers at the furnace.

At the Goshen salt-well it is the seam which supplies the fuel used in evaporating the brine, and lies one hundred and fifty-five feet above the well-head. It is four feet six inches in thickness, with a slaty parting near the middle—a character which marks it over a very large area. Its quality is also typical of the seam—black, rather soft, highly bituminous, and cementing.

In the valley of the Conotton, Coal No. 6 crops out at a great number of localities, and may be traced nearly to Leesburgh. At New Cumberland it is five feet in thickness, the upper bench remarkably bright and handsome.

Near New Philadelphia this is the coal mined by Daniel Knisely, J. W. King, and S. G. Crite. At Knisely's mine, below town, the coal is fifty-seven inches in thickness, with a slate parting eight inches above the bottom; coal of medium quality. At King's bank it is three and a half to four feet in thickness, with a band of pyrites one foot from the bottom; coal of fair quality. At Crite's mine the coal lies sixty feet higher than at Knisely's, and the outcrop of Coal No. 4, with its limestone, is seen ninety feet below it.

South of New Philadelphia No. 6 is opened at numerous places in the valley of the Tuscarawas and that of the Stillwater, showing local variation in thickness and quality, but usually recognizable by its position, its thickness, its slate or sulphur parting, and by its black and pitchy appearance.

At Dennison, Coal No. 6 is worked for the supply of the railroad locomotives and machine shops, and for shipment west. The principal mine is twenty-six feet above the railroad track. The bed is three feet ten inches thick, free from slate, but with a small seam of pyrites eighteen inches above the bottom. The dip of the bed is toward the north-east. In this direction, about three-fourths of a mile distant, is an opening in the same bed, worked by Mr. J. L. Morris and his associates. The coal is of similar character to that of Dennison. At the east end of Morris's mine the coal is considerably below the railroad. In this vicinity it is carried by its easterly dip beneath the surface, and, going eastward, nothing more is seen of it before reaching Steubenville, where the valley of the Ohio is cut nearly to its level, and it is reached by shafts.

Between Dennison and New Philadelphia Coal No. 6 is opened at intervals in the hills along the east side of the Stillwater. The mines are, however, for the most part worked only in the winter. The coal here seems to be of the same general character as at Dennison.

In the district lying between the New Philadelphia road and Rockford, this coal seam crops out along the hill road from Eastport, and still more conspicuously in the valley of Pike Run. In this valley the coal is from four and a half to five feet thick, but sometimes contains two small seams of pyrites. Messrs. O. Young & Co. mine it quite largely for shipment. Their coal is of good quality, with a parting two feet from the bottom, the lower bench containing more sulphur than the upper. At Hannatown it is just above the surface of the valley, and beyond this locality the coal mines of Leggett, on the east, and Page, on the west side of the same hill, are opened in this seam. In Leggett's mine the coal is from four feet ten inches to five and a half feet thick, free from slate and pyrites, and remarkably sound, so that it may be extracted in cubical blocks of large size. Coal No. 6 is also met with at the school-house two and a half miles south-west of Rockford, three and a half feet thick, and at Raynsberger's, on the Leesburg road, near the county line, four feet thick.

South of Newcomerstown this is the only coal bed of importance met with to the county line. It is first seen at the red school-house, just south of the river, at one hundred and thirty-five feet above the railroad, and is only two and a half feet thick.

At the Borth settlement, in Oxford township, and along the valley of Bird's Run, there are numerous openings on this seam, which ranges from three and a half to three feet ten inches in thickness.

In the valley of the Stillwater, south of Uhrichsville, as the strata dip toward the south-east, Coal No. 6 soon passes beneath the surface and disappears.

At Newport it lies just above the water level, and was worked many years ago, but contained so much sulphur as to be almost valueless as a fuel, and copperas was made from the superabundant pyrites found in it.

Going still further south, it is last heard of at Freeport, where it was struck in a boring forty feet below the bottom lands of the Stillwater.

At Uhrichsville, Coal No. 6 has been mined quite extensively for several years by Mr. S. W. Andreas. The coal at his mine, which is on the west side of town, lies forty-five feet above the railroad. It is similar in character to that of Dennison, being four feet thick, with a parting eighteen inches above the bottom. Mr. Andreas has also several ovens, in which he cokes the small coal from his mine, supplying a fairly good article to manufacturers and for shipment westward.

At Lock 17, Coal No. 6 lies one hundred feet above the railroad, and is the only bed worked here; it is three and a half to four feet thick. At a bluff on the canal, about a mile east of the town, a fine section is exposed of the strata, from forty feet above Coal No. 6 down to twelve feet below the Putnam Hill limestone. Twenty feet below No. 6 is a coal seam two feet in thickness (No. 5), and seventy feet lower is the upper limestone, one and a half feet thick, underlain by one foot of coal. The Zoar limestone is said to be found in the bed of the river, and to have a thin stratum of cannel under it.

At Trenton and Newcastle, Coal No. 6 has been worked for many years, and the product sent by canal to Cleveland. It has there established the reputation of being a "strong" coal, well adapted to the generation of steam, but containing too much sulphur to be used in the manufacture of iron. In this region it varies from four to five feet in thickness. At Port Washington it lies about one hundred feet above the canal, is from five to seven feet thick, is very bright, black and handsome, but contains a great deal of sulphur. In the valley of Stone Creek this coal is thin and poor. On Oldtown Creek, however, it appears better, attaining a thickness of four to five feet, and furnishing coal of good quality.

In the north-western part of the county, Coal No. 6 is opened in various places, and in the valley of Sugar Creek, about Dundee, is unusually good.

From the facts which I have given, it is apparent that within the limits of Tuscarawas county, Coal No. 6 represents a vast amount of mineral fuel. As a general rule the coal it furnishes is rather soft, contains considerable sulphur, and is highly cementing in character. It is evident, therefore, that some method of treatment must be adopted that will convert this into a first-class fuel for manufacturing purposes. The importance of this problem cannot well be over-estimated. If by any cheap process of preparation this coal may be made to supply a pure fuel, it will be a source of great wealth to the county. It will, no doubt, supply many of the purposes of a mineral fuel in its natural state—that is, it serves well for household use and for the generation of steam—but for the manufacture of iron it will be necessary to eliminate a considerable portion of the sulphur it contains before the best results will be attained in its use. It forms a strong adhesive coke, and one that has high heating power, and is capable of bearing a heavy burden, yet if not purified, the sulphur it contains will, perhaps, preclude its use. Under these circumstances, I cannot too strongly urge the adoption, in the southern portion of Tuscarawas county, of such methods of coal washing as are found to be efficacious in the treatment of similar coals. It is probable that simply by the imitation of methods that are now in use in our own country, and one still more generally employed abroad, a good coke can be formed from No. 6 coal, and that when so treated this will furnish a fuel which will not only serve for the manufacture of all the iron ore found within this county, but will invite and bring to this source of fuel the iron ores of Lake Superior.

Tuscarawas county already enjoys such facilities for transportation that her resources need no longer be considered as land-locked and left undeveloped. By the great east and west route—the Pittsburgh, Cincinnati and St. Louis Railroad—which traverses the southern portion of the county, ready communication is afforded with Pittsburgh on the one hand and Columbus and Cincinnati on the other; but it is evident that toward the East the demand for coal will be fully supplied from Steubenville, Connellsville, and Pittsburgh, while between Tuscarawas county and the markets of the West the production of the Coshocton, Cambridge, and Perry county mines will be interposed. Hence, the natural outlet for the fuel of Tuscarawas county is plainly in the direction of the great coal-less region bordering the lakes. Already several lines of transportation have been opened to Lake Erie, and it only remains to be shown that an abundant supply of good fuel can be procured in Tuscarawas county to prove that this will be the theater of great mining and manufacturing enterprises.

Mahoning Sandstone and Coal No. 6a.

Above Coal No. 6 we find in Tuscarawas county a mass of strata about one hundred feet in thickness, which usually contains little that has economic value. Immediately over the coal is a stratum of black or gray shale of variable thickness, and above this, generally, though not always, a massive sandstone, the equivalent of what is called in the eastern counties of Ohio and the western of Pennsylvania, the Mahoning sandstone. This varies in thickness from nothing to nearly one hundred feet, is usually coarse, and very frequently is in part a fine conglomerate, in which the pebbles range in size from that of a grain of wheat to a bean.

The sandstone is well shown in the hill above the tunnel on the Tuscarawas Branch Railroad, and on both sides of the valley of the Tuscarawas from Zoar to Dover. Its conglomerate character is conspicuously developed on the west side of the Tuscarawas below Zoar, where masses of the rock have fallen down from the hills into the road.

In places this sandstone comes down to, and even cuts out, Coal No. 6. In the hills south of Huff's Run, below Mineral Point, it rests upon the coal, and, as usual in such cases, this is thinned and deteriorated by it. Below Zoar Station for some distance along the river, Coal No. 6 seems to be entirely cut away by the sandstone, but about the Goshen salt-well it comes in again in full force, and the sandstone thins out and almost disappears. Passing southward along the valley of the Tuscarawas, the Mahoning sandstone is visible at intervals all the way to the Coshocton line, but in many places it is wanting, being replaced by shale. The changes which occur at this horizon are well shown on the two sides of the Stillwater Valley at Uhrichsville. In the hill south of Dennison, which rises to the height of three hundred and fifty feet, no heavy bed of sandstone is seen, almost the entire mass being composed of shale; while on the west side of the valley, over and south of the mine of Mr. Andreas, the sandstone is well developed, in places reaching a thickness of seventy-five feet.

In most places where the Mahoning sandstone is not very thick, traces of a coal seam may often be found, about fifty feet above Coal No. 6. In the northern and central portions of the county this is not well shown, but in the southern townships it is thicker and more constant, in places forming a workable and valuable coal, which we have designated as No. 6*a*. In the hill above Dennison it is seen in the road, overlain by a brecciated limestone, which is unlike anything found lower in the series. The coal is here too thin to be of much value. Further south, at Wallace's, near Newport, it is two and a half feet in thickness. In this vicinity it lies from twenty to thirty feet below Coal No. 7, the intervals being filled by the brecciated limestone, referred to above, two or three feet in thickness, argillaceous shales, and the fire-clay of No. 7.

Coal No. 7, and its Iron Ores.

This coal is quite a constant feature in the sections exposed in Tuscarawas county, but throughout the northern and central townships, it has little economic value. On entering the county from the north, it is first seen in the tops of the hills about Zoar Station, and thence southward, is continuous in all the highlands to the Guernsey county line. It is locally known as the blackband coal, from the fact that the important blackband deposits of the county rest directly upon it, and hence its place is well known to a large part of the inhabitants.

On the old furnace tract at Zoar Station, Coal No. 7 is three to three and a half feet in thickness, soft, sulphurous and poor. In the highlands, between the Conotton and the Tuscarawas, it is shown in all of the blackband ore mines, being usually taken out with the ore. It is here from one to two feet in thickness, and generally quite sulphurous In the highlands west of the Tuscarawas, in the townships of Salem, Bucks, Auburn, and Sugar Creek, quite a large territory lies above the horizon of Coal No. 7, and it is opened at numerous localities, in connection with the important deposits of blackband ore found there. Throughout this region, the coal is thin and poor. On the south side of the Tuscarawas, it improves greatly in thickness and quality, as it does to the east between Dennison and Leesburg. It has, however, nowhere in Tuscarawas county, the value that it has in Guernsey, where it is the "Cambridge Coal," the most important of all the coal seams found there.

In passing up the valley of the Stillwater, from Uhrichsville, Coal No. 7 is first seen in the hill above Dennison, and is apparently about three feet in thickness. It lies, by barometer, just one hundred feet above Coal No. 6, or one hundred and fifty feet above the railroad at Uhrichsville. Passing southward over the hill, its outcrop may be again seen near the house of Mr. Job Gatchell. Further up the Stillwater, eight miles above Uhrichsville, Coal No. 7 is seen on the farm of Mr. Wallace, where it may be directly connected with No. 6. About twenty feet below it, is coal No. 6*a*, two to three feet thick, part cannel; and sixty feet below this, ten to twelve feet above the creek, is the No. 6, formerly worked for boiling brine and making copperas—a locality referred to in the notes on Coal No. 6. About a mile south, Mr. William Houck has opened Coal No. 7, where it appears better than at any other place examined in the county. It is four feet ten inches thick, very clean, bright and black, and apparently free from impurities. On the east side of the Stillwater, near by, is what seems to be a good exposure of blackband iron ore, to which reference will be made further on. Higher up in the valley of the Stillwater, and beyond the Harrison line at Tippecanoe and Freeport, Coal No. 7 is extensively worked, and chiefly supplies the demand for fuel in this vicinity.

In going north-east from Dennison toward Leesburg, the rapid easterly dip of the rocks brings Coal No. 7 under good cover before crossing the county line. It is here of unusual thickness, ranging from four to six feet, but is generally divided by one or two partings, and is not of first quality.

From these facts, it will be seen that Coal No. 7, though widely distributed through the county, is only of local importance, and that its chief interest is derived from the iron ore with which it is so generally associated.

In the south-eastern part of the county, a thin coal is found above No. 7, but it is nowhere of workable thickness, so that the bed we are considering may be reckoned as the highest workable coal of the lower series.

As will be seen by reference to the general description of the carboniferous system, and the reports on Harrison and Belmont counties, above Coal No. 7 is a mass of shales and sandstones, with a few thin seams of coal, which constitute what have been called the Barren Measures. Above these lie, first, the Pittsburgh coal, with its associated heavy limestones, and then the other members of another and higher group of coals.

A striking feature in the Barren Measures is formed by beds of red or mottled shales; and it may be worth while to remember that no such strata are ever found below Coal No. 7; so that, wherever these red shales are seen, it may be inferred that all the workable coals are below and none above them.

There is also found in many localities above Coal No. 7, a more or less massive sandstone, which is prone to run into conglomerate, though the pebbles it contains are rarely larger than beans. This sandstone, which, from its development on the upper Stillwater, we have called the Stillwater sandstone, in some places so much resembles the Mahoning sandstone below, that the two have been confounded, and the coal seams Nos. 7 and 6, which hold the same relative position to these two sandstone beds, have been mistaken one for the other. It is, however, generally not difficult to distinguish the two groups, for coal No. 7, in Tuscarawas county, nearly always thin, has almost invariably an important deposit of iron over it, either blackband, "mountain," or kidney ore, and at no great distance above it, the red shales may usually be found. An excellent exhibition of No. 7 and its strata, can be seen in the divide between New Philadelphia and New Cumberland. On opposite sides of this divide, the valleys cut down to the Putnam Hill limestone, so that going from either, the starting point is the same. The best section is obtained from the New Philadelphia side. Here the limestone lies just in the bottom of the valley, above which are Coal Nos. 5 and 6, in their normal places—the first thin, the latter from three to five feet thick, and good. About one hundred feet above this, Coal No. 7 may be seen in the road, apparently not more than two feet in thickness; over this the kidney ore, and in places the mountain and blackband ores, forms of this iron deposit which frequently alternate.

Above the iron horizon, lies a bed of red, yellow and mottled shale, of which the colors are bright and striking; a formation characteristic of this level. Over the shale is the Stillwater sandstone, here comparatively thin, but in part a well marked conglomerate. Above this, a heavy mass of olive shales, the typical barren measure material, reaches one hundred feet higher to the top of Mt. Tabor.

Blackband and Mountain Ore.—The blackband ore of Tuscarawas county has been so fully investigated during the forty years through which it has been sought and worked, and so fully described in our reports, that comparatively little will need to be said of it here. It is already known to most persons that this variety of ore is simply a black bituminous shale impregnated with iron. The degree of impregnation varies greatly; most of our black shales contain some iron, but generally too little to have any value as ores. In those varieties which are classed as blackband ore, the quantity of metallic iron varies from twenty-five to forty per cent.

To an uneducated eye this material has very little the appearance of an iron ore, and would be, and doubtless has been, frequently passed as simply a black shale. It is highly charged with carbonaceous matter, and its specific gravity is usually not so high as to arrest attention. Its valuable properties are therefore so much masked that it was rather by accident than otherwise that Mushet, in 1801, discovered the value of the blackband of Scotland, and laid the foundation of the great iron industry of that country. To a practiced hand the greater weight of the iron-bearing shales will serve for their detection, but where the quantity of iron contained can not be conveniently measured, a sufficient test will be afforded by burning a heap of the shale in the open air or elsewhere, when, if it contains iron enough to be valuable, this will "loop," as it is said, that is, will agglutinate and form scoriaceous masses of great density.

When subjected to the action of the weather the blackband ore decomposes like any other shale, and its carbonaceous matter being removed by oxidation, it falls into a mass of thin brown or rusty flakes, which, though looking no more like iron ore than the unchanged material, should be recognized by the explorer, for this is the only form of the ore which will be exposed to his examination in natural outcrops.

The geological position of the blackband of Tuscarawas county is, as has been stated on a preceding page, immediately above Coal No. 7 and at the base of the Barren Measures. This is a strongly marked iron horizon, although the ore found here varies considerably in character.

It would seem that this ferruginous deposit was made by the drainage from a surrounding land area into a circumscribed basin of comparatively shallow water. In some parts of this basin carbonaceous mud heavily charged with iron accumulated, which subsequently formed the blackband; in others clay without vegetable matter, but generally containing considerable iron, and this, as is usual in such cases, subsequently segregated to form nodules of kidney ore. In the deeper portions of this basin, where the water was clearer, a limestone was deposited, and this also, in some localities, contained iron enough to become a valuable calcareous ore, now known as *mountain ore.* These three kinds of material were precipitated almost simultaneously, and they are frequently found to alternate one with another, so that along a somewhat extended outcrop the ore worked will be in one place blackband, in another mountain ore, and in a third shell ore; and also on one side of a hill Coal No. 7 may be overlain by a sheet of blackband even eight or ten feet in thickness, while on the other side of the same hill no blackband occurs, but instead some other form of ore, or even barren material. Wherever blackband and mountain ore are found together, as they frequently are, the former is always beneath the latter, from which we learn that it was really deposited first. Generally, in such cases, the mountain ore is found to thicken in one direction, the blackband in the other, showing that the calcareous deposit extended from a lower level—a deeper portion of the basin—up over the carbonaceous mud which had previously partly filled it. From what we know of the formation of coal we can positively assert that Coal No. 7 accumulated in a marsh, precisely as peat now forms by a growth of vegetation in the open air; in other words, that it was practically a land surface. That this peat bed was subsequently covered with shale and limestone proves that it was depressed and covered, first with shallow water, in which carbonaceous mud and clay were first deposited, the former deriving its organic material from the disintegrated peat. As the subsidence progressed the water in the basin became clear enough to permit the formation of limestone, which was naturally purest and thickest in the deeper places, and thinned away to an edge on the muddy shallows.

It has been reported that the blackband ore has in a few places been found to reach a thickness of twenty feet, but no such development of the deposit has come under my observation. It usually ranges from three to six feet, but at the mines of Mr. A. Wilhelmi, in Auburn township, and in the Patterson ore-bank, near Port Washington—now owned by the Glasgow Port Washington Iron Company—I have seen ten and even twelve feet of solid ore.

The limestone ore shows equal irregularities of thickness. At Wilhelmi's mine, in one of the old openings, it is seen increasing from nothing to three feet in thickness, running down a slope of blackband ore, and practically taking its place. Throughout the area occupied by the limestone, that is, over parts of Stark, Carroll, and much of Tuscarawas, the limestone is met with at intervals, having, where present, a thickness of four to five feet. Even where not forming an iron ore, it contains so much iron as to assume, in weathering, a decided buff color, and it is frequently referred to in our notes and reports as the Buff Limestone. The greatest development of this stratum that has come under my observation is in the hill above New Cumberland, on the east side of the Conotton valley. Here it is apparently nearly twenty feet in thickness; as usual, nodular in structure, and containing so much iron that some of the nodules are good mountain ore.

The iron found at this horizon, in the form of blackband, or mountain ore, where present in full force, constitutes by far the richest ore deposit of the State. Tracts of many acres might be specified underlain by a continuous sheet of blackband, eight feet in thickness, and, since this contains twenty-five per cent. of metallic iron, it is equivalent to a sheet of cast-iron over two feet in thickness of equal extent. The inhabitants of Tuscarawas county may, indeed, congratulate themselves that they are the possessors of nearly all this valuable deposit found in the State, and that so large an aggregate area of the county is underlain by it; that it has already largely contributed to the wealth of the county, and is destined to be an important source of revenue for many years to come; but it is greatly to be regretted that only a small fraction of the original deposit now remains. This evidently was once continuous throughout the greater part of the county, but lying as it did high in the series, and near the surface of the plateau, which once occupied all this portion of the State, it has suffered terribly by the erosion that has carved the present varied topography out of that plateau, and only a meager remnant in the hilltops bordering the broad valleys marks its horizon.

Outliers of the blackband stratum are found in the highlands of Osnaburg and Paris, in the central part of Stark county, in those of the western side of Carroll and the north-eastern part of Coshocton, while local representatives of the deposit are found in nearly all the townships of Tuscarawas county. It is evident, therefore, that the basin in which it accumulated once stretched over all the interval between these limits. It may have reached much further to the north and west, as in this direction all the old landmarks are cut away by the erosion of the surface; but on the south and east we are apparently able to trace its former boundaries; since, with abundant exposures of the horizon where the blackband lies, no indications of its existence are found much beyond the line of Tuscarawas county.

The blackband ore of this region was first discovered and utilized by the Zoar Community over forty years ago. The portion of their lands which lie in the northern part of Fairfield township, includes hills that run up into the Barren Coal Measures, and these were found to contain valuable beds of blackband and mountain ore. To work these, a charcoal furnace was erected near by, where iron continued to be manufactured for twenty years This is the most northern outcrop of the blackband in Tuscarawas county. Both varieties of ore occur here, varying much in their respective developments; the blackband from three to eight feet in thickness; the mountain ore from two and one-half to five, perhaps averaging three feet of good ore.

From the Fairfield furnace the blackband deposits run through the highlands toward Dover, and south between the Conotton and Tuscarawas. In this district the best known ore beds are those of Clover Hill, so long worked by Messrs. Tod & Rhodes, the Junkin bank, and the mine of the Tuscarawas Coal and Iron Company. Ore is also found on the farm of Benjamin Riggle, worked by Mr. Burton, of Massillon. The blackband here is five feet in thickness, with three feet of mountain ore over it. On the farm of Hugh Kelley an outcrop of the blackband, thin and near the surface, is seen.

The most important deposits of blackband ore in the county are in the townships of Auburn, Bucks, Salem, and Oxford. Of these, the first four lie on the highlands west of the Tuscarawas, and are drained by Sugar Creek, Stone Creek, and Oldtown and Buckhorn Creeks. Here the land in some places rises to the height of one hundred and twenty-five feet above the blackband horizon, and quite a number of more or less extensive basins, or patches of ore, are known to exist, some of which have been worked for twelve or fifteen years. The most important deposit seems to be that of Mr. A. Wilhelmi, in section 24, Auburn township, where the ore has been taken from seven or eight acres, and thirty or more acres still remain. This constitutes perhaps the largest continuous deposit yet known. The average thickness of the ore here is from five and one-half to six feet, though a maximum thickness of eleven feet of good ore has been met with in the workings.

A section which I took at Wilhelmi's bank, is as follows:

		FT.
1.	Shale and sandstone	125
2.	Fine black shale	1–3
3.	Blackband ore	9
4.	Coal No. 7	2
5.	Fire-clay	1
6.	Slope, covered, mostly shale	95
7.	Coal No. 6	3
8.	Fire-clay and shale to creek	15

At another opening the section exposed is—

		FT.
1.	Shale	15
2.	Mountain ore	2–2½
3.	Blackband ore	2½
4.	Coal	1½

Here the mountain ore is seen to run out to an edge.

There are several limited deposits of blackband in the vicinity of Wilhelmi's mine, and between that point and New Philadelphia, belonging to Gabriel Shull, U. Shaw, and others. A large amount of ore has been taken from Wilhelmi's mine, for the most part manufactured in Massillon, and has been proved to be of excellent quality. Its composition in the natural state is given in the tables below. Like all blackband ore, it is calcined with great facility, scarcely requiring any other fuel than that contained in itself. When so calcined, on an average two tons of ore will make a ton of iron which closely resembles Scotch pig, is used for the same purposes, and is equally esteemed.

Three miles west of Phillipsburg a deposit of blackband is leased and mined by Mr. H. Andemann, and the ore is also found in some other hills in the vicinity. Farther south, on the farm of Jacob Rheinhart, I noticed the characteristic outcrop of the blackband in the road near Mr. R.'s house. No exploration has, however, been made in this vicinity to determine its thickness and extent.

Still further south, in Salem township, west of Port Washington, are deposits of blackband ore, which have been already shown to be quite extensive, and some of them have been worked for a long time. The more important of these have been purchased by the Glasgow-Port Washington Iron and Coal Company, an organization of Scotch capitalists, attracted by the resemblance of the ores of this region to those of their own country.

They have erected two large and fine furnaces, and but for the depression in the iron trade would now be producing a large quantity of first-class iron. The purchases made by this company are supposed to include more than one hundred acres of blackband territory, and it is evident that if suitable fuel can be prepared from Coal No. 6, which is here from five to seven feet in thickness, this will become the theater of an active and successful iron industry.

The southern limits of the blackband area have, up to the present time, not been well defined, and it was until recently supposed that no important deposits of it existed south of the Tuscarawas. Extensive explorations have, however, been lately made by Mr. A. Wilhelmi, in Oxford township, which have resulted in the discovery of "basins of ore," which rival in extent and value any before known. These are all located within two or three miles of what is called Post Boy Station, on the Marietta, Pittsburgh and Cleveland Railroad. The several tracts controlled by Mr. Wilhelmi and his associates are supposed to include one hundred and fifty acres of productive ore ground, where the blackband varies in thickness from three to nine feet. All these tracts are within easy reach of the railroad, and it may be confidently expected that a large contribution will be made from this district to the wealth of the county.

I am informed by Mr. Wilhelmi that in his explorations for blackband, in Oxford township, he discovered, by boring, an important body of ore unknown elsewhere, lying from forty to fifty feet below the blackband stratum. He reports it as a light-gray silicious ore, shown by analysis to contain thirty-nine per cent. of metallic iron, and consisting of closely approximating layers or plates, having an aggregate thickness of from three to nine feet.

On a former page I have referred to the discovery by my associate, Prof. J. T. Hodge, of a well-marked stratum of blackband on the Stillwater, some eight or nine miles south of Uhrichsville. No effort has been made, so far as I can learn, to determine accurately the extent and value of this deposit, but it affords another indication of the southward reach of the blackband, and such as should encourage further exploration in this part of the county. In this connection I will mention that I am informed by Prof. J. J. Stevenson that a well-defined, though perhaps not extensive development of blackband is found on the farm of Mr. Proctor, in Liberty township, Guernsey county.

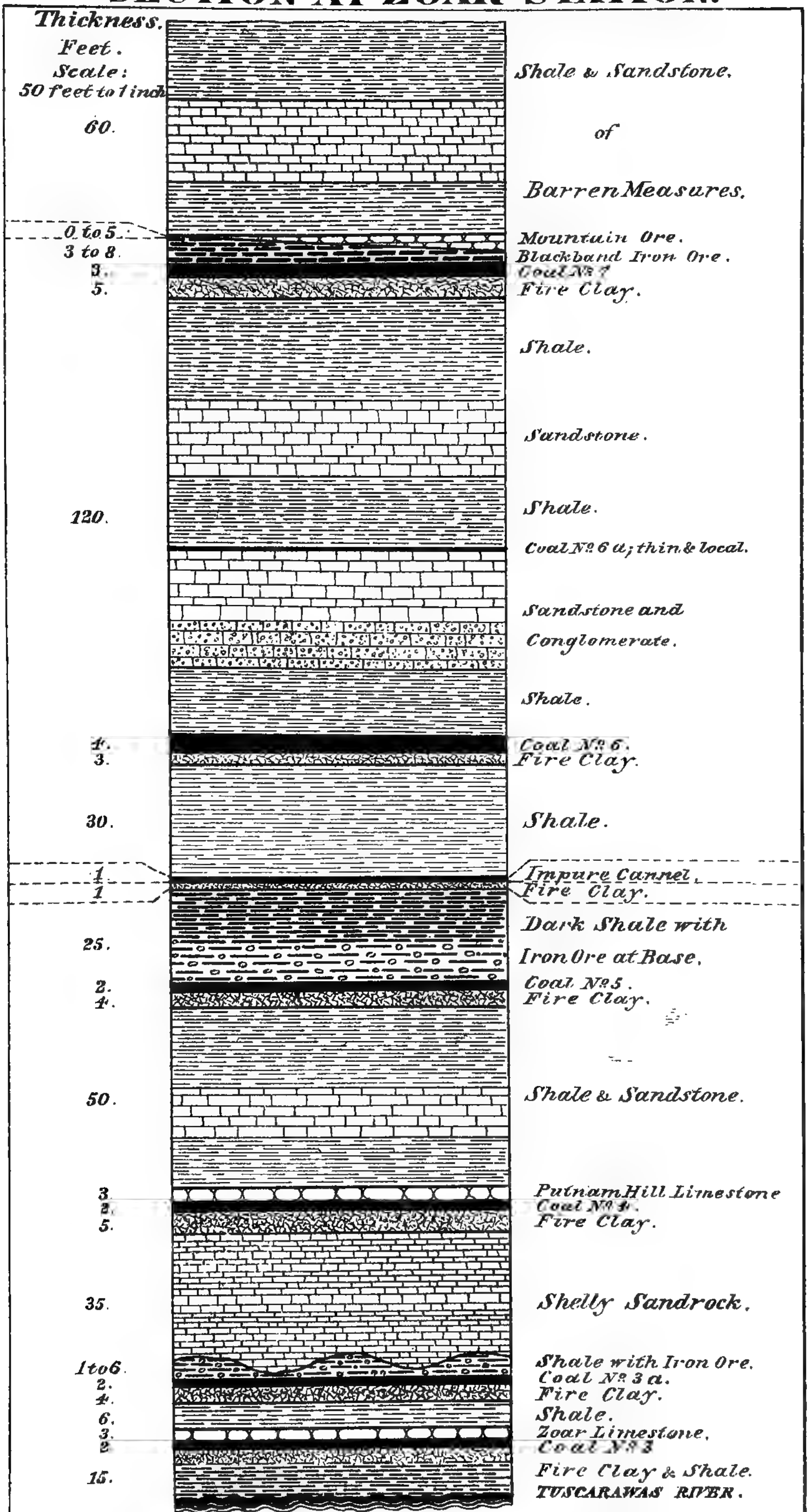
In the preceding notes upon the strata, outcrops of which occur within the limits of Tuscarawas county, so much has been said incidentally of the geological structure of different localities, that those who have read these notes will probably have a clear idea of the geology of the county; but it has seemed to me that the interest and value of this report will be somewhat increased by brief sketches of the structure of certain limited districts which have more or less topographical and geological unity. I therefore add a few pages of what may be called geographical geology.

The Tuscarawas Valley.—At the point where the Tuscarawas River enters the county, at Bolivar, it has cut through Coal Nos. 3 and 4, and these, with their overlying limestones—the Zoar and Putnam Hill—are visible in the hills on either side. The lower of the coals (No. 3) is rarely accessible, and is not of workable thickness. Coal No. 4 was, for a time, worked by Mr. J. A. Saxton, as has been before mentioned, this being the only point in the county, so far as I know, where it seemed worth mining, and here its rapid changes of thickness, together with the somewhat inferior quality of the coal, caused the enterprise to be abandoned.

Coal No. 5 is here good, is from three to four inches thick, and has been mined at various places on the south side of the Sandy valley, to and above the tunnel. The hills between Sandyville and Mineral Point are capped by the Mahoning sandstone, and the overlying shales, which are above Coal No. 6; this coal showing frequent outcrops, but everywhere thin and of rather inferior quality.

At and below Zoar, the Zoar limestone lies very near the water level, in some places forming the bed of the stream. The Putnam Hill limestone lies some fifty feet higher, just at the break of the low hills on the east side. As usual, both these limestone carry more or less iron ore on their surfaces, and the ore of the upper stratum has been sparingly worked by stripping. Between Zoar and Mineral Point the hills rise above the level of Coal No. 5, and the band of kidney ore, which lies just

TUSCARAWAS COUNTY.
SECTION AT ZOAR STATION.



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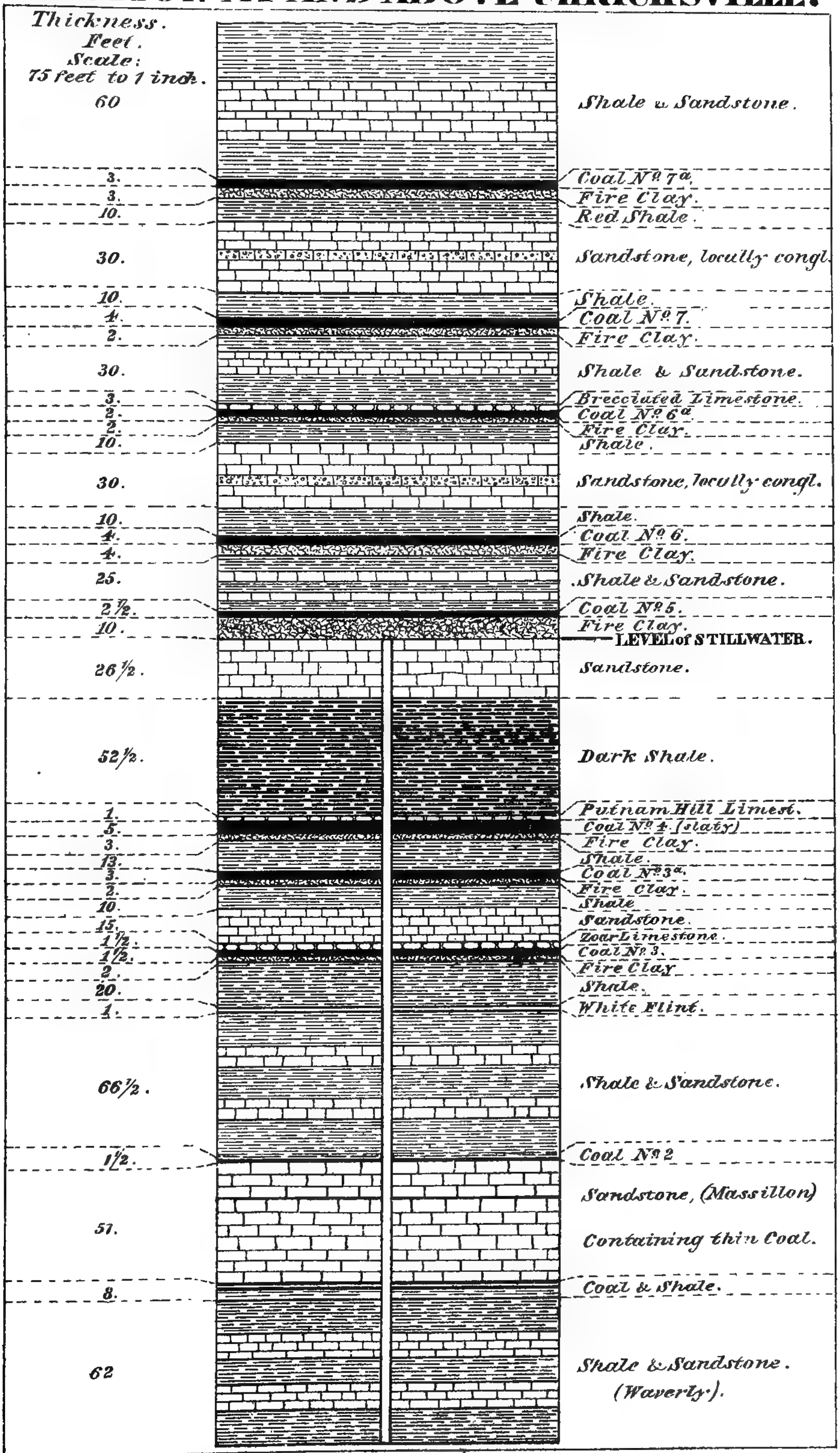
TUSCARAWAS COUNTY.
SECTION AT AND ABOVE UHRICHSVILLE.



W J Morgan & Co Photo Lith Cleveland O.

over it—and which runs all through this portion of the county—has supplied a large amount of ore, which has been manufactured at the old Bolivar furnace, or sent to Massillon and Dover.

On the west side of the river, opposite Zoar, the hills contain Coal Nos. 5 and 6, both of about the same thickness—three and a half to four feet—and both having been somewhat worked. Coal No. 5 is of the better quality, and was formerly quite largely mined by Mr. Wm. Medill. In one place it was found folded upon itself, and thickened up, as is described on another page.

At Zoar Station we have one of the most comprehensive sections in the county, and one so complete, and so well exposed, that it has been given as a typical illustration of the geological structure.

Between Zoar Station and Dover there is no marked change in the geology. The hills are capped with the shales of the Barren Measures, containing some valuable deposits of blackband ore, which have already been described. Coal No. 6, partially cut away, and replaced by sandstone, comes in on the south side, near the Goshen salt-well, and thence extends continuously southward. Coal No. 5 is in this interval apparently too thin to be of much value, and the same may be said of Coal No. 4. Between these two seams is a thin seam of cannel, having a thickness of a foot or more, but deserves mention only that it may not mislead the explorer. Along the railroad grade Coal No. 3*a* is shown at many places, here assuming greater dimensions than any where else in this region, but having little value.

At Canal Dover the nearest outcrop of coal is on the west side of Sugar Creek. Coal No. 5 is here three to three and a half feet thick and of good quality. The shales above it are thickly set with nodules of iron ore, as usual, and the deposit has been extensively worked here by stripping.

Between Dover and Trenton, Coal No. 6 is mined at frequent intervals on both sides of the valley, and is the chief source of supply of fuel to the inhabitants.

Between Trenton and the line of Coshocton county, the strata all lie nearly horizontal, and the section of the hills on either side is pretty much the same throughout. Coal No. 4 lies generally a little above or below the bottom lands, Coal No. 5 fifty feet higher up, and generally too thin to be of much value. Coal No. 6 is worked almost continuously, of fairly good quality and thickness, but in some places, as at Port Washington, attains unusual dimensions. It is, on the whole, however, inferior in quality in this section to what it is either at Coshocton or Urichsville. To illustrate the structure of this portion of the valley, the very full section afforded at Port Washington is given in another place.

The Valley of the Stillwater.—The geological formation of the country bordering the Stillwater has been already pretty fully described. The dip of the rocks being for the most part south-easterly, and the Stillwater running north-westerly, it crosses in its course a large number of strata, and affords an unusually complete section, reaching from the Upper Coal Measures above the Pittsburgh seam, in Belmont county, to the horizon of Coal No. 4, near Eastport. Where it enters Tuscarawas county, Coal No. 7 is the highest important member of the series, here of unusual excellence. With this coal extending from Stillwater to Newport, and No. 6, so well developed about Uhrichsville, the valley is well supplied with coal, and it is also probable that in Rush township valuable deposits of blackband will hereafter be discovered.

The Valley of the Conotton.—The Conotton, in its descent from Leesburg to Zoar Station, passes down from Coal No. 7 to Coal No. 3, and in a large part of its course it opens what promises to be excellent developments of Coal No. 6. In places, Coal No. 5 is also found, of good thickness, while the hills on both sides contain more or less important deposits of blackband and mountain ore. The extension of a railroad through this valley will certainly develop a large amount of mineral wealth, and make this, which has hitherto been barren ground, an important contributor to the business of the county.

The Valley of Sugar Creek.—But little has been said on the preceding pages in regard to the country bordering Sugar Creek, inasmuch as its resources have been, up to the present time, imperfectly developed. In its northward course, from Auburn to Deardoft's Mills, Sugar Creek drains a district which is generally high, and where the hills rise high enough to include the blackband ore. Recent explorations lead to the conviction that on both sides of the county line ore-beds exist which will prove to be of great value. Coal No. 6 is freely opened in the lower part of the valley, and in many places is specially good. At Deardoff's Mills the stream cuts down nearly or quite to the base of the Coal Measures, and exposes a bed of coal which has been supposed to be No. 1. No explorations have been made to determine this question, but it seems to me very doubtful whether this is the Massillon seam, for several reasons, viz.: 1st. It lies too near the overlying coals. 2d. It is overlain by a black fossiliferous shale, which, though containing a peculiar group of shells, most of which are new, is, apparently, a coal-measure bed. 3d. A little way east from Deardoff's Mill the Zoar limestone is seen lying but little above the level of the bed of coal in question.

The hills south of Deardoft's Mill rise above Coal No. 7, within two miles, and afford the most comprehensive, though not the most complete, section to be found in the county.

Fire-clay and Fire-brick.—In the notes on Coal No. 5 it has been mentioned that this is underlain by a bed of fire-clay of peculiar character and excellence, being non-plastic, or "hard clay," and specially adapted to the manufacture of fire-brick.

As this has already become the basis of a considerable industry in the county, it deserves a somewhat fuller notice than it has received.

The clay under Coal No. 5 varies from three to six feet in thickness, and also considerably in its character. In places it is nearly all plastic, in others mostly non-plastic, but more generally the bed is somewhat irregularly composed of the two varieties. The hard clay is the more valuable, and is similar in character to that of Mt. Savage, Maryland, "Hawes's clay," Mineral Point, Cambria county, Pennsylvania, and that of Kier Bros., Salina, Westmoreland county, Pennsylvania, all of which are largely used and highly esteemed for the manufacture of fire-brick. Judging from the composition of the clay under Coal No. 5, in Tuscarawas county, as well as from trials that have been made of the various objects manufactured from it, we may claim that it is fully equal in quality to any of those that have been mentioned, and that the articles made from it are equally resistent to the action of fire.

The area over which the clay of Coal No. 5 assumes this peculiar character is apparently limited, as in Stark county, on the north, and in the southern part of Tuscarawas county it is of the ordinary plastic character. The points where it is chiefly dug are near Bolivar, at Mineral Point, and at one or two places between the latter town and Canal Dover. Two quite extensive establishments, those of Mr. C. E. Holden, at Mineral Point, and of Messrs. Barrett and Rhodes, at Canal Dover, have been constructed for the manufacture of fire-brick from this clay. Both factories are quite complete, and capable of producing any article in this line which the industries of the country demand.

Analyses of fire-clays are given at the end of the chapter.

Fire-stone.—Many of the sandstones found in Tuscarawas county would doubtless prove, upon trial, very resistent to fire, and capable of serving a good purpose in the construction of furnace-hearths, etc. Only one, however, has attracted special attention in this connection. A nearly white sandstone, quarried by the Tuscarawas Coal and Iron Company, in the Valley of the Tuscarawas, below Zoar Station, has been, for some time, used as a firestone, and has proved so refractory as to merit special notice and commendation.

Building Stone.—Nearly all the sandstones which occur in the Lower

Coal Measures, at one or another locality in Tuscarawas county, furnish good building stone, and it may be said that no part of the State is better supplied with building materials of all kinds. The white sandstone, to which reference is made in a preceding paragraph, would make a very beautiful and durable building stone; perhaps the handsomest of any yet known in the county. At Mineral Point, a sandstone which lies between Coals No. 4 and No. 5, has been quarried to some extent, and shows well. About Urichsville the Mahoning sandstone, which overlies Coal No. 6, has also been shown to be well adapted to building purposes. Indeed, there is no considerable area within the county limits where a buff or brown sandstone, similar to those last mentioned, cannot be easily and cheaply obtained.

Salt.—In a review of the mineral resources of Tuscarawas county, salt should not be omitted. It is now produced in considerable quantity from brine raised at several wells in the vicinity of Canal Dover. These wells begin at nearly the same horizon—about two hundred feet above the base of the Coal Measures—and are sunk to nearly the same depth (about nine hundred feet). The salt-water is derived apparently from the same strata in the Waverly group. In the Sugar Creek well, which has a depth of eight hundred and ninety-four feet, the salt rock, a porous sandstone, was reached at eight hundred and eighty-six feet; while in the Goshen well, which is nine hundred and fourteen feet deep, the salt-water was obtained at the depth of eight hundred and sixty-five feet.

The strength of the brine is 10° Beaumè, 40° of the salometer, and it is estimated that seven barrels of water produced one barrel of salt = 280 pounds = 5½ bushels of 53 pounds each—the bushel being fifty pounds, but three more are packed to allow for drying.

The daily production at the Sugar Creek well is said to be from sixty-five to seventy barrels; that of the Goshen well was about forty-five barrels at the time of my visit. The flow of water is strong in both, and the production might be increased. From the former well, considerable gas escapes which is used for heating and lighting, and contributes toward the pumping. The daily comsumption of coal in addition is about eighteen tons.

The Sugar Creek well is owned and operated by Mr. J. S. Deardoff; the Goshen well by Messrs. Scott and Kennedy.

Bromine.—In the process of manufacturing salt, a considerable quantity of bromine is produced. After the crystallization of the salt, the bitter water is drawn off, and evaporated to 45° Beaumè; it is then distilled in a special apparatus. The product from one hundred and eighty gallons of the bitter water (the capacity of the still) is said to be fourteen or fifteen pounds of bromine, and the daily product of one still is seventy pounds. The bitter waters of these wells are said to be much richer in bromine than those of the southern part of the State.

In concluding this report, I take pleasure in making my acknowledgments to all those who have so cordially coöperated with me in my efforts to investigate the geological structure and resources of the county. Among these Mr. Joseph Welty, of New Philadelphia; Hon. H. Harmount and A. Wilhelmi, of Canal Dover; Mr. C. E. Holden, of Mineral Point; Michael Miller, of Zoar; Dr. Chalfant and Mr. E. S. Ferguson, of Uhrichsville, and Mr. L. H. Watson, of Port Washington, deserve special mention for the valuable assistance and information afforded by them in the prosecution of our work.

ANALYSES OF IRON ORES.

	Specific gravity.	Water.	Carbonic acid.	Volatile matter.	Iron, sesquioxide.	Iron, carbonate.	Silicious matter.	Alumina.	Manganese.	Lime, carbonate.	Lime, phosphate.	Lime.	Magnesia, carbonate.	Magnesia.	Phosphoric acid.	Sulphur.	Total.	Metallic iron.
Blackband Ore.																		
Drift Mine, raw, Tusc. C. and I. Co. (Wormley)	2.321			21.10	8.79	35.71	26.22	0.70	1.70	3.04			1.85		0.492	0.11	99.722	24.06
Drift Mine, calcined, Tusc. C. and I. Co. (Wormley)	3.411	0.25			75.00		17.02	0.60	1.65			2.80		1.48	0.773	trace.	99 573	32.50
Junkin's Mine, raw (Wormley)	2.341	4.00	7.70		9.50	39.31	30.32	0.00	1.30	4.02			2.50		0.55	0.31	99.51	25.63
Junkin's Mine, calcined (Wormley)	3.371	1.25			66.50		27.16	0.30	1.05			2.00		1.06	0.07	0.61	100.	46.55
Glasgow, Port Washington, C. and I. Co., Port Washington (Wormley)	2.473	18.80			6 25	38.51	27.20	1.00	2.35	2.72			2 49		0.63	0.21	100.16	22.96
Jacob Honck, Rush Township (Wormley)	3.321	7.31			12.65	49.54	20.84	0.00	1.25	3.99	0 89		3.33		.41	0.16	100.37	32.46
Mountain Ore.																		
Shriver Mine, Tusc. C. and I. Co., raw (Wormley)	3.311	2.65			42.50		13.08	trace.	2.20	31.85			5.63		.057	0.22		29.75
Zoar Station, Tusc, C. and I. Co., raw (Wormley)	3.132	6.10			19 59	38.38	17 28	1.10	0.90	8.93			6.13		0.99	0.02		32.23
Kelley's Mine, raw		6.00	17.10		47.81		9.65	2.90	0.20	10.07			5.20		0.38	0.23	99.54	33.47
Kidney Ore.																		
Mineral Point, over Coal No. 5, raw (Wormley)	3,434	.00			7.60	64.17	8.96	2.60	1.35	7 35			6.50		0.863	0.18	99.573	36.31
Mineral Point, over Coal No. 5, calcined (Wormley)	4,076	2.88			75.00		8.46	0.60	1.85			5.94		3.64	1.26	0.12	99.15	52.50
Block Ore.																		
Zoar Station, over Coal No. 3 (Wormley)	3.133	3.11			9.10	56.76	18.24	0.40	1.60	4.53	0 69		5.12		0.32	trace.	99.87	33.59
Zoar Station, over Coal No. 4 (Wormley)	3.538	0.71			10.29	56.02	14.48	0.60	1.20	7.40	0.41		8,75		0.19	trace.	99.96	34.18
Red Hematite.																		
Top of hill, Uhrichsville, Barren Measures (Wormley)	3.720	2.90			78.30		8.24	5.40			3.03		1.95		1.39	trace.	101.21	54.81
Edie's Farm, two miles south of Newport (Wormley)	4.650	2.40			85.71		8.68	.40	1.50	0.54			0.60		.00	.00	99.83	60.00

ANALYSES OF COALS.

	Specific gravity.	Water.	Ash.	Volatile combustibles.	Fixed carbon.	Total.	Sulphur.	Sulphur left in coke.	Fixed gas—cubic ft. per lb.	Ash, color of—	Coke.
Coal No. 6, Newcastle (Wormley)	1.365	3.20	7.95	33.00	55.85	100.	2.26	......	2.24	Gray.	......
Coal No. 6, Uhrichsville, Andreas' Mine (Wormley)	1.294	3.20	4.60	34.20	58.00	100.	1.59	......	3.20	Gray.	......
Coal No. 6, Trenton, Buckeye Mine, Lower Bench (Wormley)	1.283	2.20	5.00	35.80	57.00	100.	4.00	2.14	3.24	Fawn.	Comp.
Coal No. 6, Trenton, Buckeye Mine, Upper Bench (Wormley)	1.262	2.40	2.90	36.00	58.70	100.	2.20	0.97	3.15	White.	Comp.
Tunnel Seam, Mineral Point (Wormley)	1.375	3.20	4.15	37.70	52.95	100.	3.64	......	......	Brown.	Comp.
Coal No. 7, Houck's Farm, four miles south of Newport, Rush Tp. (Wormley)	1.262	3.20	6.20	30.80	59.80	100.	3.10	1.48	3.00	Fawn.	......
Upper Vein, Wetherbury Land (Wormley)	1.290	4.70	7.40	29.50	58.40	100.	2.04	1.37	3.15	Fawn.	Comp.

ANALYSES OF FIRE-CLAYS.

	Water, combined.	Silica.	Alumina.	Iron, sesquioxide.	Lime.	Magnesia.	Organic matter.	Alkalies.	Total.
Under Coal No. 5, Mineral Point, hard (Wormley)	11.70	49.20	37.80	......	0.40	0.10	......	......	99.20
J. L. Gill, Port Washington, plastic (Wormley)	3.54	59.95	33.85	......	2.05	0.55	......	......	99.94
Mineral Point, hard (Wormley	11.70	52.50	34.78	0.27	......	......	......	......	99.25
Mineral Point, hard (Wuth)	13.65	54.21	31.03	.38	.46	.15	.12	......	100.
Bolivar Star Brick-clay, hard (Wuth)	10.89	56.56	30.22	.45	1.06	.24	.51	.08	100.01
Limestone Hollow, hard (Wuth)	11.67	49.68	36.46	.22	1 19	.47	.13	.18	100.

Analyses of Cokes.

	Ash.	Carbon.	Sulphur.	Hydrogen.	Total.
Commercial Coke, made by Mr. Andreas, Uhrichsville, Coal No. 4 (Wormley)	12.90	84.25	2.85	....	100.
Buckeye Works, Trenton, Coal No. 6 (Wormley)	10.60	85.92	2.91	.32	99.75
Dover Furnace (Wuth)	23.81	73.93	2.26	....	100.

Analyses of Limestones.

	Silica.	Iron and alumina.	Lime, carbonate.	Magnesia, carbonate.	Total.
Limestone used at Blast Furnace by Tusc. C. and I. Company (Wormley)	1.00	3.30	93.70	1.82	99.82
Gray Limestone used as flux (Wormley)	12.00	3.40	82.90	1.05	99.35

CHAPTER LVII.

REPORT ON THE GEOLOGY OF COLUMBIANA COUNTY.

BY J. S. NEWBERRY.

SURFACE FEATURES.

The topography of Columbiana county may be said to be wholly due to erosion. It originally formed a portion of the great table land of the Coal Measures, of which the surface sloped gently to the south, the northern margin of the county reaching on to the divide which separates the waters of the Ohio from those of Lake Erie. In process of time the drainage of the southern slope of this divide, following certain lines, determined by slight irregularities of the surface, has excavated the deep valleys of several streams which terminate in the still deeper trough of the Ohio.

All the streams which form this system of drainage take their rise near the northern line of the county, and, descending with rapid currents, at their mouths they flow more than five hundred feet below the summits of the high lands which border them.

This system of excavation has given great variety to the surface, and has fashioned it into a series of rounded hills rising two hundred to three hundred feet above the broad valleys which separate them. The lines of the landscape formed by these alternations of hill and valley are flowing and graceful, and perhaps no part of our State affords more charming views than those which may be seen in various parts of Columbiana county.

Only the north-western corner of the county is occupied by the Drift clays and gravels which have modified the scenery and agriculture of so many of the counties lying further north and west. The soil is for the most part formed by the decomposition of the underlying rocks, which re sandstones, shales, limestones, beds of fire-clay, and coal. These in their disintegration have produced a soil of great fertility, and here, a in many other parts of the coal area, we find the hills scarcely less productive than the valleys, and their very summits frequently crowned with luxuriant crops of corn and wheat.

The higher lands of the county, with their rounded outlines, excellent soil, and sunny exposures, have proved to be especially adapted to the cultivation of fruit, and in the northern and eastern portions many thousands of acres are occupied with orchards of peach and apple trees, of which the abundant yield finds a ready market among the inhabitants of the more northern counties.

The highest *lands* in Columbiana county are found in the north-western corner, where the summit of the great divide is reached. The drainage from this district is—west into the Tuscarawas by the Sandy, north through the branches of the Mahoning, and south to the Ohio by the Little Beaver and Yellow Creek. In this region many of the hill-tops rise to the height of more than seven hundred feet above Lake Erie. The highest *point* in Columbiana county, measured by the Geological Corps, is "Round Knob," in Madison township. This, as indicated by a a single observation with the aneroid barometer, is eight hundred and forty-four feet above Lake Erie, and seven hundred and fifty-four feet above the Ohio at Wellsville, the lowest point in the county. The diversity of level which is exhibited in the county will be seen from the following table:

ALTITUDES IN COLUMBIANA COUNTY.

		FT.
Round Knob (above Lake Erie)		844
Wellsville	"	115
Liverpool	"	120
Salineville	"	306
Yellow Creek Summit	"	543
Sandy Summit	"	612
Mahoning Summit	"	627
Salem	"	620
Leetonia R. R. crossing	"	440
Columbiana	"	555
Palestine	"	455
New Lisbon	"	393

GEOLOGICAL STRUCTURE.

The rocks which immediately underlie the surface in Columbiana county are all portions of the Carboniferous system, and include not only the entire group of the lower Coal Measures, but, in the high lands, some portion of the Barren Measures.

The dip of all the rocks of the county is toward the south-east, about with the flow of the streams in the lower half of their courses. Hence in the valley of the Little Beaver, between New Lisbon and Glasgow, although the fall of the stream is three hundred and two feet, the strata exposed are the same all the way, and, with occasional waves, by which they are raised or depressed, they hold nearly the same relative level.

From this description it will be seen that the lowest points topographically in the county are geologically the lowest, and the strata are so regular and uniform in their arrangement that the sections afforded by all the deeper valleys are essentially the same.*

The lowest rocks actually exposed in the county are the sandstones and shales which lie beneath Coal No. 3 of the Ohio series. Of these, a somewhat massive stratum of white sandstone forms the bed and immediate banks of the Little Beaver, from New Lisbon to Glasgow.

Near the Ohio the stream cuts through this sandstone, and it will be noticed as forming conspicuous shoulders in the bluffs. Above this lies Coal No. 3, with its limestone, both of which may be traced from a point several miles above New Lisbon nearly to the Ohio.

On the North Fork of Little Beaver, from the mouth of Leslie's Run to Fredericktown, these same strata are exposed, dipping with the stream to its mouth. On Yellow Creek a similar section is exhibited. The high lands which border the valley of this stream rise six hundred feet above it at its mouth, three hundred and fifty feet at Salineville, and they are capped on either side with the red shales of the Barren Measures, which overlie the highest of the workable coals of the lower group.

In the central and eastern portions of the county the summits of the hills are formed by the same strata. For example: in Round Knob we find one hundred and seventy feet of the upper portion composed of green and red shales and red sandstone, typical representatives of the Barren Measures; then comes the Crinoidal limestone, which also runs through the high lands bordering Yellow Creek; and beneath this another great series of olive shales streaked with red, and two small coal seams (*7a* and *7b*) just as we find them on the western border of the county and in the high lands of Carroll.

In the north-eastern corner of the county, near Palestine, the hills are capped with the gray, green, and red shales of the Barren Measures, beneath which come Coal No. 7 (Burnett and Joy's seam), and next below this the Carbon Hill or Four-foot seam, which is the representative of the second seam in descending order, or Big Vein of Yellow Creek.

In the south-eastern portion of the county the hills are found to have the same general structure—a mass of barren shales forming their summits, beneath which are the representatives of the coal seams so extensively worked at Palestine and Salineville, here unfortunately exhibit-

*The valleys of the Little Beaver and Yellow Creek are cut to within one hundred and fifty feet of the base of the Coal Measures, and it is probable that the old partly filled valley of the Ohio passes below the lower bed of coal.

ing a less important development than over the greater part of the county area.

The general succession of the strata exposed in Columbiana county will be best seen by referring to the engraved sections on Charts Nos. 1 and 3 of the series published with Vol. II.

Fuller details and descriptions of the local changes which they exhibit will be given in the notices of the different districts, topographical and economic, into which the county may be divided.

Valley of Yellow Creek.—No other part of Columbiana county, rich as it is, rivals in mineral resources the valley of Yellow Creek; and, indeed, it is doubtful whether any district in the State of equal extent can boast of a more abundant supply of coal, or that which is more readily accessible. For this reason, and because the structure of the valley has been much misunderstood, I shall venture to give a somewhat detailed description of it, and of the coal seams which constitute its special objects of interest.

The misapprehension which has existed in regard to the order and equivalence of the strata in the valley of Yellow Creek, has arisen in part from a radical misconception of the system which prevails in our coal field, and in part from the fact that the extensive mining operations carried on in the valley have been located at several somewhat widely separated points, between which intervals have remained where the connection of the strata has not been distinctly traced.

Coming into the valley of Yellow Creek from that of the Ohio, we find it bounded at its mouth by hills rising to the height of five hundred to six hundred feet, which contain five workable seams of coal.

Beside these there are several thinner ones, one of which, with a thickness of about one foot, lies near the level of the Ohio, and two others, a few inches in thickness, occur high up in the Barren Measures. Of the larger seams, the lowest is called the *Creek Vein*, because it lies near the level of Yellow Creek, from Linton up as far as Irondale. This is a caking bituminous coal of moderately good quality, but rather soft, and containing considerable sulphur. From eighteen to thirty feet above this, lies what is called the *Strip Vein*, from the fact that it was formerly worked by stripping off the soil and earth which covered its outcrops. This seam has an average thickness of two and a half feet, and is of great excellence wherever it is opened in the valley. The interval between this coal and the Creek Vein is mainly occupied by black shale, which contains a notable quantity of nodular iron ore; it also contains, in places—as at Linton and New Salisbury—a stratum of limestone three to four feet in thickness. At Yellow Creek Station the Strip Vein is well exposed in the cut of the Cleveland and Pittsburgh Railroad, lying for some distance just in the grade.

About fifty or sixty feet above the Strip Vein, at this point, occurs another seam, which is here thin, but higher up in the valley it attains a thickness of from three to three and a half feet, and is known as the *Roger Vein.*

At a variable distance above the Roger Vein — near Yellow Creek Station it is said to vary from sixteen to forty feet—occurs what is known as the Big Vein, in dimensions the most important seam in the valley. At Linton this is from seven to seven and a half feet in thickness, the lower four or five inches being cannel, and containing great numbers of fossil fishes and amphibians. The Big Vein is here, as higher up the creek, a typical caking coal, of which the value is somewhat impaired by the quantity of sulphur it contains.

About sixty feet above the Big Vein—the interval being filled with black and gray shale, sandstone, and a bed of limestone—occurs a coal seam, known here as the *Groff Vein*, from four to five feet in thickness, of very good quality. Above the Groff Vein is a great mass of red, gray, and green shales, with some red sandstone, two small seams of coal, and one or more irregular beds of limestone—a characteristic mass of the Barren Measures.

The coal seams enumerated in the above sketch are supposed to be Nos. 3 (Creek), 4 (Strip), 5 (Roger), 6 (Big), and 7 (Groff) of our lower group of coals.

Borings made in the valley of the Ohio, below the mouth of Yellow Creek, all seemed to indicate the presence of a thick seam of coal at a distance of eighty or one hundred and forty feet below No. 3; but the result of recent explorations has proved that it consists largely of black shale, and is practically worthless. Whether it represents Coal No. 1 of our series is not yet fully determined, but this seems probable from the fact that no coal has been found below it.

In passing up the Yellow Creek Valley, the coal seams I have enumerated are all opened, and well known at Collinwood, Hammondsville, Irondale, and New Salisbury, and no one of the many miners in the valley questions their identity and connection. To the latter point the dip of the strata nearly coincides with the fall of the stream, the coal beds are all exposed, and with the exception that some diversity is visible in the intervals which separate them, the structure of the valley is uniform and regular. Above New Salisbury, however, the stream rises more rapidly than the coal seams, and there is here a slight arch in the strata. This carries Coals Nos. 3, 4, and 5 beneath the bottom of the valley, just above New Salisbury. Between this point and Salineville the coal seams are not well shown, and have been very little worked; as a consequence, some confusion has been produced in the minds of the inhabitants of the valley in regard to their identity. Comparing the sections which we have taken at different points on the creek, and which I now place side by side, it would seem that there was no just cause for the difficulty which has been experienced in identifying the Salineville coals with those which have been enumerated as occurring at points lower down on the stream.

At Salineville the strata rapidly rise toward the north and west. Three coal seams are exposed here—the upper, called the Strip, the next the Big, and the third the Creek Vein.

Over the upper or Strip Vein lies a mass, nearly three hundred feet in thickness, of red and greenish shales, with beds of sandstone, which no one will fail to recognize as a portion of the Barren Measures. This is further proven by the presence, at a distance of about two hundred and fifty feet above the Strip Vein, of the Crinoidal limestone, one of the most reliable guides in the entire coal series.

Under the Strip Vein at Salineville, as at Linton, we also find a bed of impure limestone, which is quite persistent.

From fifty to sixty feet below the Strip Vein lies the Big Vein of the Salineville series, varying from five to seven feet in thickness; and about forty feet below this another coal seam, under which is another bed of limestone.

By comparing this section with that taken at Irondale or Linton, no one will fail to be convinced that, with the common horizon of the Barren Measures and Crinoidal limestones above, we have in the Strip Vein of Salineville, the Groff Vein of Linton (or, in other words, Coal No. 7), and in the Big Vein of Salineville, the Big Vein of the lower portion of the valley; still further, that in the coal seam which lies below the grade at Salineville Station, but which comes out at the old gas well, we have the representative of the Roger Vein, or Coal No. 5, with its characteristic limestone under it.

Going north from Salineville, the railroad rises with great rapidity, but for some distance above town the Strip Vein (Coal No. 7) is visible in many localities along the side of the track, and seems to be dipping with the grade. It is here quite extensively mined by the Hartford Coal Company, and is often referred to as the Hartford seam. In the upper portion of the valley of Yellow Creek the relations of the strata are seen more distinctly than on the railroad.

The records of borings made for oil, salt, or, indeed, for any thing but coal, are proverbially unreliable as evidences of the succession of coal strata, but in the gas well, and at McGiluray's well, above Salineville, two seams of coal are reported to have been passed through, which hold about the proper position for Coals No. 3 and No. 4. Mr. James Farmer reports that coal was passed through in the salt well bored by his father, about one hundred feet below the third, or Roger seam of the Salineville series, but as no record was kept, this report can not be regarded as certainly accurate. At Irondale Mr. Morgan found one foot of coal twenty-five feet below the Creek Vein (Coal No. 3), which is apparently the little coal seen at various points below, and at one hundred feet his boring passed through another seam not over eight inches in thickness. No coal was found below this.

There are rumors of coal being struck in other borings made in the valley, but no exact information has been attainable from this source.

In the shales exposed in the cut at the summit above Salineville are seen a thin seam of coal and a stratum of limestone. These, with another thin seam of coal shown in the neighboring hills, evidently belong to the Barren Measures, and represent higher members of the series than the coals worked at Salineville.

Among the peculiar elements of the Salineville section, I should notice a black, nodular limestone, containing many fossils, which is seen above Coal No. 7, on Tidball's Run and at Hartford. It will be recognized by its black color and the numerous white mollusks which it contains.

At New Salisbury and at Linton, a dark gray limestone, two feet in thickness, shows itself under Coal No. 4. The interval between No 4 and No. 5 is composed mainly of shales, chiefly gray, and below the Roger coal the limestone, which has been referred to, often divides the fire-clay. At Yellow Creek Station it is two feet or more in thickness, and is highly ferruginous; at Collinwood it is said to have a thickness of seven feet; at Hammondsville it is one and a half feet in thickness; at Deep Cut from two to four feet, and is visible at Salineville.

This is the most conspicuous limestone in the Yellow Creek series, but it is an unreliable guide, since locally a limestone is found under each of the coals. Under the Big Vein at Irondale and Collinwood, just as in the central and eastern portions of the county, a limestone occurs; and under No. 7 a limestone is conspicuously shown at Salineville and Linton.

In the interval between Coals No. 5 and 6 we everywhere find more or less micaceous sandstone and sandy gray shale. At Salineville this was deeply eroded before the deposition of No. 6.

Coal No. 6 is generally covered with a black shale a foot in thickness in the upper part of the valley—thicker below. Over this is found a gray shale, and this supports a massive and coarse, often pebbly, yellowish sandstone, that has frequently cut the shale entirely away, and formed many "horsebacks" in the mines. This is, apparently, what is known as the Mahoning sandstone in western Pennsylvania. It shows the pebbly character, to which I have alluded, in many portions of Ohio, as near Liverpool, in the eastern part of Columbiana county; in Tuscarawas county, near Zoar, etc.; and this serves as one of several means for identifying the Big Vein of Salineville with the Big Vein of the northern and eastern portion of Columbiana county, or Coal No. 6 of Stark, Tuscarawas, Coshocton, etc.

Above Coal No. 7 the prevailing rock is ochreous-yellow or olive-green shale, often sandy, and, near Salineville, it contains, at its base, some heavy masses of sandstone. Near the top of the green shale series is commonly found a red shale, which deeply colors the summits and upper portions of the slopes on either side of the valley.

Above this we find from two to six feet of fossiliferous limestone (the Crinoidal limestone) and a thin seam of coal. Over these are twenty to thirty feet of green shale, covered, and sometimes replaced, by ferruginous sandstone, generally friable and yellow, but occasionally massive and reddish. Fragments of this stratum may be seen in the hill-tops all the way from Salineville to Linton.

Salineville.—At Salineville Coals No. 6 and No. 7 have been very extensively mined by Messrs. James Farmer and John Hayes, by the Pennsylvania and Ohio Coal Company, and by several other mining firms. Mr. Farmer was a pioneer in the development of the coal industry in this locality, and to his energy is largely due the fact that Salineville has been one of the chief contributors to the coal supply of Cleveland and the Lake market. Coal No. 7 is here a very bright, silvery, and pure coal, largely used and highly esteemed as a mill coal, and for this purpose extensively shipped to Cleveland. It is about three and a half feet in thickness.

At Salineville Station Coal No. 6 is from six to seven feet in thickness, and lies near the grade of the road, or about three hundred feet above Lake Erie. In this vicinity it shows, as do the other strata, numerous folds and much disturbance; it dips toward the north-east, and passes below the level of the creek a few rods from the station.* Below this point the limestone which lies beneath Coal No. 7 makes its appearance

*It rises rapidly in the opposite direction. At the salt well it is fifteen feet above grade; at the Pennsylvania and Ohio Company's mine, thirty feet, and one hundred rods above, seventy feet above the station.

on both sides of the railroad, and is conspicuous in the banks of the creek at and above the first railroad bridge.

Coal No. 7 here thins out and disappears, its fire-clay being distinctly traceable for some distance beyond where the coal ceases to show itself. The north-easterly dip of the strata in this vicinity is best shown by the limestone which appears on the grade of the road at the east end of the railroad bridge, but is in sight on the north side of the stream something like twenty feet below grade. Here very valuable tracts of coal lands are held on the right side of the railroad by Mr. John Hayes, who has opened two mines, both of which are now in active operation.

Some question has been raised with regard to the identity of the coal seam mined by Mr. Hayes, and considerable difference of opinion prevails on this point among the inhabitants of Salineville. Without further explorations, it will not be possible to decide this question beyond appeal; but, from the facts which have come under my observation, I am inclined to regard the seam worked by Mr. Hayes, at the Empire Mine, as the Big Vein of Salineville, here improved in quality, and approaching in character to that of the Little Vein (No. 7). This subject could be stripped of all doubt by sinking a few trial pits, and, doubtless, soon will be settled in this way. Waiting such evidence, however, I am led to the conclusion announced above, by the following facts:

1st. At the point nearest to the Empire Mine where the strata are exposed—as at the railroad bridge—Coal No. 7 has *completely run out*, while in the basin of the Empire Mine, at a distance of two hundred yards, the coal mined is five feet nine inches in thickness.

2d. Where last seen at the railroad bridge, the limestone under Coal No. 7 is rising in the direction of the Empire Mine, whereas the coal in the mine *is twenty feet lower, and yet is dipping toward the railroad bridge.*

3d. Though a limestone is formed beneath the coal between the two mines opened by Mr. Hayes, *another limestone is cut by the air shafts, which are carried to the surface above the coal.*

4th. The coal seam struck in boring, forty-two feet beneath the coal of the Empire Mine, was less than two and a half feet in thickness, which would seem to be much more in keeping with the thickness of the Roger Vein than the Big Vein.

While these facts seem to lend a strong probability to the view I have advanced, they come far from deciding the question at issue, and they may be shown by actual demonstration to be entirely illusory. Whatever may be ultimately determined in regard to the relations of the coal seam mined by Mr. Hayes, no one can question the great value of the property which contains it.

The following sections, taken at Salineville and below, will, perhaps, aid in the settlement of this question:

SALINEVILLE.

		FT.	IN.
1.	Limestone	10	0
2.	Gray shale, with nodular ore	15	0
3.	Coal (Strip Vein)	1–3	0
4.	Fire-clay	3	0
5.	Shale	5	0
6.	Nodular limestone	4	0
7.	Sandstone and shale	40	0
8.	Coal (Big Vein)	6	0
9.	Fire-clay	3	0
10.	Limestone	2	0
11.	Sandstone and shale	20	0
12.	Coal (Roger Vein)	2	6

RAILROAD CUT BELOW STATION.

		FT.	IN.
1.	Slope	15	0
2.	Sandstone	25	0
3.	Clay shale	16	0
4.	Coal (Strip Vein)	0	6
5.	Fire-clay	3	0
6.	Limestone	3	0
7.	Shale and shaly sandstone	35	0
8.	Coal (Big Vein) below creek	5	6

SECTION AT RAILROAD BRIDGE.

		FT.	IN.
1.	Slope	20	0
2.	Sandstone and shale	25	0
3.	Coal (streak)	0	0
4.	Fire-clay	3	0
5.	Earthy limestone	4	0
6.	Gray shale to creek	20	0

SECTION AT EMPIRE MINE.

		FT.	IN.
1.	Earth	3	0
2.	Limestone	3–5	0
3.	Sandstone and shale	20	0
4.	Coal	5	6
5.	Fire-clay	4	0
6.	Limestone	4	0
7.	Sandstone and shale	38	0
8.	Coal	2	6

HAYESVILLE.

		FT.	IN.
1.	Earth	9	0
2.	Sandstone	15	0

		FT.	IN.
3.	Shale	16	0
4.	Limestone	3	0
5.	Clay, sandstone, and shale	22	0
6.	Coal	3	0
7.	Fire-clay	3	0
8.	Shale and sandstone	39	0
9.	Coal (reported in shaft)	5	0

The relations of the Salineville coals to those of the lower portion of the valley, and to those of the surrounding country, have been shown by several lines of observation radiating from this point.

Following up the valley of Yellow Creek, Coal No. 7 (the Salineville Strip Vein) may be traced into the edge of Carroll county, where it is concealed for a short distance by the shales of the Barren Measures. It reappears in its true relative position and character on the waters of Big Yellow Creek, near Mechanicstown and Scroggsville, and is there worked in several mines. Thence it may be traced down Big Yellow Creek, through the northern part of Jefferson county, and connected with the coals of Hammondsville and all the lower portion of the valley.

Going north from Salineville toward New Lisbon, the road passes over a divide, of which the summit is three hundred and fifty feet above Salineville Station. This ridge is composed altogether of the strata of the Barren Measures, mainly red and gray shales, with two thin coals (*7a* and *7b*), and the Crinoidal limestone, all in their proper places with reference to Coal No. 7; the limestone lying two hundred and forty feet above it.

Descending the divide toward the north, and coming down into the valley of the West Fork of Little Beaver, near Garver Post-Office, we find the shales of the Barren Measures succeeded below by a heavy sandrock and two coals, the upper two feet eight inches to three feet thick, of excellent quality, and resembling the Salineville Strip Vein. The second seam, some sixty feet lower, is not well shown where first seen, but further down the stream, toward and at West Point, both these coals outcrop, and are worked at numerous localities. Beneath the lower one, which is five feet in thickness, and separated from it only by the fire-clay, is a limestone. This coal can be traced north and east from this point to the limits of the county, and is distinctly recognized everywhere as the Big Vein. It is our Coal No. 6, the Upper Freeport coal of Pennsylvania.

In descending the valley of Yellow Creek from Salineville, as has been mentioned, the Big Vein is seen dipping below the creek near the station, Coal No. 7 being visible on either side of the valley, but gradually thinning out, and, at the railroad bridge, having entirely disappeared.

At Mr. John Hayes's upper mine (the Empire Coal Company) the coal worked is four to five feet below the railroad grade. Forty-two feet below it two borings struck a seam of coal which measured, in one case, twenty-four, and, in another, twenty-seven inches. At the lower mine of Mr. Hayes, the coal worked lies above grade, is three to five feet in thickness, with a slate parting. It is hard and bright, but contains more sulphur than No. 7, at Salineville. Fifty-two feet below it a seam of coal, said to be five feet thick, was struck by Mr. Hayes, in a shaft. On Tidball's Run Coal No. 7 has been worked by stripping in the bottom of the valley. It is three feet thick, but explorations made toward the east show that it thins out to one foot. Higher up Tidball's Run, the Barren Measures are seen overlying No. 7, and containing the black, nodular, fossiliferous limestone, to which reference has already been made.

In the point opposite the lower mine of Mr. Hayes, a coal seam was formerly worked, just above the water level. It here dips toward the north-east, and is unquestionably the same as that worked by Mr. Hayes. Forty feet above it, in the cliff, is a bastard limestone, over which is a fire-clay and a thin streak of coal which may represent No. 7.

Further down the creek, near the mouth of Piney Run, a coal seam is seen in the cliff, twenty feet above Yellow Creek. It is three and a half to four feet in thickness, with a parting of slate one foot from the bottom—evidently the same seam as that mined by Mr. Hayes, and that once worked at the point above. Over the coal is a thin stratum of blue shale, then a sandstone, and a slope of one hundred feet where the rock is not well shown, but is apparently gray shale. Above this is a cliff of gray shale, and back from the creek the characteristic strata of the Barren Measures.

In the interval between the lower mine of Mr. Hayes and New Salisbury, the exposures of coal are now quite imperfect. Considerable mining was formerly done here, mostly for the supply of the salt works, but for some reason—probably because the coal seams do not here exhibit their best development—very little coal has been taken out for many years.

The coal worked at McGarry's Bank is apparently No. 6, No. 5 being here below drainage, but said to have been reached in borings.

At New Salisbury Coals No. 3, No. 4, No. 5, and No. 6 are shown, and we have the general section of the lower portion of the valley.

At Irondale the entire series of coals may be recognized, and here are extensive mines, a furnace, rolling-mill, and an establishment for coal washing, which will be more fully described in the report on Jefferson county.

Col. Charles Whittlesey, the first geologist who observed the coals of the Yellow Creek Valley, holds the opinion that the three workable coal seams of Salineville dip beneath those of the lower part of the valley, and, therefore, are not to be identified with any of the series exposed at New Salisbury, or below; but it has been impossible for me to accept this view, for the following reasons:

1st. The coal seams of Salineville are overlain directly by the strongly marked and highly colored strata of the Barren Coal Measures, including that constant and reliable guide, the Crinoidal limestone. These strata are continuous to the Ohio River, and the upper three coals of the lower valley hold essentially the same relation to them that they do at Salineville.

2d. The borings made at Salineville show that the Salineville coals are underlain, at about the proper distance, with two closely approximating seams, that apparently represent the Strip and Creek Veins of the lower valley.

3d. Deep borings, made at numerous points from above Salineville to the mouth of the creek, show that the Salineville seams do not underlie those of Irondale, Hammondsville, and Linton, and that no workable seam occurs below the five formed above and below drainage at Salineville, and fully exposed below New Salisbury.

To facilitate comparisons between the sections taken at Salineville and lower down the creek, they are published side by side upon the following page.

Parallel Sections in Yellow Creek Valley.

Section at Salineville.	FT.	*Section at Irondale.*	FT.	*Section at Collinwood.*	FT.	*Section at Linton.*	FT.
1. Crinoidal limestone	5	1. Crinoidal limestone	5	1. Crinoidal limestone (reported)	0	1. Crinoidal limestone, fragments of	0
2. Red and olive shales, etc., Barren Coal Measures	230	2. Red and olive shales, etc., Barren Coal Measures	220	2. Red and olive shales, etc., Barren Coal Measures	200	2. Red and olive shales and sandstone, Barren Coal Measures	200
3. Coal No. 7	3	3. Coal No. 7	2½	3. Coal No. 7	3–4	3. Coal No. 7	3–4
4. Clay and shale	5	4. Clay, shale, and sandstone	49	4. Fire-clay, limestone, shale, and sandstone	35	4. Clay and shale	10
5. Limestone	0					5. Limestone	5
6. Shale and sandstone	50					6. Shale and sandstone	50
7. Coal No. 6 (Big Vein)	5–6	5. Coal No. 6 (Big Vein)	5–6	5. Coal No. 6 (Big Vein)	5	7. Coal No. 6 (Big Vein)	6–7
8. Fire-clay	4	6. Sandy fire-clay	3	6. Fire-clay	3	8. Fire-clay	5
9. Limestone, shale, and sandstone	25	7. Limestone and shale	15	7. Limestone and shale	58	9. Interval, said to contain Coal No. 5 and limestone	80
10. Coal (Roger Vein) No. 5	2½	8. Coal (Roger Vein) No. 5	2	8. Coal No. 5 (Roger Vein)	2½		
11. Fire-clay	5	9. Fire-clay	4	9. Fire-clay	3		
12. Shale	15						
13. Limestone	5	10. Limestone	3–5	10. Limestone	3–7		
14. Shale and sandstone reported in gas well	95	11. Shale, with kidney ore and thin coal	50	11. Shale and sandstone	52		
15. Cannel coal (No. 4?)	12	12. Coal No. 4 (Strip Vein)	2½	12. Coal No. 4 (Strip Vein	2½	10. Coal No. 4 (Strip Vein)	2½
16. Interval	28	13. Fire-clay and shale	18	13. Fire-clay and sandstone	18	11. Fire-clay, shale, and limestone	20
17. Coal (Creek Vein?)	4	14. Coal No. 3 (Creek Vein)	3¼	14. Coal No. 3 (Creek Vein)	3–4	12. Coal No. 3 (Creek Vein)	4
18. Fire-clay	0	15. Fire-clay	6	15. Fire-clay	5–6	13. Fire-clay	5

Hanover and Vicinity.—The north-western portion of Columbiana county, including the townships of Knox, Butler, West, and Hanover, is all high land, and, as has been mentioned, this forms a portion of the divide between the waters of the Ohio and those of Lake Erie. The altitude of the valley is generally more than five hundred feet above the Lake, while the hills rise from one hundred to two hundred feet above this level. Notwithstanding its general elevation, this is the only portion of the county in which any deposits of Drift occur. At and north of Hanover, the surface is in many places strewn with bowlders of northern origin, and heavy beds of sand and gravel, and sometimes of clay, cover the underlying rocks. The Drift coating is, however, generally thin and irregular, and the materials which compose it are coarse.

Coal No. 6 is the seam which is generally mined in this part of the county. This may be traced through from Paris and Mapleton, in Stark county, to New Franklin, near which place it is well shown at Courtney's mine. Here the coal is five feet ten inches in thickness, soft, and black, with considerable sulphur. It has a slate parting eighteen inches above the bottom, and lies at an altitude of five hundred and seventy-five feet above Lake Erie.

Crossing the railroad at Moultrie, Coal No. 6 is first opened in Columbiana county at New Chambersburg, in the mine of Jacob Milburn. Here it lies at about the same level as at New Franklin, namely, seventy-five feet above the railroad at Moultrie. The coal is six feet thick, rather soft, but bright, black, and handsome, containing a moderate amount of sulphur. A thin parting of shale lies from twelve to eighteen inches above the bottom. The roof is gray shale, containing a great number of impressions of fossil plants. Below it is fire-clay and an impure limestone.

From the examination which I have had made of the Chambersburg coal, I infer that it would make excellent coke; and from its proximity to the railroad, if this should prove true, it would have great value as a source of supply of fuel to the Cleveland furnaces.

In the interval between New Chambersburg and Rochester, the hills rise to the height of from six hundred and seventy-five to six hundred and ninety feet above the Lake, and the surface is generally covered with Drift. Large bowlders of cherty limestone were seen on the hillsides at a higher level than Coal No. 6, but were not traced to their source. Coal No. 6 is opened half a mile east of Chambersburg, is there five feet in thickness, and is said to be found in all the valleys of the vicinity. At Rochester it is mined chiefly by William Somerville. At his opening the coal lies fifty feet above Rochester Station, is four and a half feet thick, soft and cementing in character, with considerable sulphur. It contains a slate parting eighteen inches above the bottom.

A well bored here passed through—

		FT.
1.	Gravel and clay	15
2.	Cannel coal and slate	4
3.	Clay	6

This cannel coal has been opened in several places north and east of this locality, but has proved impure and of little value.

At Lynchburg a coal seam is opened, which is apparently No. 6. The section there is as follows:

		FT.
1.	Drift	10
2.	Sandrock	20
3.	Shale	5
4.	Coal, with slate parting	4½
5.	Fire-clay	3
6.	Sandrock	0

At Sylvester Reeder's mine, by the old canal in Hanover, the coal lies about twenty feet above Hanover Station. The section here is as follows:

		FT.
1.	Gray Shale	40–50
2.	Coal, with parting in middle	3½
3.	Fire-clay	5

At the canal bridge, near this mine, a limestone is said to have been cut through, in building the canal, about thirty feet below the coal.

The same coal as that worked by Reeder is opened on B. Petit's farm, lot thirty, Hanover. It is here about four feet in thickness, and has a slate parting near the middle. In the fire-clay which underlies it is another thin seam of coal, as at Somerville's mine.

On Mordecai Miller's farm, lot thirty, is an outcrop of limestone forty feet above the coal worked, which is the same with Reeder's and Petit's, and probably No. 6. Just beneath the limestone is a seam of coal, but of what thickness could not be ascertained. This is possibly Coal No. 7, here unusually near No. 6, and having a limestone over it, as it generally does in Stark county.

At the mine of John Burton Coal No. 6 is four and a half feet thick, the roof is shale, overlain with sandstone, and in one of Burton's openings the sandstone descends and cuts out the coal. In the cut at the railroad summit the rock exposed is mainly gray shale; this includes, however, a thin seam of coal and a band of limestone. Possibly these may represent the horizon of Coal No. 7, which, in all this region, is thin or wanting, but without further explorations this question can not be satisfactorily decided. Borings made in the vicinity are reported to have passed through a workable seam of coal from forty to sixty feet below the surface. This is, perhaps, the Big Vein (No. 6), here showing the commencement of the rapid dip which carries it down to the level of the station at Salineville.

The Sandy and Beaver Canal, now abandoned, runs from Lynchburg, past Hanover, on about the same level, to the high land which separates the head-waters of the Little Beaver and Sandy. The canal passes this divide through a tunnel which forms the summit level. The rock excavated in this tunnel is a massive light-colored sandstone, but the hills of the divide are mainly composed of the gray or greenish shales of the Barren Measures. The highest land between Hanover and Dungannon is, according to barometric observation, one hundred and seventy-five feet above Hanover Station, or seven hundred and fifteen feet above Lake Erie. East of Dungannon, the tributaries of the West Fork of Little Beaver cut down valleys where coal is mined in several places. The exposures are here very imperfect, and in the time at command it was impossible to determine the relations of the strata shown here with those exposed in other parts of the county.

On the farms of Messrs. Copeland and Thompson, near the corners of Franklin, Hanover, Center, and Wayne townships, the following sections were obtained:

Section on Farm of J. J. Copeland.

		FT.	IN.
1.	Shale, containing coal one foot thick near top, and black at bottom	60	0
2.	Coal	3	0
3.	Fire-clay and shale	40	0
4.	Limestone, with iron ore	3-5	0
5.	Coal	1	0
6.	Sandstone	20	0
7.	Coal	1	0

Section on Thompson's Farm.

		FT.	IN.
1.	Slope (covered)	30	0
2.	Coal	3½	0
3.	Fire-clay and shale	40	0
4.	Limestone	3-5	0
5.	Coal	0	4
6.	Fire-clay	1	0
7.	Sandstone	20	0
8.	Coal	1	6
9.	Fire-clay and shale	15	0
10.	Limestone in bed of creek	0	0

In the eastern part of Hanover township the summit of the divide is occupied by the highly colored shales of the Barren Measures, beneath which are seen, near Gilford, Coals No. 7 and No. 6, occupying their normal positions.

New Lisbon and Vicinity.—Passing over into the valley of the Middle Fork of the Little Beaver, we find, above New Lisbon, in the southern portion of Salem township, Coal No. 6 attaining, in some localities, a thickness of from six to seven feet, as on the Shelton, Arter, and Teegarden farms. On the Martin farm Coals No. 6 and No. 7 are both exposed in the same section. No. 7 is here but two feet in thickness, but very pure. Coal No. 6 lies sixty feet below it, and is four feet in thickness, having its typical character. At Teegarden's mill the valley is cut lower. The limestone under Coal No. 6 is here exposed in the hillside, and Coal No. 5 is seen in the bed of the stream.

Further down the creek Coal No. 4 is cut through, here consisting mainly of a mass of black shale containing a large amount of nodular ore, and eight inches of coal. Below it, near the level of the creek, is a bed of blue limestone, and under it Coal No. 3. This has been quite extensively worked by Mr. C. H. Andrews, and shipped to Niles for use in the rolling-mills, and also largely manufactured into coke on the spot.

It is here three feet and a half thick, highly bituminous, and containing considerable sulphur. The fire-clay beneath it is six to eight feet thick, and is worked for the manufacture of fire-brick.

Above the black shale which incloses Coal No. 4, an earthy limestone is found, which is, perhaps, the eastern extension of the Putnam Hill limestone, so largely developed in the Tuscarawas Valley. Above this a trace of coal (No. 5?) is seen, nearly cut out by sandstone. Still higher in the hills is found the white limestone—the Freeport limestone of Pennsylvania—here four to six feet in thickness, of a light color, as its name implies, and furnishing a much whiter lime than most of the Coal Measure limestones.

From this point to New Lisbon, and below, the walls of the valley are made up essentially of the same elements. The stream runs upon the sandstone, which lies below Coal No. 3.

Coal No. 3 has been opened at a great number of localities, and in former years was extensively worked. On the north side of the stream it varies in thickness from three to four feet, and is of fair quality. On the south side it is thinner, and over a considerable area seems to have nearly run out. As usual, the shales above the limestone over No. 3 contain much nodular iron ore, and large quantities of it have been dug from the alluvial lands bordering the creek, where it has been left in the erosion of the valley.

At the quarry of Mathers & Zippernick, one mile above New Lisbon, the following section is exposed:

		FT.	IN.
1.	The white limestone	4	0
2.	Shale	6	0
3.	Coal (local)	1	0
4.	Shale	30	0
5.	Sandstone	50	0
6.	Dark shale	35	0
7.	Iron ore	0	8
8.	Coal No. 4	0	8
9.	Dark shale	30	0
10.	Limestone	3	0
11.	Coal No. 3	3	0
12.	Fire-clay	5–8	0

The sandstone in the above section lies in massive layers, and varies in color from a very light gray, almost white, to a reddish brown. It is somewhat coarse in texture, but is an excellent building stone, and has supplied the material of which the new and handsome court house at New Lisbon has been constructed.

At New Lisbon quite an industry has sprung up in the manufacture of fire-brick and hydraulic cement. The materials employed in these manufactures are derived from two horizons—first, the clay beneath Coal No. 3, which is used for fire-brick at the works above New Lisbon; second, the fire-clay and hydraulic limestone beneath Coal No. 5, in the vicinity of the town and below. Of these clays, the first has the ordinary plastic character; the second is non-plastic. Analyses of both these clays will be found in the tables at the end of this report—the plastic clay from the land of Mr. Robbins, the other from that of Daniel Harbaugh. The latter belongs to the group of clays usually termed hard clays, such as the Mt. Savage, Hawes's Clay, Mineral Point, Cambria county, Pennsylvania, the clay of Kier Brothers, Salina, Westmoreland county, Pennsylvania, the clay of Sciotoville and of Mineral Point, Ohio, and seems to occupy the precise geological position of the latter. All this class of clays are peculiarly adapted to the manufacture of fire-brick. The New Lisbon clay will compare favorably in quality with most of those cited above, and the brick made from it by the Eagle Fire-brick Company has an excellent reputation.

Salt is also to be reckoned among the products of this portion of Columbiana county. Brine of fair strength has been obtained in several wells, but only one is now pumped—that at the Young America Salt Works, where from thirty to forty barrels of salt are produced per day. In former times a large amount of salt was made in the valley of the Little

Beaver and at Salineville, the latter town taking its name from this fact, but the cheapness with which salt has been produced in Michigan and New York has caused most of the salt works of northern Ohio to become unprofitable, and, as a consequence, many of them have been abandoned.

A similar cause has limited the production of hydraulic cement. That made at New Lisbon is reported upon favorably by those who have used it, and the condition of the old locks of the Sandy and Beaver Canal, which were laid up with it, prove that it is a strong and durable cement; but the Lake markets are supplied in such abundance and so cheaply from western New York, and the region bordering the Ohio, from Barnesville, Belmont county, and Louisville, Kentucky, that the sales of cement made here have been, and probably will continue to be, much restricted.

In the cliff opposite the town of New Lisbon a section of nearly one hundred feet of rock is exposed. Here the blue limestone lies a few feet above the creek, and Coal No. 3 is seen under it, thinner than on the north side of the valley. Above is a mass of black shale, twenty feet in thickness, containing some iron ore, and apparently representing Coal No. 4. In this shale are large numbers of fossil mollusks (*Solenemya radiata*); it is regularly stratified, and is evidently an aqueous deposit. We have here an interesting exhibition of the changes which sometimes take place in coal seams. Coal No. 4 is the seam known as the Strip Vein at Hammondsville and Linton, the upper seam cut in the Salem Shaft, and the coal worked at Albany and Leetonia. In all these localities it is a remarkably pure coking coal. Further north, however, in Canfield and Berlin townships, Mahoning county, it is a very variable seam, sometimes becoming cannel throughout, and from five to six feet in thickness; sometimes half cannel and half cubical coal, and about four feet thick; oftener still, a seam of bituminous coal, two and a half feet thick, with six to ten inches of cannel at the top. In passing from Green Village to New Lisbon, this coal is seen to diminish in thickness, while the associated shale becomes thicker and more bituminous, until, finally, as I have stated, the coal is entirely lost, the carbonaceous matter being distributed through a sufficient amount of earthy sediment to form nearly twenty feet of bituminous shale.

At Elkton, below New Lisbon, this black shale contains a foot of bituminous coal in its lower part. Four miles further down the creek, on the Williams farm, the coal seam has increased to three and one half feet in thickness, with another foot of coal five feet above it. Below it Coal No. 3 is seen, less than two feet in thickness.

Midway of the cliff, opposite the town of New Lisbon, Coal No. 5 is visible, but is here quite thin. It is found on both sides of the valley in this vicinity, but attains a thickness of only about two feet. It can also be seen in Arter's Hollow and many of the lateral tributaries to the valley. Two miles below New Lisbon it locally thickens to four, and even five, feet, where it is known as the Whan coal. It lies about fifty feet above Coal No. 3, and is here of excellent quality. Unfortunately the area over which it exhibits this unusual development is small, and the deposit has been nearly worked out by the New Lisbon Coal Company.

On the opposite side of the valley, on the Kemble farm, Coal No. 5 is again seen, but thinner, and from this point to the Ohio it is found in all the hills, but rarely exceeds two feet in thickness. Above it the white limestone is conspicuously shown in all the sections at and below New Lisbon. Below this is a thin seam of coal, which is shown in the section exposed at Mathers & Zippernick's quarry. This is apparently local, and nowhere attains workable thickness.

Above the limestone, and generally separated from it only by a fireclay, is the Big Vein (Coal No. 6), which also stretches through to the Ohio, but is usually much thinner than in the northern part of the county.

On Mr. Petit's farm, two and a half miles south-east of New Lisbon, Coal No. 7 is found on the top of the highest hills, and has here a general thickness of about three feet. From fifty-five to sixty-five feet below it is Coal No. 6, three feet nine inches thick, and looking well.

The section of the strata on the hill opposite Mr. Kemble's house is as follows:

		FT.	IN.
1.	Coal (Petit's) No. 7	2	6
2.	Clay and shale	0	0
3.	Coal No. 6	3	6
4.	Clay	0	0
5.	Limestone (white)	0	0
6.	Coal No. 5 (Whan seam), about one hundred feet above creek	3	6
7.	Clay	0	0
8.	Black shale	20	0
9.	Limestone and ore	0	0
10.	Shelly sandrock	0	0
11.	Coal (thin) in bed of creek	0	0

Near Elkton some boring has been done for Coal No. 1, which was reported to have been found in the old salt wells, and was said to be from four to nine feet in thickness. The later explorations do not, however, fully confirm the traditions so long current with reference to the lower coal. In the borings made by Mr. H. C. Bowman, Coal No. 1 was reached one hundred and fifty feet below the bed of the creek. Its thickness was eighteen inches, and a thinner seam was found twenty-one feet above it.

On the south side of the creek, near Elkton, on the Barnes farm, a seam of coal has been opened about one hundred and fifty feet above the creek. It is three feet nine inches thick, contains much sulphur, and is apparently Coal No. 6.

The Valley of West Fork.—In the valley of the West Fork, from Garver Post-Office to West Point, and thence to Williamsport, the section of the rocks is essentially the same, as the course of the stream is nearly at right angles to the dip. Coals No. 6 and No. 7 are exposed in the valley and in the area between New Lisbon, Garver, West Point, and Williamsport, at a large number of localities. In this valley they seem to be of greater average excellence than along Middle Fork. In passing from Garver Post-Office to West Point, no coal outcrops are seen until the house of Mr. J. Robinson is reached. Here a coal seam is opened on the south bank of the creek, seventy-five feet above it. It is apparently Coal No. 7, is three feet eight inches thick, and of excellent quality. A thin parting is seen in it about four inches from the bottom. Beneath it is a fire-clay, and some six feet below this a limestone. At Mr. H. Mason's, three-quarters of a mile below Mr. Robinson's, is an old coal opening some fifty to sixty feet above the creek, and about fifty feet below it Coal No. 6 is opened. It is fifty-six inches in thickness, of good quality, resembling the Big Vein at Salineville, but better.

About one mile below Mason's, on the same side of the stream, is an old coal opening, apparently in Coal No. 7. It lies some seventy-five feet above the creek. Half a mile lower down, Mr. James McLane has a coal opening at about the same altitude. The coal is here good, but only thirty inches in thickness.

A little below, on the same side, and near the creek, are several old openings and one new one. The coal is here fifty-one inches thick, of excellent quality. It lies forty feet above the stream, and is, without doubt, No. 6. Two limestones are seen here—one some thirty feet above the coal, the other almost immediately below it.

Along the road for half a mile, to West Point bridge, Coal No. 6 is freely opened, from forty-two to forty-four inches in thicknes, of excellent quality, and containing little sulphur. The fire-clay below it is eighteen inches thick, resting immediately upon two feet of limestone.

The section at West Point is as follows:

		FT.	IN.
1.	Slope (covered)	55	0
2.	Sandrock	25	0
3.	Gray shale	45	0
4.	Coal No. 6	4	6
5.	Fire-clay	1	6
6.	Limestone	2	6

On the farm of Mr. Joseph Spence, at West Point, Coal No. 6 is opened, and he states there are three other seams above it.

On the farm of Mr. H. Bennett, on the south side of the creek, at West Point, Coal No. 7 is opened from three to three and a half feet thick, and its quality is said to be excellent.

In all this vicinity Coals No. 6 and No. 7 lie above drainage, are of good, workable thickness, and in quality will compare with any other coals in the county. It is to be regretted that greater facilities for transportation are not enjoyed by the inhabitants of Wayne and Madison townships, since if a market could be opened for their coal, from its quality and quantity it would prove a source of great and constantly increasing wealth.

Valley of the Ohio.—In Liverpool and Yellow Creek townships the Coal Measures are more deeply cut by the streams than in any other part of the county. The valley of the Ohio opens all the lower coal strata, with the exception of Coal No. 1, and it is doubtful whether this is of workable thickness. Abundant means of transportation are furnished both by the river and railroad. It, unfortunately, happens, however, that the coal seams which attain so great a development in most other parts of the county, are here often diminished in thickness, or cut out by heavy beds of sandstone, so that their value is greatly impaired. This deficiency is, however, in large part, compensated for by the abundance and excellence of the fire-clay, which is associated with one or more of the coal seams.

On the chart of sections taken along the course of the Ohio, and published with Vol. II., the development of the coal seams in the bank of the Ohio, between Wellsville and Liverpool, will be seen at a glance. Coals No. 3 and No. 4 are generally present in the hill, but are almost universally thinner than further north; neither of them attaining a thickness of three feet. The fire clay under No. 3 is, however, of unusual thickness, and that under No. 5 (?), as proved by extensive trials, is of superior quality. These have already become the basis of a great industry in the manufacture of earthenware, terra cotta, etc.—an industry which has mainly centered at Liverpool and Wellsville, and yields a gross annual product of more than half a million of dollars.

Coal No. 6, and, occasionally, Coal No. 7, are found higher up in the hills, of workable thickness; they no where, however, attain such dimensions as about West Point, or in the valley of Yellow Creek.

At Smith's Ferry, on the State line, the following section is exhibited:

	FT.	IN.
1. Slope, covered, reported to contain a seam of slaty coal ten inches thick	60	0

		FT.	IN.
2.	Massive sandstone, fine conglomerate (Mahoning)	6 to 75	0
3.	Sandy shale, in places wanting	6	0
4.	Coal, soft and sulphurous, with parting ten inches from bottom (No. 6)	4	0
5.	Fire-clay	4	0
6.	Limestone	2	0
7.	Interval, with some outcrops of shale and sandstone, said to contain non-plastic clay eight feet thick	125	0
8.	Sandy shale	10	0
9.	Block coal (strip vein), good for blacksmiths' use (No. 4)	2	0
10.	Shale and clay	15	0
11.	Coal, "clay seam" (creek vein), No. 3, very sulphurous	2	6
12.	Fire-clay	8 to 10	0
13.	Cannel coal, reported	1	6
14.	Slope, covered to river	75	0

The bed of the river is here sandstone, reported to contain a thin coal; and it is also reported that a thick seam of coal was here passed in boring at one hundred and forty feet below the surface of the Ohio; or one hundred and ninety to one hundred and ninety-five feet below the railroad. Too much confidence should not be placed in the accuracy of this statement, but it is quite certain that a coal seam, of workable thickness, was passed through at about the depth specified, in some of the oil wells bored at Smith's Ferry. As a general rule, those who bored for oil profess to have met with no coal, but their testimony is of little value, since the boring was usually done with a rope, no attention being given to the character of the strata passed through, and nothing having any value in the eyes of the operator but the oil, which was the special object of search. It is quite possible, too, that the lower seam is as irregular here as elsewhere, and that it is thin or wanting over a large part of the territory which has been bored for oil.

The clay under No. 3 has been opened near Smith's Ferry for the manufacture of fire-brick, but the enterprise is now at a standstill. The "block coal" (No. 4) has been mined, and is used in several places between Smith's Ferry and Liverpool. It is said to be of excellent quality, as it is, indeed, along all its line of outcrop, down to the mouth of Yellow Creek, and up the valley of that stream to Irondale.

In the valley of Dry Run, and that of Little Beaver, near its mouth, the sections of the coal strata are not fully exposed; but the shales, coal seams, and fire-clay seem to be largely replaced by beds of sandstone, the products of rapid currents of water, which cut away the softer materials, and left barren masses of sand in their places.

In the section taken at Harrison's pottery, one mile east of Liverpool, four seams of coal are seen, of which the lowest is No. 3, the highest probably No. 6. Of the these, the latter has a thickness of four feet, while forty feet below it is another coal, twenty-six inches thick, which perhaps represents No. 5.

At Harker's, on the north side of Liverpool, where most of the coal used in the vicinity is obtained, the following section was taken:

		FT.	IN.
1.	Slope, with old clay opening near top and sandstone at base	120	0
2.	Shale	5 to 10	0
3.	Coal, old opening fallen in (reported thickness)	2	6
4.	Interval, partly covered; massive sandstone, twenty-five to thirty feet thick, near the base	50	0
5.	Coal	1	20
6.	Fire-clay, used for pottery	8	0
7.	Interval; gray shales above, massive sandstone, twenty to twenty-five feet thick, below	110	0
8.	Coal, thin. No. 4. (?)		
9.	Fire-clay and shale, with nodules of calcareous iron ore	15	0
10.	Coal No. 3	1	0
11.	Hard, blue, sandy fire-clay	15 to 20	0
12.	Slope, with sandstone at base to river	45	0

In Ellison's Hill, north of Liverpool, five seams of coal have been discovered, which are probably the same with those opened in the Yellow Creek valley, though the section presents some peculiarities in the intervals which separate them. For example, above No. 3, which is only eight inches in thickness, no coal is seen—though one may be present—within a distance of fifty feet. At this level is a seam eighteen inches thick; sixty-five feet above it, another, twenty-five to twenty-seven inches thick; sixty feet above this is a coal seam forty-five inches in thickness, probably No. 6; and eighty feet above that lies another coal, No. 7, (?) four feet thick.

At N. A. Walker's pottery, on the west side of Liverpool, is a better exposure; and here the following series of strata are seen:

		FT.	IN.
1.	Greenish shales, reported to contain a coal two feet thick, about one hundred feet above the next lower seam	40	0
2.	Sandstone	85	0
3.	Gray shale	8 to 12	0
4.	Coal, worked, containing considerable sulphur	2	0
5.	Fire-clay	9 to 10	0
6.	Interval; shale above, sandstone below	90	0
7.	Coal, local	0	2–4
8.	Fire-clay, local	3	0
9.	Sandstone	40	0

		FT.	IN.
10.	Coal, with much sulphur	1½ to 2½	0
11.	Fire-clay, worked	12	0
12.	Shale and sandstone	108	0
13.	Gray and black shale	10 to 15	0
14.	Fire-clay (locally, two to six feet)	10 to 18	0
15.	Coal	0	2–4
16.	Slope, to railroad	40	0

The manufacture of pottery is rapidly advancing in Liverpool. There are now twenty-two establishments devoted to it here, five of which are making excellent iron-stone china; all the materials for the latter, however, being imported, their best clay coming from Indiana.

At Wellsville the hills bordering the Ohio are composed of the following materials:

		FT.	IN.
1.	Slope, mainly shales	280	0
2.	Coal (reported) not opened	3	0
3.	Sandstone	45	0
4.	Gray, sandy shales	50	0
5.	Argillaceous shale	25	0
6.	Black bituminous shale	2	0
7.	Coal	1	4
8.	Fire-clay, shale, and shaly sandstone	50	0
9.	Argillaceous shale	15 to 20	0
10.	Sandstone	45	0
11.	Gray and black shale	5	0
12.	Coal No. 3	2	6
13.	Fire-clay, used for drain-pipe	10	0
14.	Shaly sandstone to railroad	35	0

By comparing the foregoing sections, recently taken, with each other, and with those given on Chart No. 3, which accompanies Vol. II., it will be seen that there are considerable differences in the exposures even at neighboring points; but this is chiefly due to the cause already referred to, viz., the local replacement of the coals by heavy beds of sandstone. Any one who will take the trouble, however, to follow down the river from Smith's Ferry to Wellsville, will see that there is no general or considerable change in the geological structure throughout the interval, and certain of the beds can be traced almost continuously from one point to the other.

The coal seams of this part of the county do not compare favorably with their outcrops in the valleys of the Yellow Creek and the Little Beaver, and this cause, together with the low price at which the excellent Pittsburgh coal is delivered here by river, has operated to limit the amount of coal mined in this region. Almost none has been taken out here except for home consumption.

Aboriginal Inscriptions.—In connection with the description of the south-eastern portion of Columbiana county, I venture to call attention to some remarkable inscriptions made on the sandstone rocks in the bed of the Ohio River, just above Smith's Ferry. These figures and hieroglyphics cover a surface of six hundred feet along the river, and from fifty to one hundred feet wide. They can only be seen when the river is unusually low. In the summer of 1871, after a long interval of drouth, the water of the Ohio had fallen far below its average level, and these markings were better shown than they had been since this section of the country was occupied by the whites. At this time I had some of the most interesting of these figures carefully copied, and they are reproduced on the accompanying lithograph. At the present time these inscriptions are rarely visible, and it would seem as though they had been made when the Ohio was running at a lower level than at present—a matter to which I have referred in another portion of our report. As most of these inscriptions lie beyond the Pennsylvania line, I should be hardly justified in occupying the limited space which is alloted to this report in further notice of them, but it has seemed to me desirable that the fact of the existence of such inscriptions should be placed on record, and it is hoped that this notice will prompt more thorough and careful investigation of this interesting subject.

Salt Wells.—Quite a number of wells have been bored for salt in the region between East Liverpool and Wellsville. In several of these salt water has been found in sufficient quantity and of sufficient strength to make it practicable to obtain salt from it. The brine will not compare in strength with that obtained on the Kanawha, at Grand Rapids, or at Syracuse; but from most of the wells so large a quantity of gas issues as to furnish a fuel for evaporating the brine and driving the machinery. This has reduced the cost of production to a minimum, but the industry now languishes, from the failure of the gas in some of the wells, and the cheapness with which salt is furnished to this market from other sources. Mr. James Dickey, of East Liverpool, who has been concerned in the boring of several of these salt wells, has kindly furnished me the following notes:

"I give you herewith the record of one well, which will answer for all in this neighborhood.

		FT.
1.	Excavation to rock	31
2.	Hard sandstone	2
3.	Rock (argillaceous shale), with three or four streaks of black slate	81
4.	Slate and coal, mixed	5
5.	Soft white sandstone	14
6.	Hard blue rock	3
7.	Clay shale, with streaks of coarse white sandstone	221

		FT.
8.	Hard sandrock, containing a fissure from which gas issued with such force as to throw the water twenty feet above the top of the pipe for twenty-four hours, and was then exhausted	8
9.	Hard sandrock, with strong smell of oil, and first salt water	5
10.	Hard sandrock, with partings of shale, and strong gas vein which threw water fifty feet high	56

"There are seven wells in this vicinity, within an area of four by seven miles, all yielding some gas—two a small quantity of oil, from two to three gallons per day. Five of the wells produced salt water, but only two in sufficient quantity to justify the erection of works. I had the superintendence of the well of P. F. Geisse & Co., at Wellsville, for some months in 1862. We used gas for fuel, and produced about forty barrels of salt per week. This well is now abandoned, having lost its gas but retained its salt water. I have bored two wells to the depth of eight hundred to nine hundred feet, but found nothing but sandstone and fire-clay (soapstone or clay shale) as far as I went. No salt, gas, or oil was obtained below six hundred feet. The water varies from five to eight degrees of the salometer—about five degrees in the Geisse well and in our well here. This well produces about two barrels per day, requiring only about four days' labor per month. The salt is, however, of much less value than the gas, which we use for both light and fuel in several houses beside the salt works, and have a large surplus going to waste."

All the wells referred to by Mr. Dickey were begun within one hundred and fifty feet of the base of the Coal Measures, and penetrated deeply into the Waverly. The two hundred and ten feet of shale specified in the well register given by him doubtless represent the Cuyahoga shale, while the sandstones below, which contain the gas and salt water, are probably the equivalents of the Berea grit. We may also infer that the oil and gas were derived from the black shales of the Waverly, as at Mecca and Grafton. After these had been passed, barren ground was entered, consisting of the lower Waverly shales, and, perhaps, the upper Chemung. Probably if the boring had been carried deep enough to reach the vicinity of the Huron shale, another gas and oil horizon would have been reached—that of the Pennsylvania wells; but the supply from this source would be small unless coarse sandrocks which could serve as reservoirs were found, or strata more or less disturbed. Within the last fifty years an immense number of wells have been put down for oil or salt in this portion of the valley of the Ohio, and the total absence of all indications of coal beyond one hundred and fifty feet below the level of the river proves conclusively that the base of the Coal Measures is passed at about that depth, and fully confirms the conclusions we have arrived at from the study of the strata which lie above drainage. We learn another thing from these borings, viz., that Coal No. 1, which has so great value along the northern margin of the basin, is in this region generally thin or wanting, so that it can not be counted upon with any certainty as an element in the resources of this part of Columbiana county. As the Barren Measures crown the hill-tops along the Ohio and its tributaries, we see that all the really valuable coal seams of the lower group, as developed here, are fully exposed to view, and that there is no probability of the discovery hereafter, in this district, of valuable deposits of coal, iron, or clay, in addition to those now known to exist.

Gas Wells.—All the wells mentioned by Mr. Dickey were bored for oil or salt, but the flow of gas from some of them has since prompted special efforts to obtain gas that might be used for heating and lighting. Several of these efforts have been attended with success, and gas derived from gas wells makes quite an important contribution to the comfort and revenues of the inhabitants of this section of the county. At Liverpool Messrs. Laughlin Bros., manufacturers of iron-stone china, have sunk a well to the depth of five hundred and eighty feet, from which they obtain gas for heating their boilers and for lighting all their buildings. Mr. Thompson's store also is lighted by the gas from another well. At Jethro there are several wells producing gas, which is used for lighting houses. One of these has been purchased by Mr. William Brunt, with the intention of transporting the gas to Liverpool.

Oil Wells.—Just above the mouth of the Little Beaver the coal seams are in part replaced by heavy beds of sandstone, and in some of the sections taken there only one workable seam of coal is found, and this less than three feet in thickness. Numerous borings for oil in this vicinity have also generally failed to give evidence of important beds of coal below the river level. In some of them, however, coal was struck at something like one hundred and fifty feet from the surface, under black shale, and between two massive sandrocks, one of which I have supposed to be the Massillon sandstone, the other, perhaps, the Conglomerate.

Most of the borings penetrate deeply into and sometimes through the Waverly formation, and the oil of this region plainly comes from a still deeper source, probably from the same formation with that which supplies the oil of Oil Creek, viz , the Huron shale.

The quantity of oil obtained here has always been relatively small, yet the aggregate product of several hundred wells has been such as to make this industry an important one. Very little is, however, now produced from the wells situated within the limits of Columbiana county.

The Valley of the Little Beaver.—A few miles above the mouth of the Little Beaver the banks of this stream are quite rich in useful minerals, as will be seen by the following section taken on the farm of Charles Fulke, Esq., three miles from Glasgow:

		FT.	IN.
1.	Shale and sandstone	50	0
2.	Coal No. 7	3	0
3.	Fire-clay	3	0

		FT.	IN.
4.	Sandrock	40	0
5.	Shale	10	0
6.	Coal No. 6	3	6
7.	Fire-clay	3	0
8.	White limestone	6	0
9.	Shale and sandstone	20	0
10.	Coal No. 5?	1	6
11.	Fire-clay	2	0
12.	Sandrock	25	0
13.	Blackband and kidney ore	5	0
14.	Bituminous shale	3	0
15.	Coal No. 4	2	0
16.	Fire-clay	2	0
17.	Shale and kidney ore	8	0
18.	Black shale, with blackband	5	0
19.	Blue shale (calcareous)	1	0
20.	Coal No. 3?	0	5
21.	Fire-clay	1	0
22.	Shelly sandstone	20	0
23.	Shale and kidney ore	5	0
24.	Block ore	1	0
25.	Shale	33	0
26.	Sandstone to river	20	0

On the farm of Mr. Fair, near Fredericktown, the iron ore over Coal No. 3 shows well, the shale being from eight to ten feet in thickness and highly charged with iron.

At Fredericktown the "Tionesta" sandstone forms the bed and immediate banks of the stream. It here contains a coal seam one foot in thickness. About one hundred feet above is a seam of good coal two feet in thickness. Higher up in the hill a thick but impure cannel is reported to occur, and the "four-foot seam" (No. 6), with limestone under it, is said to be visible, though I was not able to find its outcrop. The limestone which underlies it appears in the road cut in the cliff on the east side of the river.

Between Clarkson and Fredericktown Coal No. 7 is opened in several places. It is principally worked at the Hastings Mine and that of William Shannon. The coal is here from three feet two inches to three feet six inches in thickness, very bright and pure. An outcrop of coal is seen in the road, some sixty feet below the mines last mentioned, probably No. 6, but apparently not of workable thickness.

Between Clarkson and New Lisbon Coal No. 6 outcrops in many places, but has been scarcely at all worked. On the farm of Henry Walters, seven miles east of New Lisbon, it shows distinctly in the road, with the limestone under it.

The Valley of North Fork.—In the region about Achor nearly all the coal seams which have been referred to in the preceding notes are exposed and worked. They here attain good thickness, and are generally of excellent quality.

At the mine of Isaac Dyke, on Camp Run, Coal No. 6 has been worked for some years. It is here from three feet nine inches to four feet six inches in thickness, and very good. Beneath it is a stratum of fire-clay, which rests upon the White or Freeport limestone. About twenty-five feet below No. 6 is Coal No. 5, here about two feet in thickness, and not worked. At a lower interval in the bed of Camp Run Mr. Dyke reports a heavy bed of coarse cannel.

Coal No. 6 is also worked about Achor by William and John Burt, George Burson, and Mr. Boerum, all in section 15 of Middleton township. On section 5 it is worked by Hiram Burt, Madison Wherry, and the heirs of W. J. Billingsly; on section 1, by Mark Burt; section 12, by Isaac Booth; section 11, by Jane Nevin; section 22, by Isaac Dyke, Eli Guy, Ephraim Latta, and Thomas George; section 14, by John Young; section 13, by Jeremiah Booth.

Coal No. 7 is not worked in the immediate vicinity of Achor, but it is visible in the tops of many of the hills, and has been opened on the land of J. W. Billingsly in section 10.

In several places about Achor a heavy bed of cannel comes in below Coal No. 6. This is well exposed on the lands of P. T. Brown, on what is called Bald Knob, in section 11; also on the lands of J. W. Billingsly, leased by Mr. Brown, in section 10, and on the farm of W. Eddings, in section 36 of Middleton township.

The cannel coal of Bald Knob has been carefully examined by Professor B. Silliman, jr., who has published a detailed report upon it. I give below three analyses of this coal made by Professor Silliman. From these it will be seen that it is of about the character and value of the Darlington cannel, now so extensively mined and shipped to the eastern markets.

ANALYSES OF ACHOR CANNEL.

No. 1, bottom; No. 2, middle; No. 3, top.

	No. 1.	No. 2.	No. 3.
Fixed carbon	35.43	41.69	39.90
Volatile combustible matter	28.82	30.24	30.01
Moisture	.75	.80	.74
Ash	35.00	27.29	29.35

An analysis of another specimen from the same locality will be found in the table at the end of this chapter.

The relative position of this cannel coal will be seen at a glance by the following section taken on the land of J. W. Billingsly:

		FT.	IN.
1.	Gray shale	20	0
2.	Coal No. 7	3	0
3.	Fire-clay	3	0
4.	Shale and sandstone	47	0
5.	Coal No. 6	3	6
6.	Fire-clay	3	0
7.	Limestone, reported	3	0
8.	Shale	45	0
9.	Cannel coal	8	0
10.	Gray and black shale	15	0
11.	Bituminous coal (Hartford seam)	2	6
12.	Fire-clay	2	0
13.	Gray and black shale, and covered to Bull Creek	80	0

At Achor the cannel is about eleven feet in thickness. It crops out at various places between Achor and Darlington, and is in the interval seen to vary much in thickness, and in some localities to be replaced by bituminous coal. At Darlington the interval between the cannel and Coal No. 6 is nearly one hundred feet, and a thin seam of bituminous coal is found in it.

Such a difference in the relative positions of these coal-beds might lead to the supposition that there were two seams of cannel in this region. This can not, perhaps, be settled without more extended observations, but the probabilities would now seem to be that the Achor and Darlington cannels are identical, and that the variation in the interval which separates this from Coal No. 6 is only another exhibition of the want of parallelism in coal seams, so frequently shown in other parts of the State.

The coal next below this cannel at Achor is that known in the vicinity as the Hartford seam. It varies in thickness, in different localities, from two to three feet. It is generally of excellent quality, hard, bright, open-burning, and pure. This coal is also found on the lands of Jeremiah Booth and W. H. Knight in Middleton township.

The relations of the Achor cannel and the Hartford seam to the coals of the central and western portions of the county are not yet definitely determined. I formerly supposed it probable that the cannel of Darlington and Columbiana county was the equivalent of the cannel of Mahoning; and, judging from the section given by Prof. Lesley, in his Manual of Coal, that both represented the Kittanning of Pennsylvania; but later observations have thrown considerable doubt on this identification. Whether the Darlington cannel is the Kittanning coal, as stated by Prof. Lesley, I will not pretend to decide, as this is a question that more particularly concerns the geologists of Pennsylvania. I am inclined to think, however, that the Darlington and Achor cannel is not the equivalent of the Leetonia coal, which is so prone to assume a cannel character in Mahoning county, and I am rather inclined to believe that we have in the Hartford seam the extension eastward of this so well known coal. Its position is more concordant with that idea, as are its chemical and physical characters. On this supposition the Achor cannel is either an intercalated and local deposit, or is a phase of Coal No. 5. It will be noticed that the latter seam is wanting in the section taken at Bald Knob, and the cannel holds about its proper place; but at a short distance from this locality, on the farm of Isaac Dyke, Coal No. 5 is found in position, and is a bituminous coal two feet in thickness, showing no tendency to run into cannel. It should also be said that Mr. Dyke reports a heavy seam of impure cannel in the creek bed below. One noticeable feature of the Achor cannel is, that it has no fire-clay beneath it, and this would seem to indicate that it was not a true coal seam, but only a very highly carbonized bituminous shale.

The abundance and excellence of the coals about Achor will doubtless, before long, prove sufficiently attractive to draw some railroad line through this region. When this shall happen, and its mineral wealth shall be more fully explored, the questions I have raised will be set at rest. Until the coal seams are more extensively and connectedly opened, any solution now offered must be merely provisional.

In the bed of Leslie's Run, in sections 2 and 11, Middleton township, a ferriferous limestone and a coal seam are shown. The coal is, apparently, of very little value. The limestone is earthy, and contains large numbers of fossil shells. Associated with it, but below, are heavy beds of nodular iron ore, which are well shown near the saw-mill. The same deposit of iron is seen in the land of Abraham Beatty and Charles Beard, in section 25, and of J. F. M'Cowan and J. Baxter, on section 35, of Middleton township. These ore-beds mark one of the great iron horizons that run through western Pennsylvania and a large part of the coal region of Ohio.

Analyses of the coals and ore of the vicinity of Achor will be found on another page.

It is greatly to be regretted that this portion of the county, so rich in mineral resources, should not have better means of transportation by which its wealth could be made available to the inhabitants.

As I have mentioned in other portions of the report, in an oil well bored at Cameron's Mill, on Bull Creek, a seam of coal four feet in thickness was penetrated at the depth of one hundred and sixty-six feet from the surface. This was probably Coal No. 1, as, if I am correctly informed in regard to the place of the well, the boring was begun very near the level of the blue limestone and Coal No. 3, both of which come out in the bed of Bull Creek. If this conjecture is correct, it shows that under some portion of this section of the country the Briar Hill coal may hereafter be opened by shafting. In this boring, at the depth of seventy-six feet from the surface, a coal seam one foot in thickness was passed through, which apparently represents Coal No. 2.

LINE OF THE PITTSBURGH, FT. WAYNE, AND CHICAGO RAILROAD.

At Palestine, and in various other localities along the Pittsburgh and Ft. Wayne Railroad, east and west of the State line, Coals Nos. 6 and 7 are opened, and have been worked for the supply of the railroad company and for transportation elsewhere.

Among the best known of the mines in this series are what are known as the "Carbon Hill Mines," near Palestine. These are opened on Coal No. 6, which is here about four feet in thickness. As through most of the county, and in western Pennsylvania, this coal seam (the Upper Freeport) is separated, by the fire-clay only, from the "White" or "Freeport limestone," about fifty feet above No. 6, the interval being filled by shale and sandstone. Coal No. 7 is found three feet in thickness, and of very good quality. It has been worked now for some time at Palestine, in the mine of Messrs. Lawtons & Bye, formerly Burnett & Joy. Above it the hill-tops are composed, mainly, of gray shale, with some layers of red shale, which mark this as a portion of the Barren Measures.

The following is a section of the coal strata in the vicinity of Palestine:

		FT.	IN.
1.	Gray and red shale	70	0
2.	Coal	3	0
3.	Fire-clay	6	0
4.	Shale	15	0
5.	Sandstone	12	0
6.	Shale	6	0
7.	Coal (No. 6)	4	6
8.	Fire-clay, mined for use	6 to 8	0
9.	Limestone	2 to 4	0
10.	Shale and sandstone, containing thin seam of coal	27	0
11.	Coal	1	0
12.	Fire-clay	3	0
13.	Limestone	4	0
14.	Shales	70 to 80	0
15.	Blue limestone	1 to 2	0
16.	Gray shale, with iron ore	30	0
17.	Black shale, with thin seam of coal	4	0
18.	Fire-clay	5	0
19.	Gray and blue shales, with much iron ore, to Leslie's Run	15	0

In the north-eastern part of Columbiana county, in the townships of Salem, Fairfield, and Unity, the hills often contain Coal No. 6 near their summits, but it is generally thin. Below this, Coal No. 5 is either wanting or too thin to be workable; still lower, and generally near the level of the valleys, is Coal No. 4, which is sometimes cannel, sometimes part cannel and part cubical coal, and in still other localities, as at Leetonia, Washingtonville, etc., is a thin but very pure bituminous coal.

At Unity coal has been struck in a well near the saw-mill, sixty-two feet below the surface at Unity Center, which is about two hundred feet above Palestine. No facts were furnished which would serve for the identification of the coal. In section 16, Unity township, at Davis's Mine, coal is worked sixty feet below the surface. It is about five feet in thickness, in two benches, the upper two feet three inches, cannel, the lower two feet nine inches, bituminous. From its altitude, this coal was supposed to belong to a different seam from the cannel so generally worked in the southern townships of Mahoning county, but from the character of the coal this would seem to be the most natural inference.

At Leetonia Coal No. 4 is quite largely mined, and forms the basis of an extensive iron industry in this locality. It is only from twenty-eight to thirty inches in thickness, but is remarkably pure, and makes a coke of superior quality.

At the coal works of the Cherry Valley Iron Company, at Leetonia, the coal is mined by a slope, at the depth of seventy feet from the surface. It is here twenty-eight inches in thickness, in two benches, the upper one eight inches thick, the lower one twenty. It is overlain by black and gray shale which contains a notable quantity of iron, as is usually the case at this horizon. One mile east of Leetonia, on the Pittsburgh, Fort Wayne and Chicago Railroad, a new mine has just been opened on Coal No. 4 by Messrs. Delo, Van Fleet & Co., in which the coal appears to be of very good quality. It is thirty-three inches in thickness, with three inches of cannel on the top, and this overlain by the usual heavy iron shale.

At the nail factory at Leetonia a well has been bored, nominally for water, but possibly for gas, or with a view to reach Coal No. 1. A careful record is being kept of this boring, which, it is said, will be carried down several hundred feet. The results of this experiment may be of great importance to the localities where it is made.

At Washingtonville Coal No. 4 lies twenty feet higher than at Leetonia. Its associated strata are:

		FT.	IN.
1.	Gray shale	0	0
2.	Shale, with iron ore	2	0
3.	Black shale	5	0
4.	Blackband iron ore	0 to 10	
5.	Coal, upper six inches slaty	$2\frac{1}{3}$ to $2\frac{1}{2}$	

A few feet below is Coal No. 3, from three to four feet in thickness, rather soft and sulphurous; its limestone lies just above it.

At Salem the railroad station is six hundred and twenty feet above Lake Erie, and the hills on the south rise considerably higher. These contain Coal No. 6 from three to five feet in thickness, but it is sparingly mined and only for local use. Its limestone is found under it, and is conspicuously shown on the road from Salem to New Lisbon. Within the town limits of Salem a shaft has been sunk to the depth of two hundred and seven feet. The section obtained is as follows:

		FT.	IN.
1	Earth	9	7
2.	Red shaly sandstone	9	0
3.	Black shale	1	6
4.	Slaty coal	0	6
5.	Sandstone	39	0
6.	Black shale	20	6
7.	Gray shale	21	4
8.	Coal, Leetonia seam (No. 4)	2	6
9.	Fire-clay	11	9
10.	Gray sandstone	1	5
11.	Clay shale	3	6
12.	Gray sandy shale	20	8
13.	Blue calcareous coal, with shells	2	0
14.	Coal, with parting of two inches one foot from bottom (No. 3)	5	0
15.	Fire-clay	1	9
16.	White sandstone	6	3
17.	Clay shale	7	8
18.	Black shale	1	0
19.	Coal	1	6
20.	Fire-clay	20	3
21.	Iron ore	1	0
22.	Shale	13	3
23.	Dark sandrock	6	7

In the above section the Leetonia coal is the first workable seam penetrated. It is here similar in character to what it is at Washingtonville and Leetonia, but somewhat less pure. The thicker coal below is of inferior quality, containing more sulphur, but serves a good purpose for steam and household use. The upper coal has been quite largely coked, but has not produced a fuel equal in quality to that made at Leetonia, and the working of the mine has, for this reason, been temporarily suspended. The use of the coal taken from the Salem shaft has also been limited by the sale in the town of the coal mined at Albany, in the edge of Mahoning county. The latter coal is the Leetonia seam, here of unusual thickness and excellence. It is to be regretted that the boring which preceded the sinking of the Salem shaft had not been carried one hundred and fifty feet lower in order to reach the horizon of the Briar Hill coal. By attaching a drill to the machinery now standing at the shaft, a boring could be made to the depth necessary to reach Coal No. 1 with very little expense, and it is to be hoped that this exploration will be attempted, since it might crown with success an enterprise upon which much capital has been expended, and which, up to the present time, has not been remunerative.

Analyses of Coals, Clays, and Iron Ores from Columbiana County.

Analyses of Coals.

No. 1. Whan or No. 5 Coal, New Lisbon Coal Co., New Lisbon, sent by H. C. Bowman.
2. No. 3 Coal, top of C. H. Andrews's mine, above New Lisbon.
3. " middle " "
4. " bottom " "
5. Strip Vein, Salineville. (No. 7.)
6. Big Vein, " lower bench.
7. " " top "
8. Lowest seam (Roger's), Salineville.
9. Dyke's coal, Middleton, top bench.
10. " " lower bench.
11. Achor coal, "
12. " "
13. Coal from W. Nelson's mine, New Lisbon.
14. From William and John Burt's mine, 3 ft. 2 in., north-east corner section 15, Middleton township.
15. From Durk and Burson's (No. 6), 4 ft. 4 in., section 15, Middleton township.
16. From Isaac Dyke's (No. 6), 4 ft., section 22, Middleton township.
17. From Booth and Knight's, Hartford, 3 ft., section 13, Middleton township.
18. From Isaac Booth's mine, 3 ft. 6 in., center section 15, Middleton township.
19. From Carbon Hill Coal Co. (No. 6), section 25, Unity township.
20. From Joy, Root & Burnett's mine (No. 7), section 36, west half Unity township.

(Nos. 14–20:) Specimens sent by P. G. Brown, of East Palestine.

21. Cannel coal, P. Y. Brown, Achor.
22. Upper coal, bottom bench, Salem Shaft. (No. 4.)
23. " top " "
24. Bottom coal, Salem Shaft. (No. 3.)
25. I. Milburn, bottom bench, New Chambersburg. (No. 6.)
26. " top " " "
27. No. 6, Hanover Station, Ruder's bank. (No. 6.)
28. No. 1, J. Hayes, below Salineville.

Analyses of Coals, Clays, and Iron Ores from Columbiana County.

	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.
Specific gravity	1.474	1.301	1.291	1.265	1.299	1.277	1.290	1.304	1.266	1.286	1.293	1.343	1.250	1.270
Water	1.15	1.30	1.30	1.55	1.70	1.10	1.40	1.65	1.35	1.70	2.00	1.85	1.70	1.10
Ash	4.65	4.45	6.40	1.55	4.50	1.95	4.45	7.20	2.50	1.75	2.55	9.55	1.70	4.40
Volatile combustible matter	40.45	37.10	38.00	40.85	34.30	35.70	34.60	37.35	34.15	42.70	34.00	28.55	35.90	35.30
Fixed carbon	53.75	57.15	54.30	56.05	59.50	61.25	59.55	53.80	62.00	53.85	61.45	60.05	60.70	59.20
	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Sulphur	3.51	1.95	1.87	2.65	1.62	0.86	2.11	2.03	0.99	1.45	1.26	0.11	0.77	3.21
Sulphur left in coke	2.06	1.26	......	......	......	......	......	......	......	......	......	......	......	......
Sulphur forming of coke	......	......	......	......	......	......	......	......	......	......	......	......	......	......
Fixed gas per pound, in cubic feet	......	......	......	......	......	......	......	......	3.24	2.92	2.99	3.16	......	3.00
Color of ash	......	White.	White.	Brown.	Gray.	Fawn.	Gray.	Gray.	Yellow.	White.	White.	White.	Fawn.	Red B'n
Coke	......	Comp.	Comp.	Comp.	Comp.	Comp.	Comp.	......	Hard.	Hard.	Hard.	Hard.	Hard.	Spongy.
Iron	1.86	......	......	......	......	......	......	......	......	......	......	......	......	......

ANALYSES OF COALS, CLAYS, AND IRON ORES FROM COLUMBIANA COUNTY—Continued.

	15.	16.	17.	18.	19.	20.	21.	22.	23.	24.	25.	26.	27.	28.
Specific gravity	1.260	1.267	1.402	1.276	1.280	1.302	....	1.274	1.315	1.319	1.315	1.300	1.291	1.333
Water	1.50	1.85	1.00	1.40	1.60	1.40	0.85	3.00	2.60	2.20	3.90	3.20	3 10	0.90
Ash	3.80	2.30	2.90	3.60	4.00	5.00	38.30	3.15	7.70	4.40	6.70	3.90	6.10	13.00
Volatile combustible matter	33.40	32.75	34.60	32.80	29.90	36 80	28.95	31.50	36.40	36.00	32.10	33.40	29 50	30.70
Fixed carbon	61.30	63.10	60.90	62.20	64 50	56.80	31.90	62.35	53.30	57.40	57.30	59.50	61.30	55.40
	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Sulphur	1.17	1.36	1.49	1.67	2.80	2.00	0.45	1.40	2.28	4.38	1.37	2.11	2.05	2.03
Sulphur left in coke	0 627	0.783	0 74	1.208	0.97	1.05	....	0.60	0.96	1.92	0.51	1.19	1.01	1.18
Sulphur forming of coke	....	....	... ...	....	....	....	....	0.92	1.57	3.10	0.80	1.89	1.65	1.72
Fixed gas per pound, cubic feet	2.99	....	3.08	......	(?) 2.75	3.60	2.99	2.91	2.75	....	3.00	3.15	2.91	2.91
Color of ash	Red.	Fawn.	Red B'n	Choc.	Choc.	Gray.	....	Gray.	Gray.	Gray.	Gray.	Gray.	Gray.	Gray.
Coke	Metal.	Metal.	Metal.	S. Met.	S. Met.	Spongy.	... .	Comp.	Comp.	Comp.	Comp.	Comp.	Comp.	Comp.
Iron	....	....	....	....	....	....	....	....	....	....	....	....	....	....

Analyses of Iron Ores.

No. 1. Iron ore, New Lisbon, sent by H. C. Bowman, shell of ore.
2. Nucleus of iron ore, "
3. Lesley's Run, Middleton township, 12 to 14 feet.
4. Daniel Harbaugh, New Lisbon.
5. Nodular ore, Ted Garder farm, highest bed.
6. Falke farm, No. 1, A. N. L. R. R.
7. " No. 2, "
8. " No. 3, "
9. Black ore, Falke farm, No. 4, A. N. L. R. R.
10. Blackband ore, Falke farm, Little Beaver.
11. Kidney ore in blackband, Arter farm.
12. Ore bed over coal, McClymond, New Lisbon.
13. Nodular ore over coal, Whistler's, Washingtonville.
14. Hill-top, Wellsville.
15. One foot thick, with Coal No. 4, one mile above New Lisbon.
16. George Morrison's, Liverpool.
17. Oolitic ore, below Creek Vein, New Lisbon.
18. Blackband, over Coal No. 7, Garver Post-office.

Analyses of Iron Ores.

	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.	17.	18.
Specific gravity	3.211	3.658	3.184	2.984	3.226	3.182	3.529	2.360	3.000	3.666	3.207	3.188	3.539	4.190	3.207	3.173	3.107	3.384
Water, combined	10.55	....	5.45	3.39	5.88	3.77	....	6.25	4.85	8.11	8.76	....	0.78	2.20	0.00	0.31	2.79	22.87
Silicious matter	11.25	9.20	26.22	45.30	19.02	9.00	6.62	18.86	31.64	61.92	28.02	9.66	11.94	7.36	3.08	3.40	24.44	25.10
Alumina	1.20	1.60	2.90	0.60	1.20	1.40	1.90	2.10	0.20	0.30	0.90	0.80	0.50	1.00	1.40	0.80	2.60	0.00
Iron, carbonate	....	68.08	27.99	32.06	51.78	66.01	68.53	35.51	38.74	18.82	42.34	59.79	56.23	....	43.34	69.83	43.13	16.79
" sesquioxide	71.88	7.62	19.84	8.43	11.06	5.35	5.31	17.48	6.66	5.83	12.18	10.02	13.34	82.30	13.96	5.17	9.66	31.00
Manganese, oxide	1.90	2.80	0.90	trace.	2.55	3.45	3.10	0.25	3.35	0.14	1.15	0.40	1.70	4.10	3.20	5.15	trace.	0.90
Lime, carbonate	1.96	5.20	8.75	6.50	5.70	4.05	4.63	6.67	8.16	1.86	....	11.78	8.59	0.98	21.47	6.33	6.37	0.67
" phosphate	....	....	....	....	....	4.19	7.11	9.02	0.71	0.61	2.49	1.11	1.74	0.83	3.03	3.04	4.16	0.41
Magnesia, carbonate	0.81	4.76	5.41	3.40	1.82	2.27	1.44	3.63	4.81	2.19	2.87	6.39	5.33	1.08	8.84	4.74	7.71	1.43
Sulphur	0.08	0.18	0.14	0.09	0.22	0.43	0.35	0.18	0.96	0.96	0.20	trace.	trace.	trace.	0.81	0.55	0.00	0.66
	99.13	99.44	98.60	98.97	99.23	99.92	98.99	99.86	100.08	99.94	99.91	99.95	99.15	99.85	99.13	99.32	100.86	99.83
Metallic iron	50.32	38.21	27.40	21.48	32.56	35.61	36.09	29.46	23.23	12.30	28.97	35.88	35.88	57.61	30.69	37.26	27.58	29.80
Phosphoric acid	0.51	0.59	1.534	0.48	0.703	1.92	3.26	4.132	0.323	0.281	1.14	0.59	0.797	0.38	0.39	1.38	1.91	0.19

Analyses of Coke.

No. 1. Coke from Big Vein coal, yields 56 per cent., Salineville.
2. Coke from coal of John Hayes, Salineville.
3. Coke from coal of Upper seam, Salem.

	1.	2.	3.
Carbon	82.31	81.30	82.80
Hydrogen	0.55	0.34	0.32
Sulphur	2.24	2.88	2.44
Ash	14.90	15.00	14.20
	100.00	100.00	100.00

Analysis of Coal Ashes.

From coal of Joy, Root & Burnett's mine, section 36, west half Unity township.

	Per cent. of ash.	Per cent. of coal.
Silicic acid	46.52	2.326
Iron sesquioxide	12.15	0.608
Alumina	36.80	1.840
Lime	1.59	0.079
Magnesia	0.12	0.006
Potash and soda	1.86	0.093
Phosphoric acid	0.25	0.012
Sulphuric acid	0.10	0.005
Sulphur (combined)	0.35	0.018
Chlorine "	trace.	trace.
	99.74	4.987

Analyses of Fire-clays.

No. 1. Daniel Harbaugh, No. 1, New Lisbon.
2. " No. 2, "
3. Robinson's farm, New Lisbon.
4. Strip Vein, Salineville.
5. Under Coal No. 3, C. C. Thompson, Liverpool.

	1.	2.	3.	4.	5.
Silica	60.70	52.10	58.25	60.35	62.80
Alumina	37.20	38.50	27.19	28.95	26.40
Iron	......	......	3.26	trace.	1.00
Lime	1.55	1.60	1.10	1.10	0.40
Magnesia	0.36	0.51	0.97	0.60	0.54
Water	......	7.25	8.55	6.10	6.30
Fixed alkali	......	......	......	2.66	2.65
	99.81	99.96	99.32	99.76	100.09

Analysis of Waterlime.

From New Lisbon, sent by H. C. Bowman.

Silica	5.80
Alumina	8.20
Carbonate of iron	14.50
" lime	69.30
" magnesia	1.86
	99.66

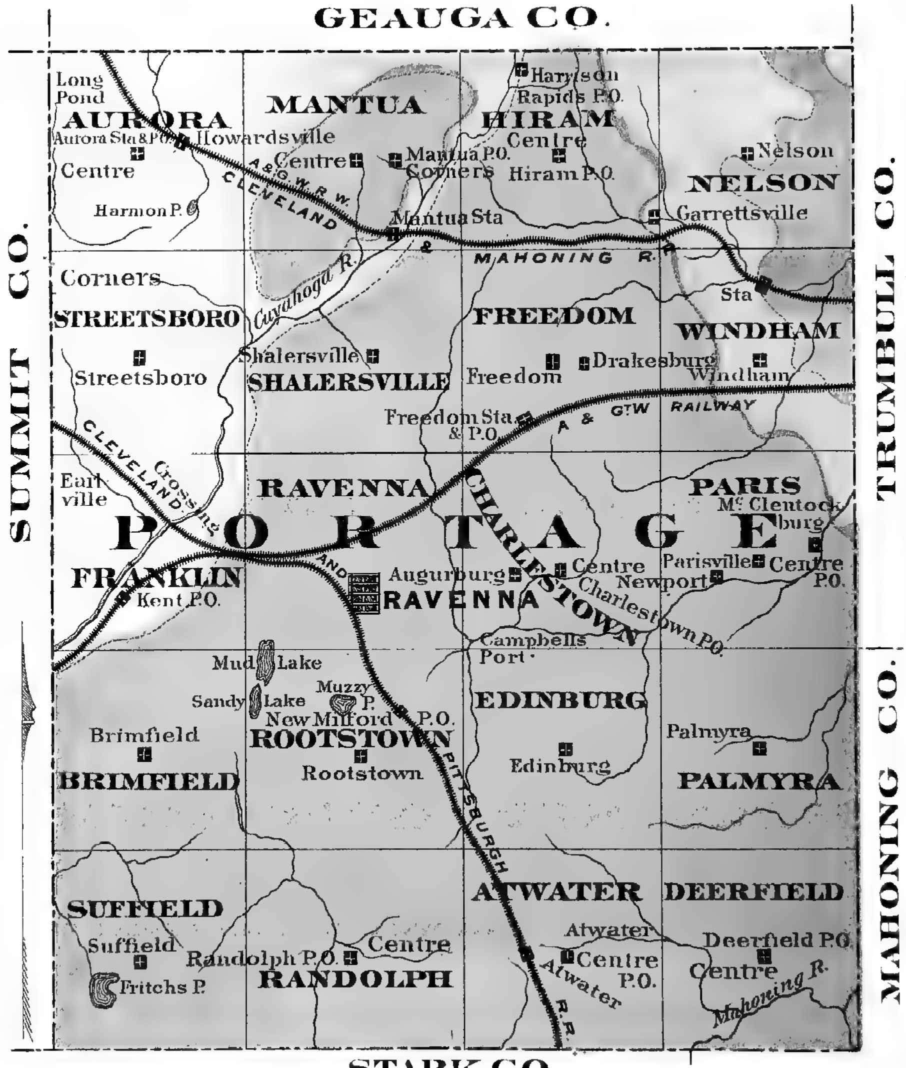
In conclusion, I take pleasure in expressing my obligations to Messrs. James Farmer and John Hayes of Cleveland, Dr. J. A. Lindsley of Salineville, Mr. H. C. Bowman and Messrs. Mathers and Zippernik of New Lisbon, Mr. P. Y. Brown of Achor, and Mr. J. T. Chamberlin of Palestine, for much valuable assistance while prosecuting the survey of the county.

Geological Survey of Ohio.

MAP OF PORTAGE COUNTY.

BY

J. S. NEWBERRY.



Explanation of Colors.

11	*Waverly Group*	13	*Conglomerate.*	14	*Coal Measures.*

W. J. Morgan & Co. Lithographers Cleveland, O.

CHAPTER LVIII.

REPORT ON THE GEOLOGY OF PORTAGE COUNTY.

BY J. S. NEWBERRY.

SURFACE FEATURES AND DEPOSITS.

Portage county lies entirely on the watershed which separates the streams that flow into Lake Erie from the tributaries of the Ohio. Its central portion rises to an altitude of six hundred and eighty-five feet above the Lake, while the valleys by which its surface is diversified descend about three hundred feet lower. The highest point of the county is near the line of the Cleveland and Pittsburgh Railroad, between Rootstown and Atwater, while the lowest is in the valley of the Mahoning, below Garrettsville.

When first entered by the whites, the county was covered with an unbroken sheet of primeval forest, consisting, on the lower and more level portions, of beech and maple; of oak, chestnut, etc., on the higher and drier lands.

Though underlain by rocks of diverse character, the surface is mainly formed by a sheet of clay, which has given a peculiar character to the agricultural pursuits of the inhabitants, and has made this a portion of the great dairy district of the Western Reserve.

In some localities on the northern and western slope of the watershed, but near its summit, are heavy beds of gravel, forming swells of the surface, or even rounded hills of considerable altitude. Typical examples of these may be seen in Randolph, Rootstown, Suffield, Franklin, and Brimfield, and near Earlville, on the lines of the two railroads which pass through the county. In the basins inclosed by these gravel hills and ridges lie most of the lakes and peat bogs of the county. These gravel hills constitute an interesting feature in the surface deposits, and will be found described in the first chapter of Vol. II, under the head of *Kames*. I have ascribed them to the action of waves on the Drift deposit of the shore and shoals which formed the margin of the great inland sea that once filled all the basin of the lakes.

In the northern part of the county the Drift deposits are generally of so great thickness as to cover and conceal the underlying rocks. Wherever exposed to view, the rock surface is found to be planed and grooved by glacial action, and usually the overlying clay may be designated as a *bowlder clay*, since it contains masses of rock derived from neighboring sources, with smaller and usually scratched and worn fragments brought from distant localities. This clay is unquestionably the material ground up by the great glacier which once covered Northern Ohio, pushed forward by its advance, and left in an irregular sheet upon the rocky foundation in its retreat. In some places the clay is finer, without gravel or bowlders, and is accurately stratified by the action of water.

Immediately beneath the soil, or projecting above the surface, are found many transported bowlders, frequently of large size, composed of granite, greenstone, and other crystalline rocks, evidently of foreign origin, and apparently derived from the highlands north of the great lakes. These bowlders are rarely found deeply buried in the Drift, and, as I have elsewhere shown, must have been floated by icebergs from their place of origin, and dropped into their present position. Some of the superficial gravels which overlie the bowlder clay seem to have been transported by the same agency.

As a whole, the soil of Portage county is productive, and although, from its tenacious character, and the dense growth of forest by which it was covered, it has required much patience and labor for its subjugation, this task has been well and thoroughly performed by the intelligent and industrious population into whose possession it came; and it has repaid their efforts by a constant and generous support through the last half century.

In common with the other portions of the great divide on which Portage county is located, its rolling surface forms numerous local basins, many of which have been, and some still are, occupied by lakes. Of these lakes, West Pond, Brady's Lake, and Lake Pepin in Franklin, Mud Lake, Sandy Lake, and Muzzy's Lake in Rootstown, and Fritch's Pond in Suffield, may be cited as examples. These lakes are supplied by springs which flow through the Drift gravels, and their water is usually clear and pure; they contain great numbers of fine fish, and are also interesting and beautiful features in the scenery. Some of these basins, formerly occupied by water, have been gradually filled up by the growth of vegetation, and now exist as swamps underlain by peat. One of the best known of these is near Ravenna, where considerable peat has been cut and manufactured. There is another and still more extensive peat marsh in Brimfield, and small ones occur in nearly every township. Usually these peat bogs are occupied with *Sphagnum* (the peat-producing moss), cranberry vines, huckleberry bushes, and larches, and they are often known as tamarack or huckleberry swamps. The peat in these swamps is not unfrequently underlain by shell marl, and both these are capable of being used with profit by the farmers as fertilizers. It is also probable that the canberry may be successfully cultivated on the swamp surfaces. In the Eastern States the cultivation of cranberries has proved to be highly remunerative to those engaged in it, and there seems no good reason why the same success should not be attained by the inhabitants of those portions of Ohio where the cranberry grows spontaneously, and where there are marshes which are well adapted to its cultivation.

Striking and typical examples of the glacial furrows which have been referred to above may be seen on the hill near the house of Mr. Theodore Clark, in the township of Edinburgh. The direction of the striæ is here N. 60° E. The rock is a sandstone, overlying the lower seam of coal. Near the center of Palmyra is a still better exhibition of glacial marks. On the hill, three quarters of a mile west of the center, the bearing of the furrows is N. 30° E. In the town of Palmyra, on a surface of sandstone exposed in front of Mr. Wilson's store, the traces of glacial action are very conspicuous; the rock surface being planed down very smooth, and marked with scratches and furrows, of which the direction is N. 26° E. In many other parts of the county similar ice inscriptions may be observed, chiefly on the surfaces of the beds of sandstone, as they are better retained on this indestructible material than on the softer or more soluble rocks.

The bowlder clay which overlies the glaciated surface varies considerably in appearance in different localities, according to the exposure and drainage to which it has been subjected, and the local circumstances which controlled its formation. In the valleys it will be found to be of a bluish color throughout. On the higher lands the upper portion is frequently yellow, sometimes down to the depth of ten or twelve feet, while the lower portion is blue or gray. This difference I attribute to the oxidation of the iron contained in the clay, where it has been exposed to the air and to surface drainage. The number and character of the pebbles and bowlders contained in the clay also varies much in different localities. In some places, as near Campbellport, the Drift deposits are largely made up of angular or little-worn fragments of sandstone, torn from their beds in the immediate vicinity; while in places remote from such outcrops of the harder rocks, the stones contained in the clay are small, much worn, and many of them are composed of granite, etc., brought from the region north of the lakes.

On the highlands the gravel beds referred to above rest sometimes on the bowlder clay, but perhaps oftener on the underlying rock, showing that the causes which produced the accumulation of gravel generally removed all the clay. Where the gravel beds overlap the bowlder clay, the materials which compose them seem to have been washed back from the higher grounds. It will be noticed that the pebbles in the gravel beds are well rounded and often irregulary stratified, while those found in the bowlder clay are sub-angular, scratched, and worn, but rarely rounded. It is evident, therefore, that the gravels have been subjected to a triturating action quite different from that exerted by glaciers on the materials which they move. The facts show, further, that water, either in shore waves or in river currents, has been the agent by which the pebbles of the gravel have been rounded; and as it is difficult to conceive of any currents which could leave beds and hills of gravel such as are found along the divide between the waters of the Lake and the Ohio, I have been led to consider these deposits as the effect of shore-waves, when the Lake basin was filled to this height, on the bowlder clay and other Drift material which once covered the underlying rocks. It is possible, too, that the drainage from the glacier, when it filled the lake basin and was melting along its southern edge, contributed to the washing of the clay and the rounding of the pebbles. In this view the gravel hills and sheets which cover so much of the great divide which crosses the State may be compared to the terminal moraines of existing glaciers, but in no moraine of which I have any knowledge are the pebbles and bowlders nearly so well rounded as in the deposits under consideration; and I am sure all who will carefully examine these will agree with me that free and swift, moving water, in large quantity, has been the chief agent in producing the phenomena exhibited. Along certain lines leading from the summit of the watershed to the Ohio, both east and west of Portage county, there are belts of gravel and bowlders, which mark, as I conceive, broad and long-existing drainage channels, by which the surplus water of the lake basin flowed through certain waste-weirs cut in the watershed, escaped southward, but the gravel hills of Portage county can hadly be referred to such a cause.

GEOLOGICAL STRUCTURE.

The number and relative positions of the strata which come to the surface within the limits of Portage county will be seen at a glance by reference to the section given below:

		FT.
1.	Superficial clay and gravel	10 to 100
2.	Shale and sandstone	50
3.	Limestone	0 to 4
4.	Coal No. 4	1 to 5
5.	Fire-clay	3 to 4
6.	Shale and sandstone	25 to 30
7.	Limestone	0 to 4
8.	Coal No. 3	1 to 3
9.	Fire-clay	3 to 12
10.	Shale	20 to 50
11.	Coal No. 2	0 to 1
12.	Sandstone	50 to 100
13.	Shale	0 to 50
14.	Coal No. 1	0 to 5
15.	Fire-clay	3 to 5
16.	Shale and sandstone	25 to 50
17.	Conglomerate	100

All the rocks enumerated in the preceding section belong to the Carboniferous system, of which they represent two members, viz., the Conglomerate and the Coal Measures. The area of the county is about equally divided between the two formations. All the northern half has the Conglomerate for its surface rock, though it is generally deeply buried by Drift clays. It is fully exposed in the valleys of the Mahoning and Cuyahoga. The trough of the latter stream is cut in the Conglomerate all the way from the point where it enters the county, in Hiram, to its place of exit, on the west side of Franklin. The Conglomerate is well seen in Mantua and Garrettsville, and still better in Franklin and Nelson. In all these localities it exhibits essentially the same characters, viz., a coarse, drab-colored sandstone, in places thickly set with quartz pebbles from the size of a pea to that of an egg. In some places, as in Windham, the stone it furnishes is finer, whiter, and more homogeneous, and would answer admirably for architectural purposes. As a general rule, however, it is rather coarse for all fine work, but furnishes a strong and durable stone, well adapted to bridge-building, cellar walls, and, indeed, to all plain and massive masonry.

Near Kent certain layers of the Conglomerate have been found, which are white enough to serve for the manufacture of glass. The coloring matter of the rock is usually iron, and it here contains much less than usual.

The best sections of the Conglomerate found in the county are in Nelson, where its entire thickness is shown—one hundred and seventy-five feet—and it forms bold escarpments, which constitute the western boundary of the valley of Grand River. These escarpments are known as the *Nelson Ledges.* They afford the most picturesque scenery to be found in the county, and are noted places of resort for the inhabitants of the surrounding region. In the extreme north-eastern corner of the county an island of the Conglomerate has been cut off by erosion from the main plateau. Though less bold in its outline, it has the same topographical character and relation as Little Mountain, in Lake county.

At the base of the Nelson Ledges the Cuyahoga shale is imperfectly exposed. This is the upper member of the Waverly formation, and will be found fully described in the reports on Cuyahoga, Summit, and Trumbull counties. A few years since quite an excitement was raised by the reported discovery of gold at the Nelson Ledges. As is usual in such cases, stock companies were formed, and many dreams of wealth were indulged in by those who obtained shares of the stock. It is hardly necessary to say that these dreams have passed like "the baseless fabric of a vision." The excitement was caused by the discovery of iron pyrites in certain beds of the Conglomerate—another of the innumerable examples of the mistake of "fool's gold" for true gold. A little knowledge of geology would have prevented this error, and would have taught the sufferers that gold could never be found in paying quantities in Portage county. That minute particles may sometimes be detected in the superficial gravels is very probable, since these gravels are largely made up of quartz pebbles, which are only rolled masses of the quartz veins contained in the crystalline rocks of the Canadian highlands, and which frequently carry a little gold. It is also probable that with sufficient care in searching for it, an infinitesimal quantity of gold might be detected in the Conglomerate, as the quartz pebbles it contains were doubtless derived from the same source with those to which I have already referred; but it may be confidently predicted that the precious metal will never be obtained from either of the sources mentioned in sufficient quantity to compensate the most idle and worthless member of the community for any time he may spend in its search.

COAL MEASURES.

Coal No. 1.—Nearly three-fourths of the surface of Portage county is underlain by coal-measure rocks, and they once covered its entire area. From the valleys of the Mahoning and Cuyahoga they have been removed by erosion, so that in the northern part of the county they are restricted to a small island west of the river, in Mantua, and a narrow arm which projects from Freedom northward, through Hiram, into Geauga.

In the northern part of Portage county the Drift deposits are so thick as to hide the outcrops of the coal rocks, and it is here very difficult to trace the line along which the edge of the lowest coal seam should be found. It is probable that coal, in greater or less thickness, underlies the principal part of Hiram, the western half of Shalersville and Ravenna, and the south-western corner of Windham. The northern and southern portion of Paris, and nearly all of Charlestown, lie above the horizon of the lower coal, as do most of Palmyra, Deerfield, Brimfield, and Suffield.

Along a belt running through the central part of the county, the land is high enough to carry the second and third seams of coal from the bottom. With this breadth of coal area it would at first sight seem that Portage county should produce as large an amount of coal as Trumbull, and much more than Summit, but up to the present time the coal production of the county has been exceedingly small. This arises from the fact that the margin of the lower coal (Coal No. 1) is so generally covered with Drift that it does not show itself at the surface in many localities, and also that this coal here, as in the Mahoning Valley, lies in detached basins of limited extent, and is entirely absent over large areas from the place where it belongs, or is so thin as to be of little value. We may expect, however, that important basins of the Briar Hill coal will be found within the limits that have been marked out. Were it not for the Drift it would be easy to follow the outcrops of the rocks, and knowing just where to explore by digging or boring, to determine the presence or absence of the coal. In the present circumstances, however, even where coal may be supposed to exist, it can only be detected by boring blindly through the Drift deposits. In many places these will doubtless be found so thick as to cut out the coal, though the surface may be considerably above the coal level. Even where the rocks which belong above the coal may be found in place, from the irregular distribution of this seam, the chances are more than equal that the result of boring will show it to be absent, or too thin to have any economic value. Since, however, the coal of this stratum is so excellent, it will be the part of wisdom for all those who own territory lying within the lines I have traced to make such explorations as may determine whether or not they are in possession of some portion of this great source of wealth. The level of Coal No. 1, in the northern half of Portage county, varies from five hundred to six hundred feet above the Lake. The dip being toward the south, the coal sinks rapidly in that direction, and rises correspondingly toward the north. At Ravenna the place of the coal is probably not far from the level of the intersection of the Cleveland and Pittsburgh and Atlantic and Great Western Railroads, or about five hundred feet above Lake Erie.

Coal No. 1 has been opened, and is now quite extensively mined, in Palmyra. It here exhibits the same general features, both as regards thickness and quality, as the coal of the neighboring counties of Mahoning and Trumbull. The coal mining of Palmyra is principally done by the Western Reserve Coal Company, to a member of which company, Mr. W. B. Wilson, of Palmyra, I am indebted for much valuable information concerning the operations of his own company, and in regard to other developments of coal made in this township. The coal mined by the Western Reserve Coal Company is reached by a shaft which is eighty-one feet deep to the coal, or ninety-five feet from the tip. It is reported that in sinking the shaft eighteen feet of earth was first passed through, and then sixty-three feet of rock, mainly shale, in which were two strata of "kidney" ore. The coal varies from two to four feet in thickness, being thickest in a "swamp" which runs north-west and south-east in a tortuous course. On each side of this crooked basin the coal rises and thins, and is worked to the thickness of two feet. The company is taking out about four thousand tons per annum, selling it at the mine at three dollars per ton. The coal is of excellent quality, being very free from sulphur, and containing little ash. It is a block coal, finely laminated with charcoal seams, and is not surpassed in quality by any coal in the State outside of the Mahoning Valley. According to our barometric measurements by a single line of observations, the center of Palmyra is one hundred and twenty feet above Ravenna Station, or six hundred and fifty feet above Lake Erie. The tip of the coal company's shaft is four hundred and thirty feet above Lake Erie, and the coal three hundred and thirty-five feet above the Lake. Owing to the variability of the barometer, these figures can not be relied upon as absolutely correct. The Western Reserve Coal Company has two hundred acres of coal land in the eastern part of Palmyra, on the center road. How large a part of those two hundred acres is underlain by coal of workable thickness has not yet been ascertained. Other companies have been making explorations in this neighborhood, and report about two hundred acres of good coal land in addition to that before mentioned.

In the north-western part of the township some three hundred acres of coal property are said to have been tested, and the coal is reported to be from three to four feet in thickness. Coal has also been found in the north-eastern and south-western parts of the township. We thus have good reason for believing that a somewhat extensive basin, or series of basins, of the Briar Hill coal exists in and about Palmyra, but years of exploration will be required before it will be known what the connection, limits, and value of this coal field are.

From the shaft in Palmyra the coal extends west and south to an unknown distance, and possibly reaches under much of the central and southern parts of the county. Since the place of Coal No. 1 is from two hundred to two hundred and fifty feet below the surface over a considerable part of the higher land, it is apparent that most of the boring yet done has formed no test of its presence or absence.

In the valley of the Mahoning, in Deerfield, an outcrop of coal may be seen which was supposed by Mr. Read, who examined it, to be the Briar Hill coal. It is, however, only about a foot in thickness, and it is probable that it is the next seam above. A boring of limited depth would decide the question. In Brimfield and Suffield there is a large amount of territory which deserves more careful exploration than it has yet received. Here the land rises to one hundred and fifty feet above the level of the coal, but the surface is generally occupied by Drift. Little is known of the nature of the underlying rocks, but from the relation which this district holds to the coal basins of Tallmadge and Springfield, in Summit, there is great probability that sooner or later good deposits of coal will be found here. It should be borne in mind, however, that from the circumstances which I have fully explained in the report on the geology of Summit, the lower coal is oftener absent than present in the place where it belongs, and it is, therefore, to be expected that a large part of the trials which may be made here will result in disappointment.

At Limaville, on the southern line of the county, Coal No. 1 has been struck in borings by Dr. J. A. Dales, at the depth of about one hundred and seventy feet, or less than three hundred and fifty feet above the Lake. According to the reports by Dr. Dales, the coal has here a thickness of over four feet. Analyses prove that it has the purity and physical charater of the Mahoning Valley coal. Should a considerable area in this vicinity be found to be underlain by Coal No. 1, it would be difficult to exaggerate the importance it would assume among the wealth-producing elements of the county, and it is sincerely to be hoped that the examinations begun here will be carried through the townships lying north, until this important question shall be definitely settled.

Coals Nos. 3 *and* 4.—By reference to the general section of the rocks of the county (page —) it will be seen that at a distance from the lower coal—generally from fifty to seventy-five feet—a thin seam occurs. This has no value in this part of the State, and requires here no further notice.

From one hundred and fifty to two hundred feet above Coal No. 1 two other seams come in, which are sometimes of workable thickness. These we have designated as Coals No. 3 and No. 4. They are separated by a distance of thirty to fifty feet, and are usually both overlain by limestone. Sometimes, however, one or both of the limestones are replaced by shale. These coal seams, here as elsewhere, have proved to be quite irregular in their thickness, although in a general way continuous from Portage through Summit, Stark, Wayne, Holmes, Coshocton, etc., to and beyond the National Road. Both these coals may be seen in the northeastern corner of Atwater, where the north and south road crosses a small stream, and not far from the locality where so much fire-clay is dug. Here the limestone of No. 3 shows in the bed of the brook at a level of twenty feet above the railroad at Atwater, or five hundred and eighty feet above Lake Erie. It is about four feet in thickness, and, as usual, has iron ore over it. The coal beneath is only a few inches thick. Some twenty feet above the limestone Coal No. 4 is seen in the road, here apparently four feet thick, but with scarcely any covering. No limestone is visible over it.

In Limestone Ridge, in Freedom, both these strata are shown. The upper one is thin, but is overlain by limestone, which is here burned for quicklime. Coal No. 3 is seen in the road at the south end of Limestone Ridge; as usual, it is underlain by a thick bed of fire-clay.

On the farm of Wilson Davidson, about half a mile distant from the last-named locality, this coal has been mined, though not largely, for a number of years. It is here about twenty-two inches thick. From the fact that this seam was represented as Coal No. 1 by the geologist who, when connected with the first Geological Survey of the State, made an examination of this region (Annual Report of 1838, p. 59), no thorough exploration has ever been made of the strata below it. Possibly such explorations would have been fruitless, as the lower seam is so frequently absent from its place; but as the true position of Coal No. 1 is at least one hundred and fifty feet below Mr. Davidson's coal, it is evident that a large area in the vicinity dererves examination by deep boring. Considerable money has been spent in boring in Freedom, but, so far as I can learn, none of the wells have been carried deep enough to determine the presence or absence of the lower coal. One well bored on Limestone Ridge is reported to have furnished the following section:

		FT.	IN.
1.	Earth	14	0
2.	Limestone	3	0
3.	Shale	54	0

		FT.	IN.
4.	Coal	1	10
5.	Fire-clay	?	
6.	Sandrock	30	0
7.	Shale	10	0

In this boring the upper limestone coal was absent, or so thin as not to attract notice. The lower limestone was absent, as seems to be the case generally in this vicinity. The place of the lower coal was not reached by from seventy-five to one hundred feet. Another hole was bored by Wm. Crannage, for Mr. Geo. Worthington, of Cleveland, without finding the coal sought for, but was almost certainly not carried to a sufficient depth.

A well sunk near the quarries on Limestone Ridge is said to have passed through—

		FT.
1.	Limestone	4
2.	Shale, with plants and thin seams of coal	20
3.	Sandrock to bottom.	

Here it is evident that the place of the twenty-two-inch seam was not reached.

Half a mile north-east of Drakesburgh a well showed the following strata:

		FT.
1.	Earth	14
2.	Shale	30
3.	Sandrock, to bottom	26

In this well the excavation was probably begun below the limestone coals, but it did not descend to the level of the lower coal.

At Hiram Center a yellow sandrock of the Coal Measures is quarried just back of the hotel. South of the Center, about one mile, shale crops out in the road below this sandrock. Near this point, but west and on higher ground, a well on Mr. Hopkins's land gave—

		FT.
1.	Earth	9
2.	Sandrock	15
3.	Shale, with one foot of coal	40
4.	"Flagstone," to bottom	3

Stratum No. 4 of this section was called by the drillers "bottom rock;" but in this vicinity no proof should be accepted of having passed the place of the lower coal, except reaching the Conglomerate.

In the south part of Hiram, coal has been taken from a natural outcrop twelve to eighteen inches thick, and used by the blacksmiths. This is probably Coal No. 1.

In going from Drakesburgh to Garrettsville the surface descends nearly two hundred feet, passing down from a broad ridge or divide, which is a marked feature in the topography, and which stretches connectedly north into the center of Geauga county. The top of this ridge, or table, is above the coal level from Freedom to Burton, and more or less coal has been found in it all the way, although it is usually thin.

At Garrettsville the Conglomerate is fully exposed, and rises thirty feet above the dépôt, or four hundred and eighty-five feet above the Lake. Two miles west of Garrettsville the base of the ridge referred to is reached, and in the ravine by the road-side the following section is exposed:

		FT.
1.	Coarse sandrock, with some small pebbles	30
2.	Irregular seam of coal	1
3.	Shale, with bands of sandstone	20
4.	Black shale, with iron	1
5.	Sandstone to base.	

The top of this section is one hundred and fifty feet above the dépôt at Garrettsville, and the coal exposed is probably about the horizon of the thin seam, No. 2, the place of Coal No. 1 being below.

In Mantua there are many natural outcrops of coal, viz., at the railroad cut, north-east of the Corners, a few inches (two to four) thick; a mile south of the Corners, on Mr. Blaine's land, sixteen inches; one and a half miles east of the Corners, six to eight inches thick. Three wells drilled near each other in this vicinity gave—

		FT.
1.	Earth	4
2.	Sandrock	36 to 46
3.	Black shale	20 to 40
4.	Gray shale	2 to 4
5.	Coal	4 to 12 inches.
6.	Sandrock (bottom not reached).	

A boring was made one and a half miles south of the Corners, to the depth of one hundred and thirty-six feet, penetrating earth, sandrock, and shale, of which the thickness is not known. Coal was found six to eight inches thick.

The center of Charlestown rises to the height of five hundred and seventy-five feet above the Lake, and an outcrop of coal is visible on the King place, in the road leading to Ravenna, and about fifty feet below the center. This is evidently the Briar Hill seam. The hill on the opposite side of the valley rises six hundred feet above the Lake, and nearly one hundred feet above the coal level, but the coal, if it exists there, is concealed. The valleys of the streams in this region are cut below the coal, and all the highlands should carry it; but, unfortunately, heavy beds of Drift conceal its outcrops, and make the work of exploration expensive and uncertain.

In the central part of Edinburgh the land is all at least one hundred and fifty feet above the coal level. This is proved, not only by barometric measurement, but by the explorations made east of the center by Mr. G. L. Chapman. He has bored many holes in search of coal, and has found it in several. In one place a shaft was sunk with the expectation of mining it. The coal, however, was found to be very irregular in thickness, and the enterprise was not successful. In making these explorations Mr. Chapman at first supposed that the coal he found was the Briar Hill seam, but it is quite certain that the place of Coal No. 1 is at least one hundred and fifty feet below the bottom of the shaft. Two beds of coal and two of limestone were passed through in some of the borings made by Mr. Chapman, all within fifty feet of the surface. The section exposed in the shaft referred to is as follows:

		FT.
1.	Surface deposits	12½
2.	Sandy shale	11½
3.	White sandrock	7½
4.	Shale, sandy above	17½
5.	Coal No. 3	3½
6.	Sandrock and shale	4
7.	Fire-clay	1½

The upper limestone is said to have been found in an adjacent field.

A boring made somewhat east of the shaft, and carried to a greater depth, affords a much better view of the geological sub-structure of this region. The record of this boring is as follows:

		FT.	IN.
1.	Surface deposits	20	0
2.	Shale	4	0
3.	Limestone	3	6
4.	Fire-clay	3	6
5.	Shale	3	6
6.	Shaly sandstone	8	0
7.	Shale	6	0
8.	Coal	0	4
9.	Shale	2	0
10.	Coal	2	6
11.	Shale	7	0
12.	Fire-clay	4	0
13.	Shale	7	6
14.	Sandrock	54	0
15.	Shale	2	0
16.	Bluish sandrock	0	6

It will be noticed that in this section a bed of limestone occurs near the surface, and that the lower part of the boring was in a thick bed of sandstone. This sandstone is the massive stratum which overlies the Briar Hill coal, sometimes coming down to it, and sometimes even cutting it out completely, but more generally resting upon a bed of shale of variable thickness. The place of Coal No. 1 is plainly below the bottom of this hole.

Since my first visit to Edinburgh, Mr. Chapman has continued his explorations, and others have been carried on by Mr. D. W. Goss, but, so far, I believe, without very satisfactory results. The many borings made show great irregularity in the deposition of the strata here, and it is evident that this has been a region through which rapid currents of water have swept, which have cut away the coal seams, and deposited sands and clays in a very unequal way. This will be evident upon an examination of the records of some of the drillings. A well bored one mile north-east of the Center gave—

		FT.
1.	Earth	20
2.	Shaly sandrock	6
3.	White sandrock	39
4.	Blue shale	3
5.	Fire-clay	3
6.	Shale, with coal streaks	4
7.	Fire-clay	1
8.	Shale	4
9.	Black, coaly shale	2
10.	Shale	3
11.	Fire-clay	2
12.	Shale	37
13.	Very hard sandrock	8
14.	Fire-clay	1
15.	Shale	42
16.	Fine sandrock	24
17.	Sandrock	3½
18.	Soft shale	3
19.	Fine, bluish sandrock	45
20.	Gray shale	50
21.	Shale and sandrock	38½
22.	Bluish-gray shale	21

It is evident that this boring has gone far into the Waverly, and it reveals the fact that the Conglomerate is here absent. This is somewhat surprising, as in the valley of the Mahoning, only a few miles distant, it is fully one hundred feet in thickness.

Another well, one-half mile east of the last, gave—

		FT.
1.	Earth	1
2.	Soft sandstone	13
3.	White sandstone	24
4.	Stratified iron ore	6
5.	Sandrock and shale	4
6.	Fire-clay	3
7.	Shale	3
8.	Fire-clay	2
9.	Dark shale	13

This is evidently not deep enough to afford a satisfactory test.

A third well, in the north part of the township, east of the Center road, gave—

		FT.	IN.
1.	Yellow clay	10	0
2.	Blue clay	40	0
3.	Sandrock	41	0
4.	Sandy shale	4	0
5.	"Flint," very hard	0	6
6.	Sandy shale	12	6
7.	Fine sandrock	26	0

This, also, was probably not deep enough.

An instructive section is furnished by a well three-quarters of a mile east of the Center; this is—

		FT.	IN.
1.	Earth	10	0
2.	Shelly rock	10	0
3.	Sandrock	40	0
4.	Clay	0	4
5.	"Sulphurous" sandrock	0	8
6.	Clay	0	3
7.	Shaly coal	0	9
8.	Coal, good	0	6
9.	Shale	0	7
10.	Coal, poor	0	11
11.	Black shale	1	6

This hole certainly did not reach near the horizon of the block coal, but is carried to about the place of the bottom of the shaft, and shows the mixed character of the deposits in even a greater degree than the shaft section.

Mr. Goss has sent me sections of three wells bored south of the Center to the depths respectively of one hundred and twenty-six and a half, eighty-eight, and seventy-eight feet. They show alternations of shale, sandstone, and fire-clay, with a little coal, but do not reach to the place of Coal No. 1.

These explorations indicate that the upper coals are not likely to be found in any valuable development in the township of Edinburgh. It is to be hoped, however, that under this broad and elevated table-land the lower coal will be somewhere found of workable thickness.

Passing south from Edinburgh the land continues high, and the surface nowhere comes nearer than one hundred and fifty feet to Coal No. 1; while in some instances it rises to such a height that the coal must be from two hundred to two hundred and fifty feet beneath.

In Atwater much boring has been done, and coal found, which has been opened both by shaft and adit. The explorations made here were undertaken on the supposition that the coal, of which outcrops had been known, was the Briar Hill seam. This was, however, an error, and there can be no question that it is Coal No. 4. The place of Coal No. 1 is far below the bottom of the Atwater shaft, and probably below the bottom of the deepest well bored in the vicinity. The coal mined at Atwater is of good thickness—from four to five feet—but it exhibits the usual characteristics of the limestone seams, being of irregular thickness and variable quality. It is a serviceable fuel for the generation of steam, and is a pleasant grate-coal, but from the quantity of sulphur it contains is not well adapted to the manufacture of iron. The following analyses of this coal, made at the School of Mines by Mr. W. P. Jenney, will indicate very fairly its composition. No. 1, upper bench; No. 2, lower bench:

	No. 1.	No. 2.
Water	3.27	3.03
Volatile combustible matter	26.06	26.42
Fixed carbon	64.50	62.50
Sulphur	1.52	2.20
Ash	4.65	5.72
Totals	100.00	99.97

At the shaft of the Atwater Coal Company the coal is from four to five feet in thickness, in two benches, separated by a bony parting. It is overlain by black shale, which contains many discoid shells (*Discina*). In the shale above is considerable granular iron ore, but not of very good quality. The shale is succeeded by sandstone, as in all this region. The coal is opened by an adit, half a mile east, on lower ground.

On John Hines's farm, one and a half miles south-east from Atwater Center, a shaft has been sunk to Coal No. 4, passing through—1, surface clay; 2, sandstone; 3, black and gray shale; 4, black shale; 5, coal. Coal is here four feet six inches in thickness, and, according to barometer, lies twenty-six feet below Atwater Station, or five hundred and thirty-four feet above Lake Erie.

About half a mile east the same coal is struck at a depth of eleven feet, on the farm of Michael Strong. It here lies ten feet higher than at Hines's, while the surface falls off rapidly towards the east. The thickness of the coal is the same as at Hines's.

In some of the borings made by Mr. Christy, near the Atwater shaft, the coal was found to be cut out by heavy beds of sandstone; no coal whatever having been reached in borings carried to a depth of two hundred feet. It is quite possible, therefore, that in this locality no workable coal exists below Coal No. 4, but it is not certain that the deepest boring has been carried to the level of the Briar Hill seam, as the surface of this portion of the township is at least two hundred feet above the level. From the proximity of the railroad, the Briar Hill coal would have special value if found under these highlands, and it seems very desirable that a sufficient number of borings should be made to determine its presence or absence. The cost of boring to the depth of two hundred feet need not exceed three hundred dollars for each hole, and experienced and reliable drillers can be found who will contract to do the work at this price. The result of boring at Limaville has already been reported, and this is such as to encourage further effort. At Limaville the upper coals are found in their proper positions, and Coal No. 1 at its regular level, far below.

It is certain, therefore, that the lower seam does exist in this region—at least in basins of limited area—and we may confidently predict that foresight and energy will bring to some fortunate person ample reward by its discovery in this part of Portage county.

FIRE-CLAY.

As I have stated on a preceding page, the Atwater coal crops out in the north-east corner of the township. The lower limestone coal is here very thin, but, as usual, is underlain by a seam of fire-clay, which is, perhaps, the most valuable in the series. This is apparently the same bed with that worked in Springfield, Summit county, and also that which furnishes most of the fire-clay made into pottery and fire-bricks along the Ohio, in Columbiana and Jefferson counties. It also forms the basis of an important manufacture in Portage county, as it supplies the material for the potteries at Lima and Atwater. It is chiefly derived from John Spire's farm, lot 10, Atwater. The bed is about twelve feet thick, divided into two layers by a parting of black slate. The upper seven feet is not used in the potteries on account of the contained iron. The clay generally immediately underlies the soil, and is worked in open pits, but it is in some places overlain by coal about thirty inches in thickness. A specimen obtained from the mine or pit (but whether from the upper or lower bench is not certain) was analyzed by Prof. Wormley, giving the following result:

Water	2.00
Silica	79.90
Alumina	14.60
Iron oxide	1.60
Lime	0.20
Magnesia	0.24
Alkalies	1.50
Total	100.04

ALTITUDES IN PORTAGE COUNTY ABOVE LAKE ERIE.

	FT.
Ravenna Station	530
Ravenna Town	560
Rootstown	550
Atwater Station	560
Atwater Center	600
Railroad Summit	603
Topographical Summit, north	685
Cuyahoga River Bridge	474
Garrettsville Dépôt	455
Mantua	536
Drakesburgh	635
Windham	372
Edinburgh	610
Campbellsport	410
Charlestown Center	575
Limestone Ridge	675
Freedom Station	575

CHAPTER LIX.

REPORT ON THE GEOLOGY OF STARK COUNTY.

BY J. S. NEWBERRY.

SURFACE GEOLOGY.

The surface of Stark county is without any striking features. It is generally rolling, and along the southern border may be called hilly, since the valleys of some of the draining streams are cut to a depth of three hundred feet. In most parts of the county the surface is pleasantly diversified by rounded hills, with very gentle slopes, and which are cultivated to their summits. The valleys that divide these hills are broad and shallow, and rarely show precipitous sides or exposures of rock.

The soil is generally light, often loam, sand, or gravel, and was originally covered with a forest composed principally of oak, but in the central portion of the county there were many glades and openings where the timber was light. This consisted largely of willow-oak and black-jack oak, which formed clumps and islands, separated by spaces overgrown with wild grasses, flowers, and scrub oak. From the nature of the soil, the farmers of the county have usually been cultivators of grain, and Stark has long been famous for its crops of wheat.

The altitude of the county is from three hundred and fifty to seven hundred and fifty feet above Lake Erie; its eastern portion reaching up on the great divide or water-shed between the Ohio and Lake Erie. Like most of the other counties that lie along the water-shed, the surface of Stark county is dotted over with lakes such as have been described as occurring in Portage county. Of these, Congress Lake, in Lake township, Myers Lake, Sippo Lake, etc., may be taken as examples. Here, too, as in the adjacent counties, we find many drained or filled lake basins, where peat and marl now hold the place formerly occupied by water.

The extent of this kind of surface is, however, not great, as Stark has little marsh land, and since it is so abundantly supplied with excellent coal, it is scarcely probable that the scattered patches of peat will ever become of importance as a source of fuel. As fertilizers, however, the muck and shell marl, to which I have referred, will be of great practical value, especially on light and open soils, such as that which covers most of the county. It may be important, therefore, for the farmers who have patches of swamp upon their land to test them by boring, to ascertain whether they are underlain by strata of peat or marl, which may be used to cheaply fertilize their fields. A post-auger, or an old three-inch carpenter's auger welded to an iron rod, will serve admirably for this kind of exploration.

In most parts of Stark county the surface deposits are such as have been transported to greater or less distances from their places of origin, and it is only on the hills of the southern townships that we find the soil derived from the decomposition of the underlying rocks. Numerous facts indicate that the county has formerly been traversed from north to south by a great line of drainage. This is now imperfectly represented by the Tuscarawas River, but it is evident that this, though a noble stream, is but a rivulet compared with the flood which once flowed, somewhat in the direction it follows, from the lake basin into the Ohio. The records of this ancient river are seen in the deeply excavated channels, now filled with gravel, in the Tuscarawas valley, and between Canton and Massillon. In the valley of the Tuscarawas an extensive series of borings has been made for coal, and these have revealed the fact that this stream is now running far above its former bed, and that it does not accurately ollow the line of its ancient valley. That old valley is in many places filled with gravel, and is now so thoroughly obliterated as to give to the common observer little indication of its existence. A few facts will show, however, that this interesting feature in the surface geology of Stark county has a real existence. The borings made for coal east of the present river, in Lawrence and Jackson townships, have in many instances been carried below the present streams without reaching solid rock, and heavy beds of gravel are found to occupy a broad and deep valley, which lies for the most part on the east side of the present water course. From Fulton to Millport, and thence to Massillon, many borings have been made, and in these, where the course of the auger was not arrested by bowlders, the Drift deposits have often been found to be more than one hundred feet in thickness. For example: two wells were bored by Mr. E. Roberts, north-east of Millport. In one the gravel was penetrated to a depth of eighty-four feet without reaching the rock; in the other it was found to be ninety-seven feet in thickness. On the farm of Gen. Beatty two wells were sunk for water, within one hundred yards of each other; one reached the rock at about fifty feet; the other, more westerly, is one hundred feet deep, all drift. At the charity school, as I learned from the Hon. A. C. Wales, a well was sunk to a depth of ninety feet, through beds of sand and gravel, without reaching the rock. An interesting fact connected with this well is that, near the bottom, logs of coniferous wood, apparently cedar, were taken out. About a mile east of this point, at the mine of J. B. Hawkins, coal is worked, and the underlying rocks are covered with a thin coating of earth only. It is evident, therefore, that here the east side of the old Tuscarawas valley is reached. As the rock is exposed on both sides of the river at Massillon and Millport, we see that the river is now running on the west side of its ancient trough, and though it here has a rocky bottom, east of its present course the rock would not be found, even at a considerably greater depth. Just how deep the ancient valley of the Tuscarawas is in this section of the county we have no means of ascertaining, but we learn from the salt wells bored at Canal Dover that the bottom of the rocky valley is there one hundred and seventy-five feet below the surface of the stream. Another, and perhaps the most important of these ancient lines of drainage, runs between Canton and Massillon. At the "Four-mile Switch," half way between these towns, rock comes near the surface, and coal has been worked at Bahney's mine and other places in this vicinity. Explorations have been made, which show that between "Four-mile Switch" and Massillon is a ridge of rock, which lies between two valleys, viz., that through which the Tuscarawas flows, and another completely filled, between Massillon and Canton.

Between Massillon and Navarre the road for the most part lies upon a terrace, the surface of which is about seventy-five feet above the river. This terrace is part of a plateau, which extends in some places more than a mile east of the river. It is composed of gravel and sand, of which the depth is not known. On the other side of the Tuscarawas the rock comes to the surface, quarries have been opened, and borings for coal have been made, which show that for some miles below Massillon comparatively little drift covers the rock. It is evident, therefore, that the ancient river channel passed under the terrace over which the road runs from Massillon to Navarre. Below Navarre the river sways over to the east side of its ancient valley, striking its rocky border on the "Wetmore tract." Here the gravel-beds, which fill the old valley, are on the west side of the river.

Taken by themselves, these deeply excavated and filled-up valleys which traverse Stark county would be somewhat incomprehensible, but when considered in connection with other facts of similar character, they help to form a record, which, though still somewhat obscured, may, I think, be at least partially read. In the chapter on Surface Geology, Vol. II., this subject is more fully treated, and I will only say here in passing, that these deeply-cut valleys constitute a marked feature in the topography, not only of Ohio, but of several of the Middle and Eastern States. They were undoubtedly formed when the continent stood at a higher level than now ; as, in some instances, they reach below the present surface of the ocean. They were certainly excavated, and by streams which, for thousands of years, flowed through them with rapid currents on their way from the highlands of the ancient continent to the sea level. A subsequent depression of the land filled these valleys with water, arrested the flow of the stream, and caused the deposition in their old channels of the material transported by their currents. In this way they were more or less perfectly filled, and sometimes obliterated. At a still later period the continent was elevated to its present level ; the lines of drainage were again established, and in some instances the accumulation of drifted material in the old valleys was partially cut away, leaving here and there terraces to mark the ancient level of the flood plain. Of these terraces, the one to which I have referred, south of Massillon, is a good example. In some cases, however, the old valleys were completely filled, and the draining streams following the line of lowest levels were turned into some new trough, so that now the old, deserted river-bed exists as a deeply excavated trough, filled to the brim with sand and gravel. Such channels are not often discovered, except when borings are made for oil or coal. Through these means we have now come to know something of a great number of them. As I have mentioned in the report of the geology of Summit county, we have evidence that at one time the waters of Lake Erie stood several hundred feet higher than now. This is proved by the lake ridges which mark the old shore lines at different periods in the descent of the water-level, and also by a series of accurately stratified clays which once filled the valley of the Cuyahoga nearly to the summit level. When the water stood highest in the Lake it is evident that the line of drainage by the Niagara was not open, and that the surplus water flowed into the Ohio by several outlets or waste-weirs. Of these there seems to have been one which connected the valleys of the Cuyahoga and Tuscarawas. Through this waste-weir a flood poured across Stark county, and brought down the materials which now fill the old valleys, as well as those which compose the gravel beds that occupy much of the central part of the county. An examination of these gravel beds will show that they are composed partly of well-rounded fragments of the adjacent rocks—usually the sandstones and limstones of the Coal Measures—partly of pebbles and bowlders of crystalline rock which have come from the Canadian highlands, and rolled fossils and fossiliferous limestone from the Trenton and Hudson groups in Canada. These foreign elements in the Drift, as I have explained elsewhere, were doubtless brought by glaciers or icebergs, and were deposited on the summit or slopes of the water-shed. They were subsequently transported by the current of the ancient Tuscarawas to the localities where they are now found, and where they are mingled with rolled masses of the neighboring rocks.

GEOLOGICAL STRUCTURE.

The succession of the rocks which come to the surface in Stark county will be most readily learned by reference to the general section which I give below:

SECTION OF THE ROCKS OF STARK COUNTY.

		FT.
1.	Soil and drift deposits	10 to 100
2.	Shale and sandstone of Barren Coal Measures only found in hill-tops of Osnaburg, Paris, Nimishillen, and Washington	30 to 50
3.	Buff ferruginous limestone, Osnaburg and Paris	0 to 6
4.	Blackband iron ore, Osnaburg and Paris	0 to 10
5.	Coal No. 7, same localities as No. 4	1 to 3
6.	Fire-clay	1 to 3
7.	Shale and sandstone, sometimes containing a thin coal-seam near the middle, hills of Washington, Nimishillen, Paris, Osnaburg, and Sandy; hill-tops of Pike, Bethlehem, and Sugar Creek	75 to 110
8.	Coal No. 6, same localities as No. 7	2 to 6
9.	Fire-clay	2 to 5
10.	Gray and black shales, with iron ore near base	40 to 60
11.	Coal No. 5, "thirty-inch seam," southern and eastern portions of the county	2 to 3
12.	Fire-clay	2 to 5
13.	Shale and sandstone, sometimes containing thin coal	40 to 60
14.	Putnam Hill limestone	0 to 4
15.	Coal No. 4, "upper limestone seam"	1 to 6
16.	Fire-clay	1 to 5
17.	Shale and sandstone, sometimes with thin coal and limestone	20 to 50
18.	Zoar limestone	0 to 4
19.	Coal No. 3, "lower limestone coal"	0 to 3
20.	Fire-clay	1 to 8
21.	Shale and sandstone, sometimes with thin coal at base	50 to 60
22.	Massillon sandstone, sometimes with thin coal at base	30 to 100
23.	Gray or black shale	5 to 50
24.	Coal No. 1, "Massillon coal"	0 to 6
25.	Fire-clay	1 to 5
26.	Shaly sandstone	30 to 50
27.	Conglomerate	20 to 50

The strata enumerated in the foregoing section all belong to the Carboniferous system, and, with the exception of a limited area in the northwestern corner, where the Conglomerate appears, the entire area of the county is occupied by the Coal Measures. The Conglomerate has been fully described in other portions of our report, and I will not here make it the subject of remark further than to say that the pebble rock of Stark county, or sandstone containing quartz pebbles, is unmistakable in character and invariable in position, and may be recognized at sight wherever it occurs. It, therefore, serves as a useful guide in searching for coal, inasmuch as no coal is found in or below it.

The only outcrops of the Conglomerate occur in the extreme northwestern portion of the county, in the corner of Lawrence township, so that it might as well be omitted from enumeration among the rocks of the county, except that it underlies, at no great depth, all portions of the surface, and deserves notice as the easily recognizable base of the productive Coal Measures.

It should also be mentioned in this connection that some of the higher sandstones of the Coal Measures sometimes contain pebbles, especially that over Coal No. 6; but the pebbles in these beds are generally quite small—rarely exceeding a bean in size—so that there is little danger that they will be confounded with the true Conglomerate.

In the adjoining counties of Summit and Wayne the Conglomerate is well exposed, and may be examined at innumerable localities. In Summit county it is thick and generally continuous, but in Wayne county it is thinner and much more irregular, so that it is probable that there are places in Stark county where it does not underlie the surface rocks, and hence it can not be positively asserted that it will *always* be found in borings to give notice that the place of the lower coal has been passed. It should be remembered, too, that the Conglomerate is not every where a pebble rock, but is always largely, sometimes altogether, a sandstone.

The Coal Measures of Stark county are composed, as usual, of sandstone, limestone, shale, fire-clay, coal, etc., and include all the lower group of coal seams seven in number. Of these the lowest, or, as we have named it, Coal No. 1—the Massillon or Briar Hill seam—is one of the most valuable in the entire series. This is well developed in Stark county, and forms one of the most important sources of business and wealth. The coal which is obtained from this seam is generally called the Massillon coal, and is so well known that little need be said of its character. Though varying somewhat in different localities, as a general rule it is bright and handsome in appearance, contains little sulphur and ash, is open-burning, and possesses high heating power. By long and varied trial, it has proved to be one of the most serviceable coals found in the State. In Stark county it is somewhat more bituminous than the coal of the same seam in the Mahoning Valley, but it is more like it in composition than its appearance would indicate. The Massillon coal is well adapted to a great variety of uses. It is successfully employed in the smelting of iron in blast furnaces, and is there used in the raw state. It is also a good rolling-mill coal, serves an excellent purpose for the generation of steam, would do well for the manufacture of gas, and is the most highly esteemed household fuel in all the districts where it is used. This combination of excellences makes it a special favorite in the markets of the lake ports, and maintains for it an active demand.

The Massillon coal seam, being generally cut by the valley of the Tuscarawas, forms a great number of outcrops in the western part of the county, and in that region more than a hundred mines are opened into it. As the dip of all the rocks in the county is south-east, it passes out of sight east of the Tuscarawas Valley, and along the eastern margin of the county it is at least two hundred feet below the surface. It will thus be seen that it ought to underlie nearly all the county, but it unfortunately happens that here, as in Summit and Mahoning, this coal lies in limited basins, and is absent from a larger part of the territory where it belongs. It is, therefore, of much less practical value than it was supposed to be before the irregularity of its distribution was ascertained. Nevertheless, the most important question connected with the geology of Stark county is that of the presence or absence of the Massillon coal in the townships east of those in which it is mined. Unfortunately, but little light has been thrown upon this subject by any explorations yet made, and from the peculiar character of this coal seam it is quite impossible to predict with any certainty what will be the result of a systematic search for it where it lies deeply buried.

Between the valley of the Tuscarawas and the western margin of the coal area in Wayne county numerous outcrops of the Massillon coal have been found, a number of important basins have been opened, and now many thousand tons are annually mined in this district. It is true, however, that even here, where this coal appears to be most uniform in its distribution, more than half of the territory which should contain it is barren, and a very large number of borings made for it have been unsuccessful.

East of the Tuscarawas Valley the geological structure is obscured, as I have mentioned, by heavy masses of drift, and Coal No. 1 has not been mined or found to any extent on that side of the river. Near Millport, however, and still further north, and east around Mud Brook church, important basins of coal have been discovered, and it is probable that when the real difficulties of the search on this side of the river are overcome—*i. e.*, when certain clues that can be followed up shall have been found—it will be learned that valuable deposits of coal stretch eastward far beyond any present knowledge.

Considerable boring has been done in the central and eastern part of the county, and such as might be supposed would go far to decide the question of the reach eastward of the Massillon coal, but I am compelled to say that these explorations have not proved the existence of any considerable body of this coal east of the river. It should be said, however, that of the borings made, only such as were made for the express purpose of finding coal are worthy of any confidence. The oil wells, by which the whole county has been pierced, were bored for oil, and nothing else. As a general rule, every other product was neglected, and when coal seams were passed through, the evidence of the fact afforded by the sand-pump was unheeded. The borings which to me appear to afford any really important information on the subject are mainly as follows:

1st. Those made by Mr. H. Foltz, on the Sprankel farm, north of Millport. Here the coal is found of good thickness, in a basin of perhaps several hundred acres.

2d. Borings made near Mud Brook church by Mr. Conrad, showing the presence of a coal basin of which the limits are not yet determined, but it certainly holds coal of workable thickness.

3d. Borings made by H. S. Belden, at Four-mile Switch, half-way between Canton and Massillon. These show that the lower coal seam is, in this vicinity, only a few inches thick, and of no value. Two borings were made here, about half a mile apart, which gave nearly the same result. The two limestone coals were found in place, the upper one of good thickness and quality. The underlying strata are quite regular, but the coal is too thin to be worked.

4th. Borings made west of Greentown, on the Foltz farm, two hundred and forty-two feet deep. Only five inches of coal were found here at the place of the lower seam.

5th. Borings made on the Wetmore farm, below Navarre. These failed to furnish any traces of the lower coal.

In all these last-mentioned localities the limestone seams (Coals No. 3 and No. 4) are found in position, and from the failure to find the lower coal of workable thickness beneath these, the impression has come to prevail that wherever the limestone seams are found the Massillon Coal is absent. I need scarcely say that this is a mere superstition, of which time will be sure to reveal the fallacy. There is certainly no such connection between the different coal beds; and numerous cases might be cited in Mahoning county where the Briar Hill coal is found in good thickness, though covered with one hundred and fifty to two hundred feet of rock, containing the limestones and limestone coals.

6th. Numerous borings made at Canton by Raynolds Bros., H. S. Belden, and others. The Massillon coal was reached in several holes, but was generally quite thin, varying from one to three feet. The most en-encouraging borings made near Canton were by Mr. Geo. Schwalm, about one mile east of the town. He reports that at the depth of one hundred and sixty feet he found six feet of bright, handsome coal, on the surface of which a blue stain was visible, similar to that on the coal mined by the Fulton Mining Company. Mr. Schwalm's boring was begun about the level of the lower limestone, which is visible at this point, so that there can be no reasonable doubt that the coal struck was the Massillon seam. How extensive this coal basin is we have at present no means of knowing. It appears to me highly probable that a coal area, perhaps of great irregularity, but yet of considerable extent, will be found connected with the basin penetrated by Mr. Schwalm. As the borings in the vicinity of Canton are likely to be resumed, it is important that some of the facts already learned should be put on record. Raynolds and Aultman bored three holes south and west of Canton, about one quarter of a mile apart. In the first, eighteen inches of coal (Seam No. 1) were found at the depth of one hundred and sixty feet. In the next and more westerly hole, three feet of coal were passed through at one hundred and sixty feet, and in the third, still more westerly, twelve inches of coal were found at one hundred and sixty feet.

In a hole bored by Raynolds Bros., one quarter of a mile north-west from the last, the following section was obtained:

		FT.	IN.
1.	Earth	4	0
2.	Shale	15	0
3.	Hard dark sandstone	0	1
4.	Cavity	0	8
5.	Hard limestone	1	2
6.	Coal	0	5
7.	Black and gray shale	2	0
8.	Gray sandstone	14	0
9.	Shale	4	5
10.	Hard blue rock	2	1
11.	Shale	11	4
12.	Light sandstone	3	2
13.	Shale	8	0
14.	Sandstone	3	6
15.	Sandy shale	5	0
16.	Sandrock, in layers varying in color and hardness	35	9

		FT.	IN.
17.	Shale, sandy below	11	6
18.	Sandrock	37	1
19.	Shale, with thin coal and fire-clay, place of Coal No. 1	3	6
20.	Barren shale and sandstone	50	0

The section of George Schwalm's boring, one mile east from Canton, as furnished by him, is as follows :

		FT.	IN.
1.	Sandstone	25	0
2.	Shale	50	0
3.	Sandstone	40	0
4.	Sandstone and shale	25	0
5.	Hard layer	1	6
6.	Blue shale	3	0
7.	Iron ore	0	6
8.	Light shale	3	0
9.	Gray shale	6	0
10.	Sandy shale	6	0
11.	Coal	6	0
12.	Fire-clay and sandstone	50	0

This boring began just below the lower limestone coal, which crops out near the well-head.

A well bored by H. S. Belden, three-quarters of a mile south of the third boring of Raynolds and Aultman, gave the following section :

		FT.	IN.
1.	Coal and sand	29	0
2.	Yellow shale	4	0
3.	Black shale	12	0
4.	Gray shale	7	0
5.	Brown sandstone	4	3
6.	Dark shale	2	9
7.	Gray sandstone	5	0
8.	Shale	4	0
9.	Coal	0	6
10.	Gray shale	2	6
11.	Gray sandrock	4	0
12.	Gray shale	2	0
13.	Fire-clay	1	0
14.	Gray shale	3	0
15.	White sandrock	5	0
16.	Dark shale	3	0
17.	Gray shale	3	6
18.	Coal	2	6
19.	Black shale	0	6
20.	Sandstone, gray, white, and red	69	8
21.	Black shale	0	10
22.	Gray shale, fire-clay, and trace of coal	11	0
23.	Gray, blue, and black shale	37	6

This boring began at the horizon of the lower limestone seam, Coal No. 3. Coal No. 2 is probably represented by No. 18, here of unusual thickness. No. 20 probably represents the Massillon sandstone; and the place of Coal No. 1 is at No. 22. The shales at the bottom of the well probably belong to the Waverly series, the Conglomerate being here wanting.

On the eastern line of the county few borings have been made which can be depended upon for giving any accurate information. At Limaville, in the north-eastern corner of the county, the Briar Hill coal has been struck by Dr. L. J. Dales in several holes. These borings, and that made by Mr. Schwalm, at Canton, show that the belief, so frequently expressed, that no valuable deposits of the Massillon coal exist east of the Tuscarawas River, is without a solid foundation, and I feel justified in predicting that hereafter some most important and valuable coal basins will be reached in the eastern portion of the county, and where their presence is not now suspected. The borings made at Limaville by Dr. Dales show the lower coal of workable thickness. It exists over a considerable area in that vicinity, as it was found in a number of holes running with great regularity. The register of one of these has been furnished me by Dr. Dales. The well was located near Limaville Station, the well-head ten feet above, or five hundred and seventy feet above Lake Erie. The coal was struck one hundred and sixty-five feet from the surface, or four hundred and five feet above the Lake. This shows a dip of about one hundred feet from the nearest outcrop of the coal in Tallmadge, eighteen miles north of west, and about the same dip from the vicinity of Ravenna, fifteen miles due north; but the coal lies higher here than at Massillon, south-west, or Youngstown, north-east; a fact due, doubtless, to one of the folds which traverse our coal field, and which has been frequently referred to in the earlier volumes of this report.

The section of one of Dr. Dales's wells is as follows:

		FT.	IN.
1.	Surface deposits	45	0
2.	Sandstone	40	0
3.	Fire-clay	2	0
4.	Black shale	3	0
5.	Blue and gray shale	28½	0
6.	Black shale	1	0
7.	Gray shale	21	0
8.	Hard black shale	1½	0
9.	Dark shale	7	4
10.	Gray shale	7	6
11.	Coal	4	0

An old coal mine, south-west of Limaville, is opened on Coal No. 4, here four feet ten inches thick, in two benches, with a slate parting;

and the same coal is opened on the land of J. McCollum, west of the residence of Dr. Dales. In both cases the coal exhibits the characteristics of the Atwater seam, and there can be no reasonable doubt that it is No. 4. Owing to the irregularity of the action of the barometer at the time when the observations were made, I can not state accurately what the level of this seam is, compared with that of the coal below, but the interval would seem to be less than usual.

The analysis of the coal taken from Dr. Dales's borings proves conclusively, however, that the coal which he struck is the Briar Hill seam. This analysis, made by Prof. Wormley, is as follows:

Water	3.20
Ash	4.30
Volatile combustible matter	33.40
Fixed carbon	59.20
Total	100.10
Sulphur	0.82

The Massillon coal district is, practically, one of the most important in the State. The number of miners employed here is about fifteen hundred. A capital of over $2,000,000 is used in the production of coal, and the annual yield of the mines may be estimated at 1,000,000 tons. Most of this coal goes to Cleveland by way of the Lake Shore and Tuscarawas Valley and the Cleveland, Mt. Vernon and Delaware Railroads, and by the Ohio Canal. A large amount is also consumed in and about Massillon, where it is used for a considerable variety of manufactures. The most important use to which the coal is here put is for iron-smelting, since it is the fuel exclusively used in the two furnaces at Massillon and one at Dover. These furnaces have been in operation for many years, and the iron which they produce has a well-established and excellent reputation. It is for the most part made of blackband ore, and closely resembles the Scotch pig. This is not surprising, since the materials and methods employed are almost exactly the same as those used in Scotland. These have proved remunerative during years of experience, yet the methods of the Scotch iron-masters can be easily shown to be susceptible of improvement. By adding close tops to the furnaces, increasing their dimensions and the temperature of the blast, there is little doubt that most important economy in the use of the fuel may be effected. With the present method of manufacture, the Massillon furnaces consume three and a half to four tons of coal for every ton of iron made. This is certainly a wasteful use of fuel, which, from its great excellence and limited quantity, ought to be husbanded with the greatest care. The Massillon ooal constitutes a great source of wealth to the county, and is the mainspring of many industries; but the fact should be recognized that this is a capital which is daily being exhausted, and, when exhausted, can never be reproduced. All the coal basins now known about Massillon will be worked out within a generation, and although new discoveries will certainly be made, and much territory will become productive where the coal is not now supposed to exist, still the value of the coal is so great, and the consumption of it so rapidly increasing, that it is to be feared not many years will elapse before the supply from this region will be exhausted.

Among the most encouraging results of recent explorations about Massillon is the discovery of an important basin of coal two miles south of the town, on the west side of the river. How large an area in this vicinity is underlain by coal of workable thickness is not yet known, but every thing indicates that this is one of the most important basins known in the region.

I give below the register of two of the several holes bored for Beatty, Uhlendorff & Burk:

WELL NO. 1 (BEGUN 111 FEET ABOVE THE RIVER).

		FT.	IN.
1.	Earth	49	0
2.	Yellow sandrock	4	0
3.	Black shale	3	6
4.	Coal	0	4
5.	Yellow sandrock	1	7
6.	Coal smut	1	1
7.	Sandrock	0	4
8.	Coal smut	1	0
9.	Sandrock	0	7
10.	Black shale	0	6
11.	Yellow sandstone	4	0
12.	Blue rock	4	0
13.	Blue shale	2	6
14.	Coal	1	0
15.	Fire-clay	2	6
16.	Black shale	7	6
17.	Coal	3	4
18.	Fire-clay	7	8
19.	Black shale	19	2
20.	White sandrock	4	6
21.	Black shale	10	2
22.	Coal	5	8

WELL NO. 4.

		FT.	IN.
1.	Earth	4	0
2.	Yellow sandrock	3	0
3.	Dark shale	2	6
4.	White sandstone	7	0
5.	Dark shale	0	6
6.	Gray sandrock	11	0
7.	Dark shale	11	8
8.	Coal	0	10
9.	White rock	4	0
10.	Black shale	29	0
11.	Gray sandstone	4	6
12.	Brown sandstone	7	5
13.	Coal	4	4

These borings are interesting from the number of alternations of rock which they exhibit, the absence of the Massillon sandstone—although it is seen in place a little above on the west side of the river—and the unusual development of one of the thin coals over the lower seam. Subsequent explorations have shown, however, that this occupies but a limited area.

At Fairview recent explorations prove that more coal exists than has been heretofore supposed, and the probabilities are that good coal territory will be found stretching from this point south-east to the Tuscarawas Valley.

No search for the lower coal has been made, so far as I know, in the south-western portion of the county. The valley of Sugar Creek seems to offer a good field for such examinations, as it is cut down to within a hundred feet of the coal level over many square miles. The necessary examinations could be accomplished here at comparatively little cost.

I subjoin a list of the principal mines in the Massillon coal district. A detailed description of them would occupy too great a space in this report. I also add analyses of the coal of different mines.

COAL MINES AND MINING COMPANIES OF MASSILLON DISTRICT.

Rhodes & Co. (old Willow Bank),	daily	production	450	tons.
Rhodes Coal Co.,	"	"	350	"
C. H. Clark & Co.,	"	"	150	"
Williamson Coal Co.,	"	"	150	"
The Ridgeway (J. P. Burton),	"	"	75	"
Massillon Coal Mining Co.,	"	"	350	"
Youngstown Coal Co.,	"	"	350	"
Crawford Coal Co.,	"	"	450	"
Willow Bank (new), Henry Holtz,	"	"	300	"
Buckeye,	"	"	100	"
Fulton Coal Mining Co.,	"	"	150	"

There are many other mines—the "Grove," the "Brookfield," the "Mountain," the "Stoffer," the "McCue," etc.—of which I have no detailed report.

ANALYSES OF MASSILLON COAL.

Specific gravity	1.253	1.269	1.247	1.337	1.250	1.328
Water	7.50	5.60	6.95	3.70	4.10	2.40
Ash	1.00	3.90	3.18	1.60	1.60	13.50
Volatile combustible	31.00	30.30	32.38	30.50	32.90	35.20
Fixed carbon	61.00	60.20	57.49	64.20	61.40	48.90
Total	100.00	100.00	100.00	100.00	100.00	100.00
Sulphur	0.49	0.19	0.88	0.68	1.07	0.975
Gas, cubic feet, per pound	3.42	3.50	......	3.64	3.15	......

No. 1. Lawrence Coal Company, lower bench.
" 2. " " " upper bench.
" 3. Blue Chippewa.
" 4. Fulton Mining Company.
" 5. Burton's coal, lower bench.
" 6. " " upper bench (thin and slaty).

Some doubt has been expressed among the residents of Massillon whether the coal that crops out at Bridgeport is identical with that worked elsewhere in this vicinity. It is thinner, and lies somewhat higher than that in most of the neighboring mines. Still its physical character and composition, as well as its relation to the associated rocks, seem to prove that it is really Coal No. 1. A similar phase of the Massillon coal is seen in the mine of the German Coal Company, just north of the stone quarry of Warthorst & Co., at Massillon Here, also, the coal is thin, very much laminated, and even somewhat slaty. This peculiarity of structure I have been inclined to attribute to the fact that the coal seam in these two mines is overlain by a great mass of sandstone, which, when all the materials were in a soft and plastic condition, must have pressed down upon the coal in such a way as to reduce its thickness and give it its laminated structure. Borings made in the vicinity of Bridgeport and Massillon have failed to find any lower seam, and it is scarcely possible that there should be another below that mined. The section at Bridgeport is *precisely what it should be if the Bridgeport coal were Coal No.* 1. The elements which compose it are as follows:

		FT.
1.	Sandrock	65
2.	Coal	1
3.	Fire-clay	2
4.	Gray shale	46
5.	Coal No. 1	2½
6.	Fire-clay	3
7.	Sandy shale	5

To bottom of canal.

The diminished thickness of the coal in the Bridgeport and German Company's mines may be due to another cause than that I have suggested, viz., a swell in the bottom of the marsh, where the coal accumulated as peat, and on which, being relatively high, the peat was thin. It is well known that the "swamps," or lowest portions of the coal mines, have the thickest coal in them, and this is simply because the peat was deepest there. On the ridges or swells of the bottom the coal is thin and high, because the top only of the peat bed reached over them. The barren ridges which so often separate the coal "swamps" were islands in, or the shores of, the coal marshes. These rose above the water-level, and on their slopes the peat diminished in thickness upward till it came to an edge. When covered with clay and sand, and compressed to solid coal, that was thickest where the peat was thickest in the bottoms of the basins, and thinned out to nothing on the slopes which bounded these basins.

The Massillon coal is usually overlain by a few feet of shale, and above this is found a massive sandstone, which I have called the Massillon sandstone. This is a marked feature in the geology of many of the counties which lie in the northern half of the Ohio coal field. It is well shown at the quarries of John Paul, at Fulton; at the Bridgeport quarry (John Vogt's); and that of Warthorst & Co., at Massillon, where it attains a thickness of from sixty-five to seventy-five feet. The stone of this stratum varies considerably in texture in different localities and different layers, but much of it affords very excellent building material, as well as good grindstones. In these a large and active industry has been created about Massillon, Warthorst & Co. giving employment to one hundred men, and shipping three hundred to four hundred car loads of block stones and fifteen hundred to two thousand tons of grindstones per annum. The product of their quarry is mainly sold in Pittsburgh, Philadelphia, and Baltimore. The stones for dry grinding—plows, springs, etc.—are especially esteemed. In Paul's quarries, near Fulton, a light variety of this stone is ground up, and the sand is shipped to Pittsburgh for the manufacture of glass.

In Mahoning, Portage, and Summit counties this rock affords a convenient guide in the explorations for coal, as it lies above the lower and under the next two workable seams. It has also in many instances been instrumental in the destruction of much valuable coal territory, inasmuch as the currents of water by which it was transported carried away the underlying coal, and now sandstone occupies its place. In the deep channels of these old currents this rock sometimes attains a thickness of nearly one hundred feet.

In many parts of Stark county borings have indicated the existence of a thin seam of coal above the massive Massillon sandstone, and it is sometimes referred to by the drillers as the "Fifteen-inch seam," but is oftener from six to twelve inches. Though persistent over a large area, it has rarely any economic value, and deserves notice in the report on the geology of Stark county simply as a tolerably constant feature in the section, and one that is liable to be mistaken for the lower coal. The distance which separates it from the Massillon seam is quite inconstant, and varies from sixty to one hundred feet. In another county this seam becomes of workable thickness, and it has therefore been named in our enumeration of the coal seams as Coal No. 2.

Another thin coal seam is also sometimes found immediately beneath the Massillon sandstone, but this is very frequently cut away by the forces which deposited this rock. It may be seen, however, at several of the quarries in the vicinity of Massillon. At Warthorst & Co.'s quarry the lower surface of the sandstone is very irregular, owing to the erosion of the underlying shale. At the north end of the quarry the junction of the sandstone and shale is well shown, and for a limited distance a thin coal seam is interposed between them. On either side of this exposure, however, the sandstone cuts out the coal and fills deep excavations in the shale. In the mine of the German Coal Company, north of the quarries of Warthorst & Co., the sandstone has been found cutting down to and through the coal and forming a "horseback," which has proved a serious impediment to the miners. As explained elsewhere, such "horsebacks" are produced by currents of water which have cut away the soft shale and coal, and have deposited sand—now sandstone—in their places. In the cliff above the Bridgeport mine the thin coal referred to above is exposed, lying between the shale and the Massillon sandstone, and it is generally met with, from one to two feet in thickness, in the borings made west of the river.

Coals Nos. 3 and 4.

At a distance of from one hundred and fifty to two hundred feet above Coal No. 1 occurs the lowest of the two limestone seams which traverse this, as they do many other of our coal-bearing counties. In Stark county Coal No. 3 is sometimes absent, sometimes has a thickness of a few inches, and rarely becomes of any economic importance. From twenty five to fifty feet above it occurs the second limestone coal. This is well developed in Stark county, and in some cases has considerable value.

In the subterranean rocky ridge which lies between the valley of the Tuscarawas and the old channel west of Canton, both the limestones referred to, and sometimes both the limestone coals, may be seen, the upper one only being of workable thickness. This is worked at Bahney's mine, and thence through on the east side of the Tuscarawas Valley to the south line of the county, at the mines of Messrs. Heer, Gribel, Shafer, Shetler, and others, the coal varying in thickness from two to five feet.

West of the Tuscarawas, in Sugar Creek township, all the highlands carry the limestone coals, and in some places the higher seams, Nos. 5 and 6. At Jacob Shetler's mine, two and a half miles west of Rochester, we have the following section:

		FT.
1.	Slope (covered)	25
2.	Coarse sandrock	30
3.	Dark gray shale	10
4.	Coal No. 6	2
5.	Fire-clay	3
6.	Shale	56
7.	Coal No. 5	3
8.	Fire-clay	4
9.	Shale	25
10.	Limestone and iron ore	3
11.	Coal No. 4	2½
12.	Fire-clay	3
13.	Shale and sandstone	50
14.	Coal No. 3 (outcrop).	

At Jacob Ricksecker's, half a mile south of Shetler's, Coal No. 5 is worked. It is three feet thick, rather soft, but looks well. The upper limestone and its coal are seen in the ravine near by. At Fisher's bank, near Sugar Creek Station, Coal No. 3 has been quite extensively mined. It is about three feet in thickness, very black and bright, rather open-burning in character, and contains but little sulphur; on the whole, a very excellent coal. Fifty feet above is the gray limestone, and on the charity-school lot adjoining, Coal No. 4 lies under it, about five feet in thickness, showing very well. On the farm of the Widow Wines, Coal No. 3 crops out at the house, No. 4 is visible in the ravine above, and No. 6 occurs about one hundred feet higher up the hill

The valley of Sugar Creek, near Sugar Creek Station, seems to promise well for the lower coal (No. 1). Its place would be reached by borings of from seventy-five to one hundred feet in the valley. No trial has been made to determine whether it is below, but the test would be so easy, and the reward of success so great, that the inducements to make the explorations seem ample.

In the northern part of the county coal seams Nos. 3 and 4 are both exposed. Between Greensburg and Greentown they are seen in the same hill, each overlain by limestone, and, as usual, each limestone associated with more or less iron ore. On the east side of the valley Coal No. 4 has been worked for many years in connection with the overlying limestone; the limestone burned for lime, the coal sold to the inhabitants of the village and surrounding country. The coal is here four to five feet in thickness, in two benches, is quite bright and handsome, and makes a good household and steam fuel. A specimen analyzed by Prof. Wormley had the following composition:

Water	3.25
Volatile combustible	38.75
Fixed carbon	55.05
Ash	2.95
Total	100.00
Sulphur	1.73
Coke	Compact.
Color of ash	White.

Passing from Greentown to Canton, Coal No. 4 is seen at Berlin and again at Ruthroff's mill. At Berlin the seam appears to be uniform in character, from three to four feet in thickness, and of moderate excellence. At Ruthroff's mill it is divided into three benches, separated by fire-clay. They are said, however, to run together, and the coal to become much thinner back in the hill.

Near Canton, and along down the valley of the Nimishillen, both the limestone seams are well shown. The upper is worked by Belden, Stoffer, and others, east of the town. It is of good thickness (about four feet), but is, on the whole, rather slaty, and contains considerable sulphur. At Browning's mill Coal No. 4 is six feet in thickness, but very slaty and sulphurous. Between this point and Sparta, Coal No. 3 is seen in the bed of the stream, rising and falling in waves above or below the water line. It is usually not more than from twelve to eighteen inches in thickness.

Near Sandyville, Coal No. 4 has been worked by Mr. J. A. Saxton, and here exhibits its usual variableness. Between the Nimishillen and Tuscarawas, in Pike and Bethlehem townships, the limestone coals are both opened in a great number of localities, and are quite extensively mined for local use. The coal which they here furnish is of fair quality, and forms an important element in the resources of this section of the county. In the valley of the Sandy, Coal No. 4 lies near the level of the stream—sometimes above, sometimes below—all the way to Minerva. At Kelly's Point it lies just above the railroad, is a cannel of good quality, two and a half feet in thickness. At the Trumbull Company's mines, near Magnolia, it lies below the surface of the valley, but has been reached in a shaft and in numerous borings, three and a half to five feet thick, in two benches; the upper part an open-burning coal, resembling the Briar Hill. On the north side of the valley it is said to be seven feet in thickness, but has not been opened to such an extent as to fairly test its quality. The coal mined by J. B. Hawkins, east of the residence of Hon. Arvine Wales, in the suburbs of Massillon, is Coal No. 3. It is here twenty-six inches in thickness, is overlain by gray shale twenty feet thick, above which lies the Zoar limestone. The coal is here one hundred and twenty feet, by barometer, above the Brooks coal (No. 1) at Bridgeport; but as the dip is easterly, the interval is doubtless considerably greater. The separation of the coal and limestone at the Hawkins Mine, though unusual, is not without precedent.

By far the best exposure of Coal No. 3 in the county is at Fisher's bank, near Sugar Creek Station. The section at that locality is as follows:

		FT.
1.	Sandstone and shale	20
2.	Coal blossom (No. 6).	
3.	Gray shale	30
4.	Coal No. 5 (outcrop).	
5.	Fire-clay	5 (?)
6.	Gray shale	45
7.	Gray limestone	3–4
8.	Coal No. 4	4–5
9.	Fire-clay	4
10.	Shale and sandstone	50
11.	Coal No. 3	3
12.	Fire-clay	3

In this section no limestone is seen above No. 3, and it may be wanting here, but it is most probably separated from the coal, as at the Hawkins Mine, and its outcrop concealed.

I give below two analyses of Coal No. 4, which will illustrate its variability of composition. No. 1 is from the Trumbull Company's shaft, Magnolia, No. 2 from Browning's mill:

	No. 1.	No. 2.
Specific gravity	1.322	1.342
Water	7.00	2.40
Ash	2.70	9.80
Volatile combustible	30.80	31.80
Fixed carbon	59.50	56.00
Total	100.00	100.00
Sulphur	0.65	2.00
Fixed gas, cubic feet	3.50	3.68

Coal No. 5.

This coal lies usually about fifty feet above the gray limestone over Coal No. 4. As a general rule, in Stark county it is two and a half to three feet in thickness, and has much less value than in Tuscarawas county, where it is sometimes four feet thick, and of superior quality.

West of Navarre, Coal No. 5 has been opened on Jacob Shetler's land, and on that of John Ricksecker, and is about three feet thick; a soft, coking coal of fair quality. In Pike township this coal is found on both sides of the Nimishillen, somewhat back from the stream, here, as at Mineral Point, holding its normal position about midway between Coals Nos. 4 and 6. It is in this region known as the "Thirty-inch seam," and the coal which it furnishes is generally good. Toward the south this seam attains its best development at Mineral Point, in the adjacent county. This is the coal mined on the Trumbull Company's property above Magnolia.

Typical exposures of Coal No. 5 may be seen at the mine of David Miller, in section 12, Canton township, three miles east of Canton, and in several other openings made on this seam south of this point. The coal in Miller's mine is twenty-eight to thirty inches thick, overlain by gray shale, with its characteristic deposit of nodular iron ore. The coal is bright and good, more free from sulphur than that of the seam below, more open-burning than the next higher seam (No. 6), which is so extensively mined in Osnaburg township. In that part of the county lying south and east of Canton township, the higher hills reach up to the Barren Coal Measures, and the blackband ore, which lies over Coal No. 7, occurs in some of the hill-tops of Osnaburg and Paris Coal No. 6, to be described further on, is here the principal seam worked. This generally lies conveniently above drainage in the valleys of Osnaburg and Paris, while in the lower part of these valleys, which are traversed by streams draining into the Sandy, Coal No. 5 is exposed in numerous localities as far up the Sandy as Minerva, and it is opened on many farms for local use. In the very bottoms of these valleys, in a few places, Coal No. 4, with its overlying Putnam Hill limestone, is reached, but is scarcely worked, except along the Sandy. A typical section of all the strata exposed in this part of the county and the corner of Carroll is given below:

		FT.
1.	Earth, with little or no drift	5 to 10
2.	Sandstone	8 to 10
3.	Shale	20 to 25
4.	Blackband iron ore (local)	3 to 8
5.	Coal No. 7	2½
6.	Fire-clay	2
7.	Sandstone and shale	80 to 110
8.	Coal No. 6	4 to 6
9.	Fire-clay	3 to 5

		FT.
10.	Blue and gray shale, with nodules of iron ore at base	40 to 60
11.	Coal No. 5	2½
12.	Fire-clay	2 to 5
13.	Sandstone and shale, with iron at base	40 to 60
14.	Limestone, sometimes changed to black calcareous shale	1 to 3
15.	Coal No. 4	2 to 7
16.	Fire-clay	2 to 6
17.	Shale and sandstone to Sandy Creek.	

At the Trumbull Company's mines, near Magnolia, the exposures above drainage and borings give the following section:

		FT.	IN.
1.	Shale, with iron ore	40	0
2.	Coal No. 5 (worked)	3½–4	0
3.	Fire-clay	3	0
4.	Sandy shale	7	0
5.	Sandrock	43	0
6.	Shale	8	0
7.	Limestone	2	0
8.	Shale	1	0
9.	Coal	3–5	0
10.	Fire-clay	4	0
11.	Shale, with iron ore	23	6
12.	Limestone	2	4
13.	Coal	1	10
14.	Fire-clay	1	0
15.	Gray shale	16	0
16.	Shale, sandstone, and fire-clay	27	6

The registers of other borings made in this vicinity are given in the report of Prof. Stevenson on the geology of Carroll county.

In Nimishillen and Washington townships, as the land is high, Coal No. 5 is generally buried beneath the surface. In Lexington township, however, on the north side of the divide, the tributaries of the Mahoning have opened the lower coals freely, and at Alliance Coal No. 5 lies ten feet below the station (five hundred feet above Lake Erie), and is worked in a shaft thirty-one feet deep, in the western part of the village. The coal is here three and a half to four feet in thickness, of fairly good quality, but, from the want of cover, rather soft, and contains considerable sulphur. The roof is black shale, with iron ore, as in so many localities in Stark and Tuscarawas counties.

The section at Alliance is carried down far below the surface by the shaft of the Alliance Coal Company. Combining the outcrops and sections of the two shafts, we have the following geological column:

		FT.	IN.
1.	Coal at Walter's and Black's mines, on road to Mt. Union	2½–3	0
2.	Fire-clay	2	0
3.	Blue, and yellow, and black shale, with iron ore at bottom	38	0

		FT.	IN.
4.	Coal No. 5	3	5
5.	Fire-clay	3	0
6.	Interval (covered)	50	0
7.	Limestone	2	0
8.	Coal No. 4	2	2
9.	Fire-clay	5	0
10.	Black shale	6	0
11.	Coal No. 3*a*?	3	0
12.	Fire-clay and sandstone	6	4
13.	Black shale	6	0
14.	Coal No. 3?	4	0
15.	Black shale	0	8
16.	Fire-clay	3	0

I have indicated above the numbers which I suppose belong to the coals. The upper one is No. 6, here thinner and nearer No. 5 than usual. The exposures of the upper portion of the section are very imperfect, the underlying rocks being almost completely concealed between the station at Alliance and Mt. Union, a vertical interval of nearly one hundred and fifty feet. The top of the hill at Mt. Union undoubtedly reaches into the Barren Coal Measures, but Coal No. 7 is thin or wanting; and if No. 6 occurred above the coal mined, it would be pretty sure to have been discovered in wells or through springs issuing from its outcrops. About Coals Nos. 4 and 5 there can be no mistake. The lower two coals I have supposed to represent the lower two in the section at Zoar Station, Tuscarawas county, as in all this region we frequently find a coal interposed between the two limestone seams Nos. 3 and 4; but since it is a very unreliable seam, and has nothing like the continuity and value of the others, it has been designated as No. 3*a*. It is, or was formerly, well shown in the railroad cut below Zoar Station, where it attains a thickness of three feet. The distance which separates these three coals is, however, so small that the middle one may only be an off-shoot from one of the others, and be quite local. As before remarked, these limestone coals are very variable, and are prone to divide and form double seams. The coal of the lower seam is said to be much the best.

No limestone is found over the lower coal, but this does not preclude its being No. 3, as its limestone is frequently replaced by calcareous shale. The fire-clay under Coal No. 4 is here of excellent quality, and is largely used for terra cotta, pottery, etc., by the Alliance Fire-clay Company.

About Mineral Point, Tuscarawas county, Coal No. 5 is underlain by a peculiar quality of fire-clay. This is non-plastic, and upon exposure breaks into angular fragments, like flint. It has proved, however, to be of excellent quality, and is now largely used in the manufacture of fire-bricks, both at Mineral Point and Dover. In most localities where this stratum is opened in Stark county, it seems to be of the ordinary plastic character, but near Waynesburg, in the valley of the Sandy, it exhibits very much the appearance it has at Mineral Point. It will be of some importance to have it generally known that the fire-clay under Coal No. 5 is so peculiar in character, and is often of such value, since it runs through several of the more southern townships of Stark county. It may be found to possess its best character in localities where nothing is now known of it.

Over Coal No. 5 we find, in Tuscarawas county, an important deposit of iron ore, and one which has supplied much of the "kidney" ore used in that county. This stratum is probably nowhere rich enough to pay for drifting, but where it crops out on the hill-sides it may justify stripping.

Coal No. 6.

This coal lies some fifty feet above Coal No. 5, or from eighty to one hundred feet above the upper of the two lower limestones, and is one of the most important and wide-spread coal seams of the State. It is the "Big Vein" of Columbiana county, the shaft coal at Steubenville, the most important seam of Holmes, Tuscarawas, and Coshocton counties, and is also the "Great Vein" of the Hocking Valley district. In Stark county it runs through all the hills east and south of Canton. It is the coal worked at Clark's mine and several others in Osnaburg, and is thence transported for blacksmiths' use to all parts of the county. In this region it varies from four to six feet in thickness, and crops out and is worked in numerous localities in Osnaburg and Mapleton. Passing thence southward, it loses in thickness and importance, until in the edge of Tuscarawas county it becomes less valuable than the next lower seam. At Waynesburg it appears well, and thence reaches round through the highlands of Paris and Washington into Columbiana county, retaining its volume and value all the way to the State line. At New Franklin, in Paris, it is opened on the farm of E. J. Courtney, where it is five feet ten inches thick, and shows, as usual, a slate parting eighteen inches above the bottom. It extends from this point northward, through Washington, as far as Alliance, but becomes thinner in this direction. In all parts of Stark county Coal No. 6 is a coking coal, generally of good thickness, and capable of affording an excellent fuel for blacksmiths' use or the generation of steam. When coked it may be used for iron-smelting. It sometimes contains considerable sulphur, but this may, however, be eliminated by washing. In the southern tier of townships—Sugar Creek, Bethlehem, Pike, and Sandy—Coal No. 6 is found in most of the higher hills. It is, however, in this region thinner and less pure than in the south-eastern portion of the county. Its best development seems to be in Osnaburg and Paris. It here lies for the most part conveniently above drainage, is from four to six feet in thickness, with a slate parting from twelve to twenty inches above the bottom. The coal of the lower bench is much purer than that of the upper, and is the portion so much esteemed for blacksmiths' use. From the large area it occupies, its thickness, and its adaptation to manufacturing purposes, this coal holds a prominent place in the mineral resources of the county, and forms a capital which will doubtless be largely drawn upon in the development of various industries. It is to be regretted that the territory where Coal No. 6 appears best is not yet traversed by lines of transportation, and its use has been much restricted by its inaccessibility.

Coal No. 7.

This seam is the highest of the lower coal group, and no workable coal is found above it in this section of the State. In the counties lying south and east of Stark, where the members of the upper coal series are represented, Coal No. 7 is overlain by a mass, some four hundred feet in thickness, of shales and sandstones, the former frequently colored red, which contain little coal, and hence are called the Barren Coal Measures. The highest hills in Stark county are composed of the lower portion of this series, generally a mass of gray shale, with more or less sandstone. The hill-tops on both sides of the valley of the Sandy have this character, and it is only here that Coal No. 7 is found. In this region it is a thin seam, from one and a half to two and a half feet thick, and the coal is of inferior quality, so that in Stark county it has no considerable value. It becomes, however, of much greater consequence in the counties which lie further south.

Blackband Iron Ore.

The chief interest which attaches to Coal No. 7 in Stark county comes from the fact of its association with the blackband ore which overlies it. This is a bituminous shale, highly impregnated with iron. It often, though not constantly, forms the roof of Coal No. 7, and where present attains a thickness of from three to eight feet. The blackband ore is generally, though not always, overlain by a ferruginous limestone, in which the quantity of iron is sometimes sufficient to render it a calcareous iron ore. From the fact that this is only found in the tops of the hills, it is sometimes designated as the *mountain ore;* and the limestone, from its ferruginous character, assumes, on weathering, a brownish color, and is hence often referred to as the "buff" limestone, to distinguish it from the blue limestones below. These ore beds are detached outliers of a great ferruginous sheet which once covered much of Stark and Carroll and all of Tuscarawas county. Patches of this ore sheet, separated from their connections by the erosion of the valleys of the Sandy, Conotton, and Tuscarawas, occur in the isolated hills of Osnaburg and Paris, the only portions of the county geologically high enough to include them. Such being the geological position of this important formation, it can not be expected to be found in any other portion of the county, even though the hills may there rise to an equal relative or absolute height with those referred to. It is important to bear these facts in mind, in order that time and money be not wasted in useless search for the blackband and mountain ore.

I subjoin analyses of the raw and calcined blackband from Robertsville:

	RAW.	CALCINED.
Water	18.60	....
Silica	31.40	12.88
Iron, oxide	18.75	69.94
Iron, carbonate	23.14	....
Manganese	1.80	3.15
Alumina	1.00	7.00
Lime, phosphate	0.72	2.35
Lime, carbonate	0.75	....
Lime	....	1.75
Magnesia	2.56	2.16
Sulphur	4.28	0.14
	99.30	99.37
Metallic iron	24.28	48.95
Phosphoric acid	0.31	1.08

CHAPTER LX.

REPORT ON THE GEOLOGY OF CARROLL COUNTY.

BY JNO. J. STEVENSON.

Carroll county is bounded on the east by Columbiana and Jefferson, on the south by Harrison, on the west by Tuscarawas and Stark, and on the north by Stark and Columbiana. It contains thirteen townships, and embraces an area of not far from four hundred square miles. The population, according to the census of 1870, is about fourteen thousand five hundred. The county town is Carrollton, a flourishing village, with nearly eight hundred inhabitants, and situated on a ridge five hundred and forty feet above Lake Erie. The railroad facilities are very poor, consisting only of the Tuscarawas Branch of the Cleveland and Pittsburgh Railroad, which passes through the north-western corner of the county. The county town communicates with this road by means of a unique tramway, which is perhaps the only one in the United States which uses the antique strap rail. The border townships on the north and south have access to market, as the main stem of the Cleveland and Pittsburgh Railroad passes very near the southern line of Columbiana, and the Pittsburgh and St. Louis Railway runs close to the northern line of Harrison. It is to be hoped that some one of the numerous railway lines projected to run through the county will be built, as the interior and eastern townships suffer very materially from lack of such facilities.

Besides the county town, there are several villages, mostly small, but giving evidence of thrift and growth. Leesville is perhaps half as large as Carrollton, and is the business center of a large section. Harlem was formerly a place of some note, owing to its mineral springs, but since stage coaches ceased to be the ordinary mode of conveyance it has become less important. Malvern and Minerva are growing rapidly under the influence of the railroad.

Much attention is paid to educational matters. The school-houses are neat, and efforts are made to secure good instruction. The county contains one institution authorized to confer collegiate degrees. Upon the whole, the inhabitants of this county are fully alive to their material advancement, and they have shown an anxiety respecting their resources such as has been displayed in no other county allotted to me. I bear grateful testimony to the very general interest manifested in regard to the Survey, and to the almost universal desire to aid in securing useful and accurate results.

The surface of the county is much diversified by erosion, the hills rising sometimes nearly three hundred feet above the valley bottoms. The average elevation of the uplands varies little from five hundred and fifty feet above Lake Erie, though the "dividing ridge" east from Carrollton is about one hundred and twenty feet higher. The strata exposed in the greater portion of the county are principally argillaceous shales, alternating with thin sandstones, which are usually soft. For this reason steep hill-sides are not common, the country is rolling, with the eminences rounded off, so that, even at a considerable distance from any stream, stretches of comparatively level land are to be seen. As one might expect from the structure of the rocks, the soil on the uplands is thin and not very rich. Where the sandstones predominate, it lacks tenacity, and is apt to wash out and expose the subsoil, which readily yields to form deep gashes in the hill-side. In the "bottoms" the soil is much richer and yields very good crops of grain. It is probable that intelligent use of the subsoil plow would improve the upland; but at the same time it is evident that this soil will not endure persistent cultivation without constant application of amendments.

For some years the farmers have done much in wool-raising, and have succeeded in producing a wool of superior quality, which has secured a high reputation. As land is worth from forty dollars in the uplands to sixty, and in some cases even one hundred dollars, in the "bottoms," it is doubtful whether a staple so uncertain in price as wool can be regarded as truly profitable. A surplus in Europe, or a diminution in the rate of tariff, affects this interest with telling force. In 1872 the price fell from seventy cents in the spring to forty cents in the fall. Intelligent farmers assert that wool can not be raised to profit at less than fifty cents per pound. Still there can be no doubt that wool-raising is, and for some time will be, the most profitable business here, owing to the quality of Carroll county wool. At the same time it would be well for farmers to consider whether their soil, well fitted for grass, and their abundant supply of good, soft water, can not be put to some other use which will bring in larger and more certain returns for labor.

The streams of Carroll county are in two systems, separated by the high dividing ridge running rudely north and south, about three miles east from Carrollton. At the east the waters are drained by tributaries of Yellow Creek, through which they empty directly into the Ohio. On the west they are carried off by Sandy Creek and the Conotton, which empty into the Tuscarawas. Springs are numerous, and yield an ample supply of good water for domestic purposes.

The larger portion of the land is under cultivation, and little remains in wood. The more common trees are white and red oak, pig-nut and shell-bark hickory, black walnut, elm, tulip-tree, locust, and sugar-maple, with some beeches and wild cherry, and very few of the cone-bearing trees. The number of species and their character show that, though thin, the soil is capable of supporting a vigorous growth.

GEOLOGICAL STRUCTURE.

Diligent examination was made to determine the presence or absence of true drift, but as none was found, excepting a few doubtful specimens in the north-east, it is probable that the boundary line of drift influence lies to the north or north-east of the county. The bottom lands of the Conotton and of Sandy Creek being made up of sand, show the mode of deposition very prettily, exhibiting lines of stratification and the position of eddies. In the Sandy Creek "bottom," not far from Waynesburg, Mr. Daniel Wagner has found two teeth of Mastodon, of large size and nearly perfect, weighing together fifteen pounds.

While making a series of borings for coal, near the village of Magnolia, Mr. John Young discovered that the course of Sandy Creek has been changed, for in one boring he passed through ninety feet of gravel and other transported material without reaching any consolidated rock. How much deeper the deposit extends is not known, as, unfortunately, the boring was stopped at that depth. Judging, however, from what has been ascertained in Tuscarawas county respecting the Tuscarawas River, it is probable that Sandy Creek at one time flowed at a level not less than one hundred feet below that of its present bed, and that the valley was gradually filled up by transported material to conform to the changing relative level.

The consolidated rocks of the county belong exclusively to the Barren and Lower Coal Groups. It is possible that the Pittsburgh coal crosses the line from Harrison county into London township, but it was not observed. Lying, as Carroll county does, on the border of the Barren Group, which probably extended originally to but a short distance further north-west, the relations between the strata of this group as here displayed are somewhat obscure, the intervals varying in the most perplexing manner. For this reason no county section can be given which would be of any practical value.

Near Perrysville, in Perry township, and at two localities in the southern portion of London township, a coal is said to have been seen in plowing on top of high hills. If this be true, as is quite likely, the coal is the Pittsburgh or No. 8 of the Ohio section. Fragments of the limestone underlying that coal were observed at several points in these townships, showing that the coal at one time reached well up into this county. From this horizon downwards, about one hundred and thirty feet, to the Crinoidal limestone, the interval is occupied by sandstones and argillaceous shales, with a non-persistent limestone about midway, one foot thick, and non-fossiliferous. The Crinoidal limestone is well marked, but shows some interesting variations. It does not seem to reach further to the north-west than Carrollton, where it is seen only on the top of the ridge. On the road from that village to Harlem it is first seen at a distance of about one mile. It is here very coarse grained, with a rude fracture like that of sandstone, and is not so rich in fossils as usual. A short distance beyond it resumes its ordinary character—dingy gray on the weathered surface—occurring in rude quadrangular blocks, and when broken showing a dull brown color. The fossils here are very numerous, but do not weather free from the rock, as they do not differ from it in hardness. The surface, consequently, is covered with sections of mollusca and crinoidal fragments, and only a few good specimens of *Lophophyllum proliferum, Retzia punctilifera, and Athyris subtilita* were obtained. The thickness of the stratum can not well be determined here, as there is no satisfactory exposure. Followed toward Harlem this limestone is seen to become double, the two layers separating more and more until, at Harlem, they are twenty-five feet apart, with Coal No. 7 *b* between them. At this village the upper layer is fossiliferous, but differs from any other exposure, in that it contains much earthy matter and tends to disintegrate upon exposure to atmospheric influences. It is light blue in color, and is apparently free from iron, as the surface of fracture does not show the dull brown tint. The lower layer is thin, hardly one foot thick, and is non-fossiliferous. It is blue, breaks with a semi-conchoidal fracture, and rings clearly when struck with the hammer. In Perry township, between Perrysville and Palermo, both layers are even, with Coal No. 7 *b* between them. The upper layer here shows none of the earthy character observed at Harlem, but is hard and flint-like, weathering into dingy nodules. It is so tough that it might be used with advantage in macadamizing roads. This duplication of the stratum seems to be confined to Lee, London, and Perry townships, as it was not observed in Union, Center, Washington, or Fox. In the last two townships the stratum is admirably exposed along the ridge road from Carrollton to Wattsville. It has been traced to the border of Columbiana county, varying greatly in hardness, color, and composition, but every where exhibiting the same grouping of fossils, which renders its identification so easy and makes it so valuable a guide to the stratigraphical relations of a district.

The shales immediately underlying the Crinoidal limestone contain a small percentage of iron. There are few localities, however, where it is concentrated, and in none is the concentration sufficient to afford a workable seam of ore. In the neighborhood of Carrollton, both west and south, a seam of inferior blackband, varying from three to six inches in thickness, is seen three feet below the limestone. In the coal shaft near Harlem, Lee township, two seams of blackband are said to have been cut, one three and the other four feet thick. The shaft was closed at the time of my examination and no specimens had been preserved, so that no definite information could be obtained. It is most likely that dark shale has been mistaken for blackband, as no evidence of the latter was seen in any of the numerous exposures near the village. In the vicinity of Cannonsburg, Monroe township, the occurrence of ferruginous shale at this horizon has given birth to much excitement, and the oracular statements of some would-be experts have done much toward rousing false hopes in the minds of the inhabitants. A number of localities in this township, said to show from ten to fourteen feet of blackband, were examined; but in every case the "blackband" proved to be only a dark, slightly bituminous shale, containing for the most part a very small percentage of iron, and holding here and there an inch of lean plate ore. As the owners generally expressed themselves dissatisfied with the results of merely physical examination, specimens of the shale obtained on the farm of Dr. Samuel Black were forwarded to Dr. Wormley, with the request that he would determine the percentage of iron. He reports its composition to be as follows:

Silicious matter	74.88
Metallic iron	8.31
Undetermined	16.51
	100 00

In Brown township, near Waynesburg, a good deal of money has been wasted in digging well-holes in this shale, the prospectors supposing that it is the extension of the blackband belt of Tuscarawas county. A little investigation would have shown that the horizon is too high, as the blackband, which is quarried only five miles from this locality, lies upon Coal No. 7, more than one hundred feet below this shale. A day's careful examination by a competent geologist would not only have prevented this ridiculous waste of hundreds of dollars, but also would have shown accurately, over a considerable extent of country, the horizon at which the blackband might be sought. The shale here contains great numbers of *Aviculopecten rectilateraria*, Cox, sp.

Springs issuing from these shales are, for the most part, more or less impregnated with iron, and where they empty into low grounds bog iron ore is found in considerable quantity. In the vicinity of Harlem, Lee township, the springs at this horizon are strongly chalybeate, and at one time they were quite famous. On Mr. Samuel Dunlap's property is a spring which was formerly celebrated as a curative for dysentery and allied diseases. Many years ago a hotel was built in the glen near this spring, and was largely patronized; but it has gone to ruin, and, strangely enough, the spring is by no means so strongly chalybeate as before. Other springs of like character occur on the farms of Mrs. Nancy Morehead and Messrs. James Gott and John Hostermann. These never fail, and always yield a large amount of water. It is quite possible that were there ready means of access to Harlem, these springs might again acquire considerable reputation, and so render the village, which is pleasantly situated, a summer resort for invalids.

Coal No. 7 *b*, underlying these shales, is somewhat irregular in its habit, but seems to thin out north-westwardly, and in the same direction to lie nearer the limestone above. On the dividing ridge east from Carrollton it is first seen two inches thick, and almost directly under the limestone. Followed toward Harlem, Lee township, it is observed becoming four inches, then one foot, continually increasing in thickness and separating itself from the limestone, until at Harlem it is found twenty feet below the upper layer of the limestone, and more than two feet thick. About half a mile east from that village Mr. Samuel Dunlap has opened it with a shaft sixty-four feet deep. The coal, as obtained by him, is a semi-cannel, open-burning, easily mined, of low specific gravity, and containing no pyrites, except in thin films upon the vertical planes. It is very handsome, but rather brittle. The layers of cannel and bituminous coal are of about equal thickness, varying but little from one-tenth of an inch. Near the top is a layer of cannel nearly four inches thick. The roof is shale, and so firm that the rooms are worked fifty feet wide with only a single row of props in the middle. The thickness of the coal is twenty-six inches, and there are no partings.

Mr. James Thompson, about half a mile north from Harlem, has opened the same bed. It is twenty-six inches thick, with a not very persistent clay parting near the middle. There is no layer of cannel on top, as at Mr. Dunlap's opening, nor are the thin layers of cannel so numerous as there. The coal is very pure, and is said to cake quite readily upon the fire. It is so easily mined that, notwithstanding its thinness, a good miner can easily dig and put out seventy-five bushels *per diem.* The roof is good, and the rooms at this bank are twenty feet wide, without props. Other openings are quite numerous. At Mr. James Gott's bank it is nearly three feet thick, and shows no parting. It breaks out in blocks, leaving little slack, and burns to a fine white ash. Mr. Samuel Gutchall has twenty-six to thirty inches of good, clean coal, but rather harder than that from most of the other banks. At Mr. John Hostermann's it varies from twenty-four to thirty inches, but is poor and slaty, and no longer worked. Mr. Crim's coal is slaty, but that from Mr. Boyer's bank, adjoining, is of very fair quality. The character of this coal is very varied here. At one bank it is clean, at another so slaty as to be worthless; at one it is open-burning, at another a caking coal. Like all the coals of the Barren Group, it can not be depended upon. A sample from Harlem yields the following upon analysis:

Specific gravity	1.267
Moisture	2.90
Ash	3.00
Volatile combustible matter	29.90
Fixed carbon	64.20
Total	100.00
Sulphur	0.96
Sulphur left in coke	0.57
Sulphur forming of coke	0.84
Fixed gas per pound, in cubic feet	3.48
Ash	Gray.
Coke	Compact.

In London and southern Perry this coal was not observed. It is undoubtedly present, as an attempt was made some years ago to work it at Rumley, in Harrison county, just by the county line. Of course no estimate can be made respecting its thickness or value. In Perry township it was observed about a mile from Perrysville, on the property of Mr. Othniel Baker. It is there one foot thick, of poor quality, resting almost directly on a bluish nodular limestone, and twenty-three feet below the upper layer of the Crinoidal limestone. From Mr. Baker's it was traced to Palermo, in Union township, where it is ten inches thick and twenty-five feet below the limestone. Northward in this township it is seen approaching the limestone and becoming thinner. Near Carrollton it is only four inches thick, and northward from that village it was not observed. In Fox township it is constant at from ten to fifteen feet below the limestone, but is always very thin.

Coal No. 7 *a* is found at from sixty-five to ninety feet below No. 7 *b*. It is traceable with extreme difficulty, partly because it is not persistent, and partly because of the varying intervals between it and No. 7 *b*, above, and No. 7, below. At several localities No. 7 is found at a horizon, relative to the Crinoidal limestone, precisely the same as that occupied by No. 7 *a* at others, and in each case there can be no doubt respecting the identification of the coals. The relations of No. 7 and No. 6 to the Crinoidal limestone are equally peculiar over a large portion of the county, the interval between the two coals varying from thirty-five to one hundred feet. These facts are certainly conclusive against any alleged parallelism of coal beds over a large area.

In south-western Perry, not far from Mastersville, No. 7 *a* is seen on the farms of Messrs. Minnick, John Suary, and B. Borland, where it is about eighteen inches thick, overlaid by an equal thickness of very good plate ore, which is certainly deserving of careful investigation. Erosion has removed the overlying deposits from a considerable area, so that the ore can be reached without much stripping. Specimens of this ore were obtained from Mr. Borland's farm, but, unfortunately, have been mislaid or missent, and we are unable to present an analysis. About one mile north from Perrysville, in the same township, this coal has been experimentally opened by Mr. Othniel Baker. When examined, the opening was not sufficiently extended to give any definite idea respecting the value of the bed. It appears to be about four feet thick, parted midway by about six inches of clay. It is sixty-five feet below No. 7 *b*. Near Leesville, Orange township, it is seen, but is very thin, and is not worked. At Harlem, Lee township, this coal is opened on Mrs. Harris's property, is twenty-two inches thick, and good for domestic use, but contains a notable percentage of sulphur. On the adjoining farm of Mr. James Thompson it is a bituminous coal, two feet thick, with a good deal of pyrites. Fourteen feet below it is a cannel seam, fifteen inches thick, which appears to be local, having been observed at no other place where No. 7 *a* is exposed.

Coal No. 7 is or has been worked in Orange, Harrison, Center, and Fox townships. In Orange township the openings are numerous, and the bed is of much local importance. At Leesville Mr. J. C. Price works it by means of a shaft thirty-five feet deep. He finds it four feet thick, without regular partings, and of nearly the same quality throughout. Pyrites occurs in streaks at various intervals through the bed, but is more abundant at the bottom. Nodules are by no means rare, and frequently weigh from twenty to fifty pounds. Horsebacks, from above and below, are somewhat annoying, as they cut out the coal quite seriously. No fire-damp has been known in this mine, but choke-damp is said to accumulate at times so as to embarrass the workmen. The coal is hard and brilliant, and can be mined only by blasting. It affords an excellent fuel for domestic use, burning well and giving off intense heat, but the proportion of pyrites is so large as to unfit it for employment in the manufacture of either iron or illuminating gas. At Smith's mill, near Leesville, this coal has been mined in the hill, and at a short distance below the mill it is worked somewhat largely during the winter. As the owner of this property has no respect for geologists, and regards the Survey as a worse than useless expenditure on the part of the State, no direct information respecting the mine could be obtained. I learned, however, that the coal is soft and can be mined with picks; that it burns readily, but gives off comparatively little heat, and is not looked upon as a profitable fuel. In this vicinity no iron ore was observed in connection with the coal.

Near the Cross Roads, in Monroe township, the outcrop of this coal was seen in the roadside, very thin, and having four inches of nodular ore above it. In Harrison township it was formerly worked on the property of Mrs. S. Bemer, where it showed a thickness of two and one-half to three feet, without ore above it. Near the steam saw-mill, about midway between Cannonsburg and Carrollton, this coal was formerly worked, but the openings were long ago deserted. The thickness is said to be about two feet. Fifteen feet below the coal is a nodular calcareous ore of low grade, of which the nodules have zinc blende as the nucleus. In Center township Mr. I. Ebersole's opening, about one-half mile north from Carrollton, shows it twenty-five inches thick, without partings, made up of very fair coal, containing little pyrites. At Mr. Sandford Moffatt's, two miles west from the village, the thickness is about the same, but the coal contains rather more pyrites. There are other openings near Carrollton, but they are not worked. Three-fourths of a mile south from that village the coal is seen in the bed of Indian Fork of Conotton.

In Fox township it is mined somewhat extensively to supply local demand. About one mile from Wattsville, Mr. H. P. Dunlap's opening shows a thickness of three feet four inches. The coal is very hard, and requires blasting. It is very clean, and the seam is free from persistent partings. Not far from Mechanicsville it is mined by Messrs. Josiah Quinn, Jacob Buckston, and others. In all these banks it runs about three feet thick, and yields a coal of good quality for domestic use. No ore accompanies the coal in this township. Two specimens of the coal yield the following upon analysis. No. 1 is from Mr. Dunlap and No. 2 from Mr. Buckston:

	No. 1.	No. 2.
Specific gravity	1.287	1.288
Moisture	2.30	2.80
Ash	6.90	2.90
Volatile combustible matter	30.70	30.20
Fixed carbon	60.10	64.10
Total	100.00	100.00
Sulphur	2.77	1.23
Sulphur left in coke	1.51	0.87
Sulphur forming of the coke	2.25	1.29
Fixed gas per pound, in cubic feet	3.56	3.80
Ash	Gray.	Red.
Coke	Compact.	Compact.

In Rose township no openings were seen where the bed is worked for its coal, but it frequently underlies blackband ore—the same deposit as that of Tuscarawas county. On Mr. Newhouse's property, between Waynesburg and Morges, the blackband is leased and taken out by Messrs. Rhodes & Carr, of Cleveland. The section there is:

		FT.	IN.
1.	Shale and débris	10	0
2.	Black shale	00	4
3.	Blackband	5	2
4.	Coal No. 7	2	0
5.	Fire-clay (seen)	2	0

At this locality the anticlinal which passes through the western portion of the county is well shown, as the excavation is directly on the crest of the axis.

The blackband is of low specific gravity, owing to the large proportion of bituminous matter, but is easily calcined, and leaves a rich ore. It has been removed from a considerable area, but for some reason the work had been stopped just before I visited the place. The ore yields as follows on analysis:

Specific gravity	2.727
Water and organic matter	19.48
Alumina	1.60
Silica	27.68
Carbonate of iron	36.95
Sesquioxide of iron	7.58
Manganese	1.20

Magnesia carbonate	2.27
Carbonate of lime	1.91
Sulphur	0.13
Phosphate of lime	0.82
Total	99.62
Metallic iron	23.12
Phosphoric acid	00.38

In Brown township no opening upon No. 7 was seen, but the outcrop of the coal was observed at several localities near Waynesburg, and at each of these there were evidences of ore in connection with it. Throughout this vicinity it lies one hundred feet above Coal No. 6, which is mined by Mr. R. B. Hamilton, near Waynesburg.

The interval between Coals Nos. 6 and 7 varies greatly. Near Carrollton it is from forty to sixty feet; near Leesville, thirty-five; in northern Monroe township, sixty; while in Rose and western Brown it is one hundred feet. The Mahoning sandstone, resting upon Coal No. 6, varies from six to thirty feet in thickness.

Coal No. 6 is the important bed of the county, but, unfortunately, is available only along the valleys of the Conotton and Sandy Creek, which include portions of Brown, Union, Monroe, and Orange townships. In Union township, about one mile south from Carrollton, on the Indian Fork of Conotton, it is mined extensively to supply Carrollton. At Mr. John Moody's bank the following section was obtained:

		FT.	IN.
1.	Sandstone (Mahoning)	6	0
2.	Shale	5	0
3.	Coal	0	8
4.	Parting	0	1
5.	Coal	1	0
6.	Parting	0	1
7.	Coal	1 to	6
8.	Parting	0	½
9.	Coal	1	0
10.	Parting	0	2
11.	Coal	1	0
12.	Fire-clay	—	—

Total thickness of the coal, 4 feet 6 inches to 5 feet.

This coal shows a considerable proportion of pyrites, both in seams and nodules. When exposed to the atmosphere, it soon becomes covered with white streaks, but shows little tendency to disintegrate. No. 3 of the section is the best for burning, and is very clean. No. 5 has numerous streaks, but few nodules of pyrites. No. 7 is variable in thickness, but is the purest portion, and in good repute for smithing purposes. No. 9 contains a band of bone coal, three to four inches thick, which ignites with difficulty, and after burning leaves a flaky ash, like that from hickory wood. Nodules of pyrites are of frequent occurrence in this layer. No. 11 makes the hottest fire, but leaves much cinder.

Directly opposite this opening is one belonging to Mr. Gause, in which the section is the same as that already given. The bed here is very badly cut out by horsebacks and clay veins. The latter strike the bed at an angle of about 50°. The former are so serious as to impair the value of the bank. One hundred yards from the mouth a sandstone horseback crosses the entry, which replaces not only the coal but also the underlying rocks to a depth of fifteen feet. Its width, as shown in the entry, is twenty yards. A few yards beyond this another occurs, and to avoid it the entry was turned, so that nothing is known respecting its extent. Unfortunately for science, though fortunately for themselves, the owners of the adjoining banks have not driven their entries in the direction to meet these horsebacks, and it is impossible to determine, with any degree of accuracy, the extent or direction of the disturbances. The removal must have occurred during or immediately before the deposition of the sandstone above, as the horsebacks are of a constitution similar to that of the sandstone stratum. In the neighboring bank, belonging to Mr. Staley, the coal is from five to six feet thick. Near Carrollton the interval between this bed and the Crinoidal limestone is only one hundred and forty feet. In Tuscarawas and Guernsey counties it is two hundred and forty to two hundred and sixty feet.

Midway between Carrollton and Cannonsburg, on the border of Monroe township, Coal No. 6 is mined by Mr. W. Scott, at whose opening the following section is seen:

		FT.	IN.
1.	Shale	3	0
2.	Coal	1	6
3.	Parting	0	½
4.	Coal	0	8
5.	Parting	0	½
6.	Coal		10
7.	Parting	0	1-3
8.	Coal	1	10
	Total	5	1

In the entry the coal occasionally becomes five feet six inches, and in one spot it reaches six feet. Throughout the greater portion of the bed little pyrites is visible, and nodules occur only near the bottom, where they are comparatively rare. Where exposed to atmospheric influence, the coal shows some white streaks and more or less tendency to decompose, so that the pyrites is pretty well disseminated. The top layer, for six inches, is poor and is not removed. Partings of mineral charcoal are frequent, and thin layers of it seem to alternate with those of coal. The blast is seldom resorted to in mining, and the bank is thought to be one of the best in the county. At Mr. Armstrong's bank, near Mr. Scott's, the bed is six feet, and yields an excellent coal, which is inferior to none found in this township.

Near Cannonsburg we obtain the following section from Mr. T. Tholy's bank:

		FT.	IN.
1.	Sandstone	—	—
2.	Shale	3	0
3.	Coal	2	10
4.	Clay	0	2½
5.	Coal	1	5
6.	Fire-clay (seen)	1	6

Of pyrites there is a notable quantity, especially in the lower bench. Streaks are numerous above, but are never so persistent as to form partings. The coal is irregularly bedded and much "slickensided." Though not very compact and apt to disintegrate upon exposure, it is quite hard and is mined by blasting. East from Cannonsburg, Mr. Wilken has the coal about four feet six inches thick. It is good, with much volatile matter, but contains enough pyrites to make it disintegrate readily on exposure. The clay parting shows many impressions of *Stigmaria ficoides.*

Near the Cross Roads, Mr. Samuel Smith has four feet six inches of very good coal, but works it no longer. In the same neighborhood, Mr. George Stoody's bank shows a thickness of four feet six inches, as follows:

		FT.	IN.
1.	Coal	2	10
2.	Clay	0	2
3.	Coal	1	6

In the upper bench there are two or three thin partings, but they are not persistent. Little pyrites appears either as streaks or nodules, and the coal has a good reputation. About a mile south from the Cross Roads, Mr. Conrad Pearch has opened the coal, which there shows as follows:

		FT.	IN.
1.	Shale	0	3
2.	Coal	1	6
3.	Parting	0	½
4.	Coal	1	7½
5.	Parting	0	⅜
6.	Coal	0	9
		4	2

The coal is compact and must be blasted. It is apparently very clean, and is regarded as among the best for blacksmiths' use.

In Orange township the bed shows the following section at Mr. John Pearch's bank:

		FT.	IN.
1.	Coal	1	½
2.	Parting	0	¼
3.	Coal	1	1½
4.	Parting	0	½
5.	Coal	0	9½
6.	Parting	0	⅛
7.	Coal	0	11
8.	Parting	0	2–3
9.	Coal	0	4–6
		4	5

No. 1 is the best coal, containing little pyrites and coming out in clean blocks; No. 3 is quite poor, containing much nodular pyrites; No. 5 is brittle, and in mining is converted into slack; No. 7 is fair, and No. 9 is rather poor. This coal is hard, requiring the blast, cakes readily on the fire, yields a compact coke, and gives off intense heat in burning. On the north branch of Myers's Creek the coal is mined by Mr. Amos Preston, at whose bank it is separated into three benches by thin persistent partings. The top bench is eighteen inches thick and yields a brittle coal, which burns well but is of inferior quality. The middle bench, thirty-one inches, is a good coal for domestic use. The lower bench, eight inches, is slaty, burning moderately well, but leaving a bulky ash. The proportion of ash is very great throughout. Nodules of pyrites are of frequent occurrence. As Smith's mill, where this bed first appears in the bed of the stream, it is but thirty-five feet below Coal No. 7.

In Brown township we find this coal mined by Mr. R. B. Hamilton, not far from Waynesburg, at whose bank the following section is exposed:

		FT.	IN.
1.	Black shale	—	—
2.	Coal	1	5
3.	Parting	0	½
4.	Coal	1	8
5.	Parting, pyritous	0	2
6.	Coal	0	6–8
7.	Fire-clay	10	0

The top coal is slaty, almost a bone coal, and is poorest next the roof. The rest of the bed yields good coal, very pure and much prized by blacksmiths. Near the middle is a somewhat persistent layer of mineral charcoal, one-half inch thick. The pyritous parting, No. 5, is irregular in thickness and varies in distance from the bottom. Two feet below the coal a thin seam of coal two or three inches thick occurs in the fire-clay. Followed up Sandy Creek the bed is seen to diminish in thickness and at the same time to deteriorate in quality. At Oneida it is only thirty inches; at Pekin it is the upper bed, and is barely twenty-eight inches, yielding a sulphurous coal. At Malvern it has been worked to some extent.

In Augusta township, about six miles from Minerva, Mr. John Gründers mines a coal which, from its position, seems to be Coal No. 6, though, from the lack of satisfactory exposures in the neighborhood, this relation can hardly be proved. The section is:

	FT.	IN.
1. Sandstone	15	0
2. Bluish shale	7	0
3. Coal	2	10

There are no partings, and the coal is evidently of good quality. At Mr. Davis's opening, near by, the thickness is rather greater. This is said to be the best bank in this section, but, unfortunately, is too far from any village to be very serviceable.

The following analyses were made: No. 1, from John Moody; No. 2, W. Scott, upper portion of bed; No. 3, middle, and No. 4 lower portion of same.

	No. 1.	No. 2.	No. 3.	No. 4.
Specific gravity	1.342	1.274	1.304	1.298
Moisture	3.10	3.10	3.20	3.30
Ash	7.90	2.40	4.30	7.40
Volatile combustible matter	30.10	34.50	30.40	32.70
Fixed carbon	58.90	60.00	62.10	56.60
Total	100.00	100.00	100.00	100.00
Sulphur	2.74	1.53	0.87	1.94
Sulphur left in coke	1.45	1.04	0.65	1.18
Sulphur forming of the coke	2.17	1.66	0.94	1.84
Fixed gas per pound, in cubic feet	3.56	3.72	3.72	3.56
Ash	Fawn.	Red.	Pink.	Gray.
Coke	Compact.	Compact.	Compact.	Compact.

Coal No. 5 was observed at but one locality along the Conotton. Near Cannonsburg, Monroe township, its outcrop, two feet thick, was seen about fifty feet below Coal No. 4. In the valley of Sandy Creek it has been opened at various points, but never worked extensively, as it is thin and usually yields coal of rather poor quality. In Brown township it has been opened at Pekin, where it is the lower bed, and is from twenty-five to twenty-eight inches thick. At Oneida it is said to be nearly three feet, and at Malvern it is about the same. At these localities it affords a readily burning coal, which is very sulphurous.

In Rose township it was at one time mined by the Trumbull Company, on whose property, near Magnolia, it is three and one-half feet thick. It is now worked at a locality about two miles south-east from that village, showing about three and one-half feet of very fair coal. It is interesting chiefly because it overlies the compact fire-clay so extensively used at Mineral Point and other localities along the Tuscarawas Branch of the Cleveland and Pittsburgh Railroad. The only locality in Rose township where this was taken out, where these examinations were made, was on the farm of Mr. Wm. Beattie, about one mile south-east from Magnolia. As at that time careful search was making at every exposure of Coal No. 5, it is highly probable that other openings are now in operation. This compact clay is very local in distribution, and deposits are quite uncertain in extent, as the hard clay often passes abruptly into the plastic variety. On the Beattie farm the clay is compact, on the Trumbull Company's property it is plastic, while on a farm about half a mile west from the last it is again compact. The section exposed on the Beattie farm is as follows:

	FT.	IN.
1. Coal No. 5	3	6
2. Shale	0	4
3. Clay, compact	6	6
4. Coal	1	6
5. Clay, plastic	2	0

Coal No. 4 here consists of one foot of alternating shale and coal, resting on two and one-half feet of fair coal. In a well sunk on the other side of the hill it is three and one-half feet thick, and good throughout. The fire-clay, No. 3, is quite dark near the top, but below is beautifully mottled. At the outcrop a layer of large nodules of iron ore and clay, two feet thick, seemed likely to cause much loss, but it ended abruptly at the distance of five feet in the entry. At the time these notes were made the work was going forward energetically, and Mr. Reis, the lessee, had his preparations well advanced for the erection of brick-works on the spot. Fifteen cubic feet of the rock make a ton, and the cost of mining is seventy-five cents. The thin coal below the fire-clay is very poor in quality, and is evidently local, as it was seen at no other exposure. Specimens of this clay were forwarded to Dr. Wormley for analysis, with the following results:

Water	9.90
Silica	48.90
Alumina	39.79

Oxide of iron	0.61
Lime	....
Magnesia	0.07
Potash } Soda }	0.65
Total	99.92

The gray limestone overlying Coal No. 4 comes to the surface at only one point within the county. It was seen in the banks of Sandy Creek, just at the Tuscarawas line. It is compact, about two feet thick, and quite fossiliferous. Blocks brought out from the shaft on the Trumbull Company's property showed fine specimens of *Productus semi-reticulatus* and *Spirifer lineatus*.

Coal No. 4, immediately underlying the gray limestone, crops out at no locality within the county. Messrs. Tod, Stambaugh & Co. mine it by means of a shaft on the Trumbull Company's property, Rose Township, two miles south-west from Magnolia. The works are in charge of Mr. John Young, to whose intelligent observation I am indebted for many important and interesting facts which otherwise could not have been obtained. The shaft by which this coal is reached was sunk almost directly on the summit of the anticlinal already referred to, and the exhibition in the entry is well worthy of note. The general section, as seen in the mine, is:

		FT.	IN.
1.	Gray limestone	2	6
2.	Black shale	0	½
3.	Coal	0	11
	Parting	0	½
5.	Coal	1	8
6.	Clay parting	0	2–3
7.	Black slate or slaty coal	0	2–7
8.	Coal	0	10
9.	Parting	0	1
10.	Coal	0	10
11.	Fire-clay	5	0
12.	Coal No. 3 (?)	2	0

The evidences of disturbance are well marked in the entry for one hundred yards from the shaft, after which, the summit of the anticlinal having been passed, the south-easterly dip is resumed, and the coal becomes compact, with a sound roof. At many points along this hundred yards the limestone roof is broken, showing fissures from six to twelve inches wide. Two of these extend well into the sandstone above, where they became enlarged so as to form reservoirs for water, which, in passing through the fissures in the limestone, has worn the rock into irregular shapes. Throughout this distance the bed is cut up by many clay "horsebacks," thrust up from below, while the coal is so crushed and distorted as to be utterly worthless. The shaly layer, No. 7, is much slickensided, and No. 10 is a mass of slaty, slickensided material, which is not removed. The upper coals, Nos. 3 and 5 of section, are good and clean, showing little tendency to run, and bear a decided resemblance to the Briar Hill Coal. Nodules of pyrites occur in these layers, but are not large or numerous, and are easily separated. The black shale, No. 7, which is quite compact, has thus far proved a very serious drawback, maintaining a thickness of seven inches along the entry, which, when visited, had been driven one hundred and fifty yards. It seems, however, to diminish eastward, being only three inches thick in a room opened in that direction. No. 8 seems to be of good quality, but shows a decided tendency to cake upon the fire. Specimens from this bank give the following upon analysis:

	UPPER BENCH.	LOWER BENCH.
Specific gravity	1.287	1.285
Moisture	2.30	2.50
Ash	4.90	6.60
Volatile combustible matter	35.90	36.70
Fixed carbon	56.90	54.20
Total	100.00	100.00
Sulphur	2.03	2.33
Sulphur left in coke	0.98	1.01
Sulphur forming of the coke	1.58	1.66
Fixed gas per pound, in cubic feet	3.40	3.48
Ash	White.	Gray.
Coke	Compact.	Compact.

In prospecting to determine the value of Coal No. 4, Messrs. Tod, Stambaugh & Co. made a number of borings, placing the work in charge of Mr. John Young. A table of the sections exhibited is given on the opposite page. These sections afford an interesting view of the changes which strata undergo within very limited distances. The whole area represented is about one hundred acres. Throughout, Coals Nos. 5 and 4 maintain the same interval, or nearly so, showing that the disturbance, whatever it may have been, causing so marked variations in the distance between 4 and 3, must have occurred before the deposition of the rocks overlying the latter. This case is very similar to one reported by Mr. Read in Vol. I., page 498, showing that the rate of subsidence was not equal in all parts of the coal field, or even within limited areas.

SECTIONS OBTAINED IN BORINGS MADE BY JOHN YOUNG ON PROPERTY OF TOD, STAMBAUGH & CO., NEAR MAGNOLIA, OHIO.

1.	2.	3.	4.	5.	6.	7.
Sandstone, 38. Slate, 2′. Coal No. 4, 4′. Black shale, 45′. Coal No. 3, 1¾′. Fire-clay, 1′.	Sandstone, 32′. Shale, 8′. Limestone, 1½′. Coal No. 4, 2¾′. Fire-clay, 1′.	Sandstone, 35′. Shale, 7′. Limestone, 3′. Shale, 1′. Shale and Coal No. 4, 5′. Black shale, 26½′. Limestone, 2½′. Coal No. 3, 1¾′. Fire-clay, 3′.	Sandstone, 32′. Shale, 8′. Limestone, 2′. Black shale, 1′. Coal No. 4, 4′. Fire-clay, 4′. Shale, 23½′. Limestone, 2¼′. Coal No. 3, 1¾′. Fire-clay, 1′.	Sandstone, 20′. Shale, 17′. Limestone, 3′. Coal No. 4, 4′. Shale, 2′.	Sandstone, 33′. Shale, 1⅓′. Coal No. 4, 4′. Shale, 3′.	Sandstone, 22′. Shale, 18′. Coal No. 4, crushed mass of coal and shale, 4′. Fire-clay, 3′.

SECTIONS OBTAINED IN BORINGS MADE BY JOHN YOUNG—Continued.

8.	9.	10. Shaft.	11.	12.	13.	14.
Sandstone, 23′. Shale, 17½′. Dark, soft sandstone, with bituminous matter, in Coal No. 4, 6′. Shale, 24½′. Limestone, 1½′. Slaty Coal No. 3, 2′. Fire-clay, 1′.	Sandstone, 11′. Shale, 29′. Limestone, 2¼′. Shale, ½′. Coal No. 4, 3′. Shale, 1′.	Shale, 17′. Sandstone, 3′. Shale, 20′. Limestone, 2½′. Coal No. 4, 4′. Fire-clay, 5′. Coal No. 3 (?), 2′.	Sandstone, 16′. Shale, 24′. Coal No. 4, 3′. Shale, 22′. Limestone, 2′. Coal No. 3, 1½′. Fire-clay and shale, 5½′.	Loose sand, 60′.	Loose sand and fragments of shale, 90′.	Shale, 3′. Coal No. 4, 3¾′. Shale, 18′. Limestone, 2′. Coal No. 3, 2′. Fire-clay, 2′.

It is but an unusually clear illustration of the law which guides all good geologists in their study of the Coal Measures, that identity of relative position is not necessarily evidence of identity of strata.

SUMMARY.

The available coal area of Carroll county is circumscribed. The strata of the Barren Group are the only ones exposed in London, Perry, Lee, Fox, and East townships, and in by far the greater portion of Harrison, Union, Center, Augusta, and Orange. The three coal beds of this group are exceedingly variable, both as to thickness and quality, so that little dependence can be placed in them as sources of supply. Coal No. 7 becomes of really workable thickness only at Leesville and in Fox township, near the Jefferson county border. Indeed, in the latter it is s to be of importance only because of necessity. At Leesville, where it is about four feet thick, the coal is of inferior quality and useful only for domestic fuel. The amount of pyrites, visible to the eye and inseparable, is so great as to render the coal worthless in manufacture of either gas or iron. No. *7a* is nowhere of economical value. Though occasionally thick enough to be worked, it always yields inferior coal. No. *7b* is available only at Harlem, and there because the coal is so soft that the ease of mining counterbalances the disadvantage of thinness. With the sole exception of Norwich, in Muskingum county, Harlem is the only locality north from the Central Ohio Railroad where the coal is mined. Every where else the bed is too thin or the coal is too slaty to be of any economical value. In Perry township, Coal No. 6 can be obtained at a depth of not more than seventy-five or one hundred feet, if the boring be made near the saw-mill, about one mile from Perrysville on the road to Palermo, and at the same distance, if made say two miles from Perrysville on the road to Kilgore. If struck at either of these localities, it would probably be of some value, as to the west and southwest of Perrysville it is rarely less than four feet thick, and usually of very good quality. In the northern portion of the county, beyond Carrollton, the same coal can be reached at a depth of from fifty to twenty feet in any of the deeper valleys, the distance diminishing northward. If one may judge from the rapid diminution in thickness and deterioration in quality shown by this bed when followed northward, it is doubtful whether any expenditure in search of it would be judicious.

When proper means of transportation can be secured, Coal No. 6 will assume very considerable importance. In its full development it is confined to the Conotton valley, in Union, Monroe, and Orange townships, where it may be worked from Carrollton to the county line without difficulty. The bed varies somewhat in thickness, but seldom falls below four feet, often reaching five and occasionally even six feet. It is rarely of bad quality, but for the most part contains too much pyrites to be employed in the manufacture of gas or, unless washed before coking, in iron smelting. The coke is usually compact, so that there is every encouragement to test its value, washed, as soon as an outlet is afforded. In the Sandy Creek valley the bed is generally too thin to be of much importance, but in some localities, in Brown and Augusta townships, it attains a thickness of four to four and a half feet, and the quality is good.

The following is an analysis of R. B. Hamilton, Brown township—No. 1, upper bench, No. 2, lower bench:

	No. 1.	No. 2.
Specific gravity	1.328	1.281
Moisture	2.70	3.00
Ash	8.40	3.00
Volatile combustible matter	33.90	33.00
Fixed carbon	55.00	61.00
	100.00	100.00
Sulphur	6.12	1.76
Sulphur left in coke	3.43	0.85
Sulphur forming of the coke	5.41	1.32
Gas per pound, in cubic feet	3.40	3.64
Ash	Brown.	White.
Coke	Compact.	Compact.

The coal mined by Mr. Davis, six miles south-east of Minerva, has the reputation of being the best mined in the vicinity.

Iron.—In the shale underlying the Crinoidal limestone in Union, Lee, Center, and Monroe townships, there is always more or less iron ore, sometimes plate, sometimes blackband, but usually in small nodules or evenly disseminated throughout the mass, which is often twenty feet thick. When concentrated in one layer, the ore is rarely more than four or six inches thick, and of by no means good quality. One can not fail to regret that so many reckless assertions have been made respecting this ore. Wandering geniuses, anxious to acquire a fleeting reputation for knowledge, have gone into ecstasies over this mass of dark shale, and have pronounced it the finest exposure of blackband that they had ever witnessed. In the neighborhood of Cannonsburg and other villages intense excitement has been aroused by these statements, whereas the truth is that in those localities there is no evidence of the presence of iron ore which would justify the expenditure of a single dollar in exploration. A foot or two of good ore, if readily accessible and compact, would be valuable; but if, instead of being in a compact layer, it is diffused throughout ten or twenty feet of shale, or is separated into layers one inch thick and one foot apart, we have not ten or twenty feet of iron ore, but simply a worthless mass. This is a so self-evident truth that one is surprised to find sensible persons so deceived as to doubt it.

Nodular ore is found over No. 7*a*, near Harlem, but not in quantity to be worth any thing. In Perry township, near Mastersville, at the same horizon, plate ore of excellent quality occurs, but further examination, which should be made, is necessary to determine its full value.

The blackband over Coal No. 7, in Rose and Brown townships, is undoubtedly valuable, and is deserving of careful investigation. Those searching for it should remember that this ore is by no means persistent, frequently changing into nodular ore in shale, and this in turn giving place to shale containing a considerable percentage of iron, but too small to render it available. Still, wherever Coal No. 7 is observed it would be well to make an excavation upon it, ten to fifteen feet from the outcrop, so as to reach sound ore if it be present. In Brown township Coal No. 7 is about one hundred feet above Coal No. 6, which is the upper coal at Pekin, Oneida, and is worked by Mr. R. B. Hamilton near Waynesburg. In this township much money has been wasted in exploring the shale underlying the Crinoidal limestone.

Fire-clay.—No critical examination was made of any of the plastic clays, as in every case they gave evidence of the presence of sufficient iron to render them valueless. On the road from Cannonsburg to Carrollton fragments of a compact clay were observed about midway between Coals Nos. 6 and 7, but the position of the bed could not be ascertained, though careful search was made. It is probably very thin. The compact clay under coal No. 5 was observed only in Rose township. Though by no means persistent, frequently giving place to the plastic variety, this clay is of so great economical importance and of such limited distribution, being found elsewhere only at Mt. Savage, Maryland, and near Grafton, in West Virginia, that diligent search should be made at every exposure of Coal No. 5. This clay will probably prove of more advantage to this valley than would an equal thickness of blackband ore.

Clay for the manufacture of brick can be obtained from the subsoil. Building stone of good quality is not plenty. The sandstones, for the most part, are shaly.

Limestone is wanting. The Crinoidal is too impure for lime, and the county contains no other excepting that over Coal No. 4, which is not available.

Water is abundant every where. The fall in most of the streams is quite rapid, and advantageous sites for mills are numerous.

CHAPTER LXI.

REPORT ON THE GEOLOGY OF HARRISON COUNTY.

BY JNO. J. STEVENSON.

Harrison county is bounded on the north by Carroll and Jefferson, on the east by Jefferson, on the south by Belmont and Guernsey, and on the west by Guernsey and Tuscarawas. It is nearly rectangular, and contains fifteen townships, with an area of not far from four hundred and fifty square miles.

Though containing no streams of navigable size, this county is well watered. Stillwater Creek and its various tributaries flow through the south-western portion, the Conotton through the northern townships, while Short Creek drains the eastern, and the tributaries of Wheeling Creek the south-eastern portion. Of the valleys cut out by these streams a few are narrow, with insignificant "bottoms," but for the most part they are broad, with smaller ones entering from each side, and bounded, usually, by hills rounded above by erosion. Though several of the townships are, by this means, almost deprived of coal, the bottom lands are so fertile as to more than compensate for the loss. Especially is this the case in Cadiz, Archer, Stock, and Nottingham townships. In Green, Short Creek, and Athens the erosive action has been energetic, but the hills are steeper, and less adapted to cultivation than in the other townships named. At the west the underlying rocks are principally sandstone, so that the soil is somewhat thin; but in the eastern portions there is a very notable proportion of lime, which renders the soil much more durable. Every where, however, good crops can be obtained in ordinary seasons.

The main source of revenue is wool-raising. In this Harrison county has been preëminent for many years, having, in proportion to her size and population, produced more wool than any other county in the State. This business has proved exceedingly profitable for the last two years, but, in view of the introduction of improved breeds into Colorado and Nebraska, one is inclined to doubt whether Ohio will be justified in raising wool much longer. In our State about one half the land is kept in pasture, while the other half is used in raising winter feed. The value of the land in Harrison county is seldom less than forty dollars per acre, while frequently it is much greater. Under such circumstances, it is difficult to compete with Colorado, where, with a climate equally favorable to the production of wool, the producer pays nothing for pasture, his flocks ranging on government land, and needs to feed for not more than two or three weeks in the winter. It is well for farmers to weigh this matter thoroughly. They should not console themselves with the reflection that sooner or later these lands at the West will be taken up, and so acquire marketable value, for such is not likely to be the case. Colorado can only be settled within striking distance of the rivers, where water may be procured for irrigation, a small portion of the Territory. In addition, the equally serious fact must be remembered that there is a rapidly increasing unwillingness throughout the country to continue the present import duty on raw material, this being regarded by many as injurious to the best interests of the manufacturing classes. Whether this be good political economy or not, may not be determined here. It only remains for those interested in wool-raising to study well the prospects of continued profit in the business.

The principal outlet for the county is the Pittsburgh, Cincinnati and St. Louis Railway, which passes through the northern tier of townships, and sends off a branch to Cadiz, the county seat. Another road is contemplated, which will run through the eastern and northern townships, and another may pass through the south-western corner. The roads throughout the county are, for the most part, good. Educational matters appear to be well attended to. The district school-houses compare favorably with those of other counties, and there are two institutions authorized to confer collegiate degrees.

GEOLOGICAL STRUCTURE.

The superficial deposits are very thin, and have been so far removed or disguised by erosion as to be no longer capable of classification.

The rock formations all belong to the Coal Measures. In North, Monroe, Franklin, Stock, Washington, and Freeport townships they belong almost exclusively to the middle division, termed by Professor W B. Rogers the Lower Barren Group, while in the remaining townships they belong to the Upper Barren Group of the same author. The prevalent south-westerly dip is disturbed by only one anticlinal, which passes nearly north-east and south-west, through German, Green, Cadiz, and Moorefield townships. In the neighborhood of Cadiz this is quite sharp, but at the south-west is not so well marked. Its steeper side is to the north-west, the dip being about double what it is on the south-eastern side.

An approximate section of the county is as follows:

		ft.	in.		FT.	IN.
1.	Débris				10	0
2.	Coal No. 12				2	0
3.	Sandstone, flaggy				50	0
4.	Coal No. 11				2	0
5.	Shale, argillaceous				5	0
6.	Limestone				10	0
7.	Sandstone				20	0
8.	Limestone				10	0
9.	Sandstone				25	0
10.	Limestone				7	0
11.	Sandstone				8	0
12.	Shale				6	0
13.	Coal	0	10	Coal No. 10	11	2
	Fire-clay	0	10			
	Shale	1	8			
	Coal	4	6			
	Shale	3	0			
	Coal	0	4			
14.	Shale, ferruginous				3	0
15.	Sandstone				60-75	0
16.	Shale				0–2	0
17.	Coal No. 9				2	6
18.	Limestone				15–30	0
19.	Shale				3	0
20.	Coal	1 to 2	0	Coal No. 8	7	9
	Fire-clay	1	6			
	Coal	5	3			
21.	Fire-clay, with limestone				5	0
22.	Sandstone				10–40	0
23.	Limestone				3–60	0
24.	Sandstones and shales				60–100	0
25.	Coal				4 to	8
26.	Shales				8–11	0
27.	Crinoidal limestone				4–7	0
28.	Shales, with iron				6	0
29.	Coal No. 7*b*				2	0
30.	Shale and sandstone				90–104	0
31.	Shale, with iron ore				6	0
32.	Coal No. 7*a*				6 to	6
33.	Sandstone				40–50	0
34.	Shales, ferruginous				5–8	0
35.	Coal No. 7				3 to 4	0

		FT.	IN.
36.	Shale, with thin limestone	25	0
37.	Coal No. 6*a*	2	0
38.	Sandstone	50	0

Borings for salt and oil made in various portions carry the section much lower. At Freeport a bed said to be seven feet thick was struck at about one hundred feet below No. 35, and at New Market it is reported four feet at about the same distance, while twenty-five feet lower another seam was found five and one-half feet thick. The upper is undoubtedly Coal No. 6, worked extensively at Urichsville, and the lower is Coal No. 5, worked at Trenton, Tuscarawas county. These two seams may properly be added to the list of available coals, as there are many localities in Freeport, Washington, and Monroe townships where Coal No. 6 can be reached by shafting to a depth of not more than sixty feet, and Coal No. 5 is not likely to be more than thirty or forty feet below it.

Lower Barren Group.—With the exception of No. 38, which, as the equivalent of the Mahoning sandstone, is the upper member of Rogers's Lower Coal Group, the strata below No. 21 of the general section belong to the Lower Barren Group. The variations of the coal seams are as striking as in Pennsylvania or West Virginia, and changes in the other strata are so frequent and abrupt as to cause much difficulty in reconciling local sections.

The Mahoning sandstone is observable only in the south-western portion of the county, in Washington township, along the Stillwater. As seen here it is usually a coarse-grained rock, containing numerous layers of conglomerate. It is slightly ferruginous, and light olive in color. Though too soft for use in door-sills or steps, it answers admirably for ordinary building, and makes a handsome stone. It can be split and dressed with great ease.

Coal No. 6*a* was seen only in Washington township, not far from Brainerd's Mills. At other points, where the strata are cut to a sufficient depth to expose this bed, it was not observed.

Coal No. 7 is well developed in Freeport, Washington, Franklin, and Monroe townships, and is worked in all of these to a greater or less extent. In Freeport township it disappears under the Stillwater a short distance south from Freeport, near which place it is worked by Mr. Leeper. At his bank the coal is about three feet thick, with a clay parting one-half to one and one-half inch thick a little below the middle. Near the top is a thin pyrites streak, and nodular pyrites is found here and there throughout the bed. The pyrites is surrounded by soft coal, and is easily separated. The coal here is of moderately good quality. A number of years ago the same bed was worked near the old mill not far from Freeport. There the thickness is said to be twenty-eight inches.

In Washington township the valley of the Stillwater offers many excellent exposures of this bed, but the people have taken little advantage of it. At Tippecanoe it has an average thickness of about four feet, and is worked somewhat. In Franklin township it has been slightly worked at and near Franklin, beyond which village it disappears under the creek. At Mr. Mulvany's bank, about one mile north-west from Franklin, the coal is four feet one inch thick, but is very friable, and is not held in high repute. Mr. Jones's bank, just north from Franklin, has about the same thickness, but yields a coal of very fair quality. In Monroe township the coal is traceable without difficulty, and is of considerable economical importance. At Philadelphia Crossing it is found sixty feet above the railroad, and is four feet thick. One mile farther up the creek toward Franklin it is three feet three inches, covered with dark, laminated shales, which pass imperceptibly into olive shales above. On the railroad it is worked by Mr. Williams, a mile from the crossing, for shipment. The bed here is about four feet thick, and yields a coal which is not so soft as that from Coal No. 6, as found at Urichsville and Dennison, in Tuscarawas county. Near the tunnel are seen two coal banks, on the north side of the railroad, where the bed has been slightly worked. The coal here is four feet six inches. At Bowerston the coal has been found four feet six inches. The coal from this bed is usually compact, and bears transportation well. It has not much tendency to cake upon the fire, and burns freely if well supplied with air. Its extent and the quality of the coal are likely to render it of considerable economic value.

The shales immediately overlying the coal are usually black or dark-colored, heavy, more or less compact, and usually contain a notable percentage of iron. This is the horizon of the "blackband" ore mined in Tuscarawas county. While none of the material yet observed by us contains sufficient iron to render it valuable, the fact that this is an important iron horizon, together with the constant presence of iron in the shale, is one which should lead property owners to make careful examination wherever an exposure of these shales is seen.

The heavy sandstone above Coal No. 7 varies much in its structure. In Washington and Freeport townships it is usually of moderately coarse grain, soft, and of a straw color, splitting and dressing nicely. The conglomerate layers are few, and the rock is very massive. In Franklin it becomes shaly, and is seldom fitted for building purposes, while in Monroe it becomes dark gray in color and very conglomeratic, containing pebbles varying from one-third to three-fourths of an inch in diameter. It is hard and brittle, but does not appear to be capable of withstanding the weather.

Coal No. 7*a* is thoroughly characteristic in its variations. In Freeport, Washington, Franklin, Stock, and Monroe townships it can be easily traced, but it rarely becomes of economic importance. In Freeport it is not worked, but may be seen near the village of Freeport about one foot thick, and capped by heavy black slate. In Washington township it is occasionally worked in a small way for domestic use. Mr. W. Welch, in section 7, has it four feet thick, of good quality, and easily worked. In the same neighborhood Mr. John Kirby finds it three feet. At Tippecanoe it lies about forty-five feet above Coal No. 7, and the interval is occupied mainly by a massive, olive-colored sandstone.

In Franklin township, about three miles west from Deersville, Messrs. McMillen & Bro. have opened this coal. The following section was obtained on their hill:

		FT.	IN.
1.	Concealed	30	0
2.	Crinoidal limestone	6	0
3.	Sandstone, with shale	90	0
4.	Shale, with iron ore	14	0
5.	Coal No. 7*a*	5	6
6.	Fire-clay	1	0
7.	Sandstone, flaggy	50	0
8.	Concealed	30	0

Coal No. 7 should certainly be found here, at the base of the sandstone No. 7.

In McMillen's bank horsebacks prove very annoying, and the thickness of the coal varies from three and one-half to six feet. The coal is hard and very handsome, but contains much pyrites, distributed in thin seams from one-eighth to three-fourths of an inch in thickness, which occur at small distances apart from the top to the bottom of the bed. It burns well and makes a strong fire, but is said to be exceedingly destructive of stove linings.

This is the only opening in Franklin township where the coal is of any value, and is the only source of supply for a considerable section of country. Attempts to discover the bed at other points have been apparently unsuccessful, and the prevalent opinion is that the deposit is local, confined only to the western side of McMillen's hill. The difficulty lies in the sudden variation in thickness, which is so considerable that the bed is not recognized. On the east side of the McMillen hill the coal was found only eighteen inches thick at the cropping, and showed no increase, though followed for more than one hundred feet into the hill. Two miles west from Deersville it is seen near the road leading through Brownsville, and is there barely sixteen inches. In the immediate vicinity of Deersville openings have been made by Mr. Irwin and others, but in each case the coal was of poor quality and barely twenty inches thick. The same difficulty is experienced elsewhere in the township, so that the McMillen coal, notwithstanding its inferior quality, has a high reputation, and is carried even to Tippecanoe, where Coal No. 7 is well developed.

In Stock township this bed was frequently seen along the Stone Fork of Stillwater. Occasional openings are seen, but the coal is so poor as to discourage all attempts to develop it. Mr. H. B. Lacey, of Laceyville, has run in about one hundred feet without finding any thing but a compact, richly bituminous shale, known in the neighborhood as cannel coal. The bed here is badly cut up by horsebacks, and varies from three to six feet in thickness.

In Monroe township, near Bowerston, an old opening is seen fifty feet above Coal No. 7. This was worked many years ago, but is now deserted, and no observation could be made. The coal is said to be four feet thick. The bed can be traced without difficulty into North township along the roads, and shows a thickness varying from three to eighteen inches.

The shales above this coal are usually dark colored, and contain iron ore, either as blackband or as nodules. In the south-western townships the ore is disseminated throughout the shale, and deposits of blackband are likely to be found there. In Franklin township the ore is in nodules. At McMillen's bank these are quite numerous, but in hardly sufficient quantity to be of any economical value. In North and Monroe townships the ore resting on the coal is well marked, but variable in quality as well as in quantity. At some points it is a rich limonite, at others a blackband, while, again, it is simply nodular ore. It varies in thickness from one to two feet and one-half, and may be reached without difficulty at many points by stripping. The indications are that this will prove to be a valuable deposit, and it is well worthy of extended exploration. Exposures may be found at several points along the road from New Market to Bowerston.

Coal No. 7*b* is quite as variable as No. 7*a*, but differs from it in that it is rarely of any value. Near Deersville, in Franklin township, it has been opened by Mr. Cornelius Vickers. It is two feet six inches thick, and without partings of any kind. It is a low-grade cannel, burning with a beautiful flame, giving a strong fire, but leaving so great a bulk of ashes that it is no longer used. In Rumley township it was opened on Mr. T. Lewis's property, near the village of Rumley, and was found only about one foot thick, so that the working was finally abandoned, after considerable expenditure of money. At no point in Harrison county does this bed seem to be available.

The shales between this coal and the Crinoidal limestone are usually black, with some ore, but not enough, so far as observed, to be of value.

The Crinoidal limestone is a well-marked stratum, and though of variable thickness is easily recognized by its fossils. It marks a well-defined horizon, being in this county never more than one hundred and sixty, and rarely less than one hundred and fifty feet below Coal No. 8, while it holds about the same distance from Coal No. 7 below. It varies in color from bluish-gray to dull brown, and weathers into rude nodules. It is exceedingly hard in some layers, while in others it contains much clayey matter. It is, in most localities, utterly useless, though occasionally it can be burned into a coarse, brown lime. One may trace it through Moorefield, Washington, Nottingham, Franklin, North, and Rumley townships, but the only locality where fossils can be obtained in good condition is at Deersville, near Mr. Cornelius Vickers's house. The following species have been obtained at that locality:

Productus Prattenanus	N.
Productus Nebrascensis	Owen.
Productus longispinus	Sow.
Productus semireticulatus	Martin, Sp.
Chonetes Smithii	N. and P.
Chonetus granulifera	Owen.
Hemipronites crassus	M. and H.
Rhynchonella Osagensis	Swallow.
Spirifer cameratus	Martin.
Spirifer planoconvexus	Shum.
Spirifer lineatus	Sow.
Spiriferina Kentuckensis	Shum., Sp.
Athyris subtilita	Hall, Sp.
Bellerophon. Sp. undetermined.	
Pleurotomaria. Sp. undetermined.	
Petalodus destructor	N. and W.
Lophophyllum proliferum	M'C., Sp.
Zeacrinus mucrospinus	M'C.

In Moorefield and Nottingham townships a coal has been found about twelve feet above the Crinoidal limestone. In Moorefield it is found two feet thick, and yields a cannel of very fair quality. Upon it rests a mass of black slate containing much iron ore, and which, in part, may yet prove to be of some economical value. In Washington township this coal is found not far from the county line on the road from Tippecanoe to Brainerd's Mills. There it is broken up into a mass of coal and ferifferous shale, in alternate layers, very thin, with a total thickness of seven or eight feet. On the other side of the hill the coal has entirely disappeared, and the iron is found in a compact layer of nodular ore one foot thick. In Nottingham it has been opened on Mr. J. Ramsay's property, four miles east from Deersville, on the road to Cadiz, where it exhibits the following section:

	FT.	IN.
Coal	1	8
Clay	1	0
Coal	1	8
Shale	6	0
Limestone	4+	

The clay parting thins out as the bed is followed into the hill, but the coal does not increase in thickness. The material yielded at this opening is exceedingly hard, breaks with a conchoidal fracture, and is of a dull black appearance. Though it burns readily, it can hardly be called coal, but is rather a very compact bituminous shale, which resists the action of the weather. It is probably altogether worthless, and at all events can not be profitably worked, for Coal No. 8 is found in the same hill one hundred and forty feet above it. This coal was not observed in German or Rumley townships.

The strata between this horizon and Coal No. 8 are subject to great variation. The following section was obtained on the road from Cadiz to Adena:

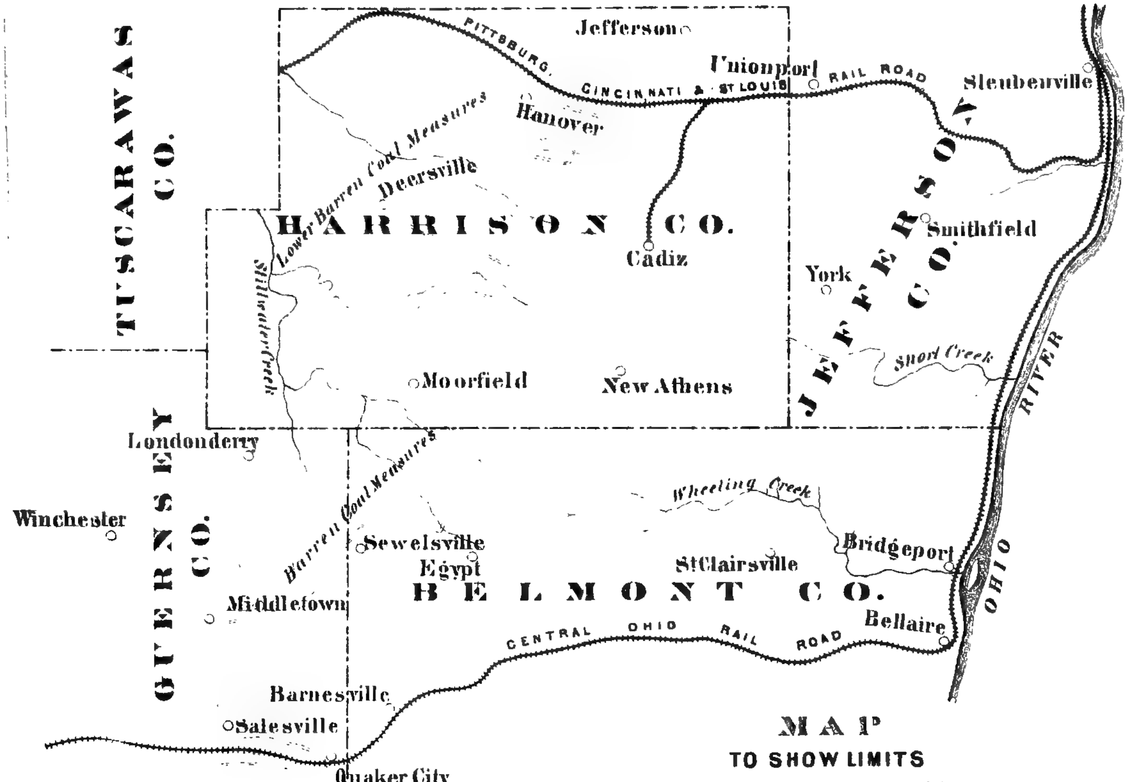
	FT.	IN.
1. Coal No. 8	8	0
2. Sandstone, with thin limestone	40	0
3. Limestone	45	0
4. Sandstone and shales	55	0
5. Coal	1	0
6. Sandstone	8	0
7. Crinoidal limestone	6	0

Another section was obtained on the road from Georgetown to New Athens, as follows:

	FT.	IN.
1. Coal No. 8	—	—
2. Limestone	3	0
3. Sandstone	20	0
4. Limestone	6	0
5. Sandstone	90	0

The section at the tunnel, near Cadiz Junction, on the Pittsburgh, Cincinnati and St. Louis Railway, is as follows:

	FT.	IN.
1. Coal No. 8	—	—
2. Sandstone	14	0
3. Limestone	4	0
4. Sandstones and shales	115	0



MAP
TO SHOW LIMITS
OF THE UPPER COAL MEASURES IN OHIO,
NORTH FROM CENTRAL OHIO R.R.
The double dotted line shows western and northern boundary of the Pittsburg Coal.

At this locality the shales and sandstones in No. 4 are very irregularly stratified, and the clayey portions contain great numbers of *Neuropteris hirsuta*, *Neuropteris flexuosa*, and *Asterophyllites*, sp., together with many stems of indeterminate character.

Upper Coal Group.—The northern and western limit of this group is very irregular, owing to extensive erosion. From the county line on the east it runs south of the railroad to about Cadiz Junction, where it turns abruptly north, and passes about half a mile east of Jefferson, in German township. Turning north-westward, it continues to the line of Carroll county, where it bends to the south-west into Rumley township, and crosses the road from Jefferson to Rumley about two and one-half miles east of the latter place. There it turns south-east, and crosses the railroad about two miles east of Fairview. After crossing the railroad it follows the northern line of Archer township almost to Hanover, where it turns abruptly south-east to almost the central line of the township, being cut out by the Clear Fork of Stillwater. It then turns sharply westward to near the western limit of Archer, where it is again deflected south-eastward by the valley of Stone Fork. This course continues to the line of Cadiz township, where it changes westward, and follows the ridge road to Deersville to within a mile of that village. There it resumes the south-easterly direction, passing through Nottingham township, and barely crosses into Cadiz township, where it again turns westward, and runs irregularly west south-west to section 26 of Nottingham, where it crosses into section 25 of Moorefield township. Here it runs south for a mile, and then turns south-eastward, and, passing through section 10, crosses the county line into Belmont county. It embraces in this county five coal beds, two of which are of workable thickness. Unlike those of the Barren Group, its strata show few important variations, and these are regular.

Coal No. 8 is fully developed and readily accessible in Moorefield, Archer, Cadiz, Athens, Short Creek, Green, and parts of German and Nottingham townships. With few exceptions, it is a double bed, consisting of roof-coal, fire-clay, and the main coal. At varying distances it contains thin partings of mineral charcoal, mixed with clay, not readily traceable in the solid coal, but very distinct at the outcrop. Within twelve or fifteen inches from the top a streak of pyrites, varying from one-eighth to three-fourths of an inch thick, is found in the main coal. Just below the center is a compact clay parting, seldom more than an inch thick, and three to eight inches below is another precisely similar. A second streak of pyrites, thinner than the one near the top, is not unfrequently found ten or twelve inches from the bottom. The coal is softer just above the upper parting than in other portions of the bed, and that is known as the "bearing-in bench." For the most part the coal is of good quality, and contains about thirty-three per cent. of volatile matter.

In Moorefield township it is extensively worked, near Moorefield village, by Mr. C. A. Skinner in section 23, Mr. J. Comper in section 22, Mr. R. Moore in section 25, Mr. J. Mansfield in section 17, and by many others. A section of Mr. Wallace's bank in section 12 is as follows:

		FT.	IN.
1.	Coal	0	10
2.	Pyrites band	0	1
3.	Coal	1	10
4.	Parting	0	1½
5.	Coal	1	2
	Total	4	0

In Mr. Mansfield's opening the coal is about five feet thick. The pyrites band is well marked, and nodules of pyrites are sometimes found weighing twenty or thirty pounds. There is no roof-coal visible in any of the openings, the bed being roofed by two feet of shale. The coal is generally regarded as inferior to that obtained further to the east.

In Athens township this coal is worked at numerous openings for domestic use. It is accessible in nearly all the deep ravines, and may be easily found, as it lies from ninety-five to one hundred feet below Coal No. 10, which is frequently seen along the ridge roads. The roof-coal was not seen at any of the openings examined, and the roof appears to be sandstone. Situated for the most part in ravines, the openings afford no satisfactory section of the overlying rocks. At Mr. James Clemens's bank, section 30, the coal is as follows:

		FT.	IN.
1.	Sandstone (not measured).		
2.	Coal	1	6
3.	Parting	0	1½
4.	Coal	0	4
5.	Parting	0	0½
6.	Coal	1	3
7.	Parting	0	1
8.	Coal	0	10
	Total	4	2

Here the pyrites streak in the upper bench is not well marked, though the upper parting contains much of the sulphuret. The parting near the bottom is full of pyrites, and is distinguished near the mouth of the bank by its white incrustation.

In Short Creek township the openings are numerous near Harrisville and Georgetown. Near the latter place Mr. A. Jamison's bank shows the roof-coal two feet and the lower coal five feet, separated by fire-clay ten inches. At Mr. John Calderhead's opening on Short Creek, near the northern boundary of the township, we find:

	FT.	IN.
1. Roof-coal	1	0
2. Fire-clay	1	to 6
3. Coal	5	0
Total	7	0

An analysis of coal from a bank near Georgetown gives the following result:

Specific gravity	1.266
Moisture	2.80
Ash	3.60
Volatile combustible matter	34.20
Fixed carbon	59.46
Total	100.00
Sulphur	1.80
Sulphur left in coke	1.04
Sulphur forming of the coke	1.65
Fixed gas per pound, in cubic feet	3.32

Coke, compact. Ash, gray.

In the same township, about two and one-half miles from Cadiz, Mr. Hamilton's bank gives the following section:

	FT.	IN.
1. Bituminous shale	0	10
2. Coal	1	0
3. Fire-clay	1	6
4. Coal	5	6
5. Limestone	2	0

This section appears to be characteristic of the bed in the north-eastern portion of the township, as similar sections were obtained at several other banks in the neighborhood. The limestone is nodular, and very hard.

In Green township the openings are very numerous, and the bed varies much in thickness. At Mr. D. Allison's bank, section 3, which is one of the best, as to management, observed in the county, we find the following section:

	FT.	IN.
1. Coal, bituminous shale (not measured).		
2. Coal	1	8
3. Fire-clay	0	10
4. Coal	5	1
	7	7

The coal in the lower portion is hard and compact, and is in high repute among blacksmiths. In the bank of Mr. William Holmes, on the road from Hopedale to Miller's Station, the intimate structure of the bed is very well shown. We there find:

	FT.	IN.
Roof-coal	0	3–8
Fire-clay	0	6–8
Coal	2	1
Parting	0	1
Coal	1	3
Parting, with pyrites	0	1
Coal (seen)	1	0

Specimens from Mr. Allison's bank were analyzed, with the following results:

	TOP.	MIDDLE.	BOTTOM.
Specific gravity	1.295	1.278	1.283
Moisture	2.50	2.60	2.20
Ash	5.20	5.45	5.20
Volatile combustible matter	33.50	31.40	32.20
Fixed carbon	58.80	60.55	60.40
Totals	100.00	100.00	100.00
Sulphur	3.32	2.30	2.26
Sulphur left in coke	1.75	1.19	1.45
Sulphur forming of the coke	2.75	1.80	2.22
Fixed gas per pound, in cubic feet	3.40	....	3.64
Ash	Fawn.	Gray.	Gray.
Coke	....	....	Compact.

In German township the coal is extensively worked in the neighborhood of Jefferson to supply a large district of country. No workable bed being known in North or Rumley, or in the adjoining portions of Carroll or Jefferson counties, coal is drawn from Jefferson to meet the demand. At Mr. Hibbs's bank, near Jefferson, the roof-coal is not exposed, but the lower coal gives the following section:

	FT.	IN.
1. Coal	1	9
2. Parting	0	½
3. Coal	0	6
4. Parting	0	1½
5. Coal	1	2
6. Parting	0	½
7. Coal	1	2
	4	9½

The coal is traceable south from Jefferson into Green township, and is worked at various points. At a short distance north from the tunnel, near Cadiz Junction, an opening shows the roof-coal 8 inches, fire-clay 1 foot, and coal 4 feet ten inches. The coal throughout is of good quality. The bed was followed into Rumley township, but there are no openings there. This is somewhat strange, when we consider that that township is supplied with coal from Jefferson. At several points along the road from Jefferson to Rumley the bed is to be seen underlying patches of from ten to twenty acres, with a good roof, and seventy feet below the hill-tops. Some of these patches contain not less than 350,000 bushels of sound coal, liberal deduction being made for unsound coal about the margin. Under the circumstances, these remnants, spared from erosion, might be profitably worked by their owners, and much would be saved to consumers.

In the central portion of Archer township the greater part of the coal has been removed by erosion, and most of what remains is in detached portions, from twenty to fifty acres in extent, and lying near the tops of the hills. Along the eastern and northern lines coal No. 8 is readily accessible, and worked to a considerable extent for domestic use. At Mr. Nathaniel McFadden's opening, in section 7, the coal is as follows:

	FT.	IN.
Coal	1 to	10
Shale	0	4–6
Coal	5–5	6

At this bank the upper pyrites band does not appear, and the upper bench is thirty-one inches thick to the upper parting. This coal is said to be remarkably pure, there being no pyrites apparent, and is so favorably regarded by blacksmiths that it is hauled for their use to a distance of eight or ten miles. At Mr. J. Atkinson's opening, in section 16, the roof-coal appears to be absent, and the section is:

	FT.	IN.
Coal	0	6
Pyrites band	0	½ to 1
Coal	1	6
Parting	0	3
Coal	0	10
Parting	0	1
Coal	1	2
	4	5

The opening of Mr. Henry Eslick, in the same neighborhood, shows a similar section. Two and one-half miles south of Fairview some deserted banks show a thickness of four feet six inches. At the infirmary the bed is five feet. This coal is seen at Mr. Feck's opening, in North township, near Hanover, but is there so near the surface as to be of comparatively little value.

In Nottingham township Coal No. 8 is worked by Mr. Albert Barrett in section 8, Mr. Hamilton in section 26, and by Messrs. Ramsay & Brown in section 6. At Mr. Ramsay's opening the section is:

	FT.	IN.
Coal	0	10
Fire-clay	0	10
Coal	4	0
Fire-clay	3	0

There are several openings in the immediate vicinity of this one, all of which give materially the same section. The coal is soft, and though liked by blacksmiths, is not much prized for domestic use. The inhabitants of Deersville prefer the inferior coal from McMillen's bank, as it is more durable and makes a stronger fire. The bed is worked quite largely in the south-western portion of the township, on the borders of Moorefield, and is carried six miles to Freeport.

In Cadiz township the openings are very numerous along the Deersville and the Moravian roads, and several deserted banks may be seen on the Cambridge road. On the Deersville road the coal seems to thicken as it passes eastward. At Mr. Ramsay's, in Nottingham, it is only four feet. Two or three miles beyond, at Mr. Alexander Henderson's opening, it is four feet six inches, while at Mr. Wm. Hendy's bank, little more than a mile west of Cadiz, the following section is seen:

	FT.	IN.
1. Coal	1	3
2. Fire-clay	1	2
3. Coal	5	6

At Mr. Hendy's bank the dip is reversed. From Deersville to this point the dip is uniformly south-east at the rate of twenty feet to the mile, but from this line to Cadiz it is north-west at not less than fifty per mile. At Cadiz the coal is fifty feet below the railroad dépôt. Messrs. Beebe and Manly work the coal with a shaft just north of Cadiz. The foreman gives the following as the section in the shaft: Coal, two feet; limestone, five feet; fire-clay, two feet; coal, five feet. If this statement be accurate, we have here an exceedingly circumscribed limestone, for it is not visible at any of the exposures in the immediate vicinity. The condition seems to be anomalous. Specimens were taken from the banks of Mr. Hendy and Messrs. Beebe and Manly, which have been analyzed by Dr. Wormley, with the following results. Nos. 1, 2, and 3 are the top, middle, and bottom, from Beebe and Manly's opening, and No. 4 is from Mr. Hendy:

	No. 1.	No. 2.	No. 3.	No. 4.
Specific gravity	1.291	1.266	1.295	1.250
Moisture	2.40	2.20	2.40	2.10
Ash	5.10	4.60	6.10	4.20
Volatile combustible matter	34.00	34.40	34.60	34.90
Fixed carbon	58.50	58.80	56.90	58.80
Totals	100.00	100.00	100.00	100.00
Sulphur	2.62	2.65	2.96	2.68
Sulphur left in coke	1.33	1.28	1.26	1.40
Sulphur forming of the coke	2.09	2.01	2.00	2.22
Fixed gas per pound, in cubic feet	3.26	3.73	3.05	3.32
Ash	Gray.	Fawn.	Fawn.	Gray.
Coke	Compact.	Compact.	Compact.	Compact.

The rocks above Coal No. 8 are usually shale, succeeded by from fifteen to thirty feet of limestone to Coal No. 9. This limestone, which is found throughout Short Creek, Green, Cadiz, and Archer townships, is not compact, but consists of numerous thin layers, differing in structure and color, and separated by thinner layers of calcareous shale. The upper layer, immediately below Coal No. 9, occupies the position of Parker's "cement-rock," at Barnesville, in Belmont county. Two analyses of this rock have been made by Dr. Wormley, with the following results:

	No. 1.	No. 2.
Silicious matter	11.10	12.80
Alumina and oxide of iron	1.90	4.20
Carbonate of lime	83.20	79.40
Carbonate of magnesia	3.22	3.48
Totals	99.42	99.88

No. 1 was obtained from the road near the cemetery, south-east from Cadiz, and No. 2 from Mr. Alex. Henderson's property, on the Deersville road from Cadiz. These analyses show that this layer, which is about two feet thick, will yield a hydraulic lime of good quality. The other layers afford most of the lime for domestic use in the townships referred to above.

Near the border of Nottingham and Cadiz townships, along the ridge road to Cadiz, this limestone is entirely replaced by sandstone, which rests directly upon a thin shale above the coal; and this continues west to the limit of the coal. In Moorefield township the displacement is not complete, and a thin limestone rests on the shale. This condition has been traced into Belmont county, and to the Central Ohio Railroad, and is persistent in Guernsey county. The line of the eastern limit of the sandstone is from north north-east to south south-west, and evidently marks the eastern boundary of a strong current from the north which cut away the limestone, and in portions of Belmont county even tore out the coal. In Nottingham township the force was greater than in Moorefield, for in the former township the limestone has been entirely cut out, whereas in the latter a small portion is left.

Coal No. 9 is a very persistent bed, and shows little variation in thickness or quality. It is only two feet six inches thick, with a two or three-inch parting in the middle. Lying only fifteen to thirty feet above Coal No. 7 and sixty to seventy below Coal No. 10, one or the other of these coals is available wherever it is exposed, and it is nowhere worked. Mr. Alex. Henderson, three miles west from Cadiz, in sinking a well passed through this bed and burned some of the coal. He found it remarkably pure, giving off no sulphurous odor when the hot coals were wet, but much softer than the coal below.

Coal No. 10 may be frequently seen at road-side exposures in Cadiz, Short Creek, and Athens, and occasionally in Rumley, Jefferson, and Archer. The coal is somewhat inferior to that from Coal No. 8, and the bed is thinner, so that it is not worked as extensively as its thickness would warrant. It passes under the court-house at Cadiz, and is exposed in the road-side, near Mr. D. Hines's house, east from Cadiz. Here, as at the neighboring exposure at Mr. Hedges's house, the cropping is too indefinite to admit of measurement.

Near the old plank-road, in Short Creek township, near Mr. Dickerson's house, and two and one-half miles south-east from Cadiz, the coal is exposed at the road-side, and gives the following section:

		FT.	IN.
1.	Shale	6	0
2.	Coal	0	10
3.	Shale	3	0
4.	Coal	4	6
5.	Shale	3	0
6.	Coal	0	4
7.	Sandstone (not measured).		

At another locality in this township, about two miles west from Harrisville, on the road to New Athens, the smaller seams are wanting, and only the main coal is found, four feet seven inches thick, and without any partings.

In Athens township this coal is worked to some extent to supply New Athens, which lies too high to reach Coal No. 8, being more than one hundred feet above Coal No. 10. The openings were all full of water at the time of examination, and nothing could be learned from them; but at a new cut, about half a mile west of New Athens, on the road to Moorefield, the section is

		FT.	IN.
1.	Coal	0	10
2.	Fire-clay	0	10
3.	Shale	1	8
4.	Coal	4	7
5.	Shale	3	0
6.	Coal	0	4
7.	Shale	4	0
8.	Sandstone (not measured).		

This coal contains a notable portion of pyrites, and is not usually held in favor. It was found impossible to procure satisfactory specimens for analysis.

The strata above Coal No. 10 are somewhat variable. Usually there are two beds of limestone of considerable thickness, but occasionally only one is found. These limestones are very ferruginous, and apt to weather into an ochreous mud. The upper one is sometimes conglomerate.

Coal No. 11 is a thin seam, of no economical importance, is nowhere worked, and is seen only on the ridge roads leading from Cadiz and Moorefield to New Athens.

Coal No. 12 is seen only at the junction of the Flushing and Moorefield roads, in Athens township, two miles west of New Athens.

SUMMARY.

The important mineral of Harrison county is coal. The distribution is very irregular, owing to the extensive removal of Coal No. 8 by natural agencies. Coal No. 7 attains to sufficient thickness in Monroe and Washington townships to be of economical importance. For domestic use it is fully equal to Coal No. 6, and being of the same thickness along the Pittsburgh, Cincinnati and St. Louis Railway, could easily be brought into competition with it. Coal No. 8, however, is likely to be the main source of supply for home use and export, as it is more generally distributed, and is thicker and better than any other seam. The analyses of this coal show a large proportion of volatile combustible matter, rendering it a useful gas coal, although the sulphur may make the purification process somewhat expensive. The percentage of sulphur remaining in the coke manufactured from it in the ordinary way unfits it for use in the reduction of iron, and necessitates washing previous to coking. The washing process has been introduced successfully in Jefferson county, and will be here as soon as a demand arises for the coke.

In a large portion of Archer, Cadiz, and Green townships, Coal No. 8

has been so eroded that it is left only in patches of varying size, separated by the valleys. These patches of coal, containing from ten to one hundred acres of the coal, will all prove valuable ultimately if properly cared for; but if the present method of penny-wise mining be continued by farmers, many of the smaller patches will be worthless before ten years. Workings should not be deserted without good cause, nor should chambering be began near the mouth of the entry. In many hills several deserted banks may be seen not one hundred feet apart. In these the timbers have rotted, the hill-side has fallen in, and now, instead of compact rock, the material is a shattered *débris*, which effectually prevents access to the coal within. The method now employed of obtaining the greatest quantity of coal in the shortest space of time, and with the least possible expenditure of money, is sure to prove ruinous.

Iron.—The ore horizons of Coals Nos. 7, 7*a*, and 7*b*, though by no means fully explored, give sufficient evidence of good ore to encourage careful examination in North, Monroe, Washington, and Freeport townships.

The *lead* tradition is strong in several localities, and one enthusiastic individual residing not far from Freeport expended a good deal of time and some money in exploration, but without success. No lead, silver, zinc, tin, copper, or gold will ever be found in economical quantities among rocks of the Coal Measures. Where lead has been found, it belonged to the stores accumulated by the Indians, and is no evidence of lead deposits in the vicinity, for lead never occurs in the metallic condition.

Building Materials.—In the eastern section of the county, stone for building purposes is not plenty, though one or two of the higher sandstones are employed. Farm-houses are built of wood, and in the villages brick is used. In the western townships, the sandstone over Coal No. 7 affords an unlimited supply. This rock is too soft to be used under foot, but certainly makes a handsome material for walls. Lime of good quality for ordinary work is obtained from the limestones under and over Coal No. 8, but none of it is white enough for in-door work. The upper layers of the limestone over Coal No. 8 will furnish a hydraulic lime. Clay, of good quality for ordinary bricks, is found nearly every where in the subsoil, though in some of the eastern townships there is sufficient limestone to render it worthless. No good fire-clays were seen.

CHAPTER LXII.

REPORT ON THE GEOLOGY OF GUERNSEY COUNTY, NORTH OF THE CENTRAL OHIO RAILROAD.

BY JNO. J. STEVENSON.

Guernsey county is bounded on the north by Tuscarawas and Harrison, on the east by Belmont, on the south by Noble, and on the west by Muskingum and Coshocton. It is somewhat irregular in shape, has twenty townships, and embraces an area of somewhat more than five hundred square miles.

The portion lying to the north of the Central Ohio Railroad has suffered much from erosion, and its surface shows numerous deeply excavated valleys and many sharply defined ridges. The drainage system consists of Wills Creek and its tributaries, which form almost a net-work over the entire county. Wills Creek follows a tortuous course north and south through the western portion, and has a fall of barely one foot per mile. It is a sluggish stream, carrying a good deal of water, which, at one time, was thought sufficient to justify an attempt at slack-water navigation. Formerly tremendous freshets happened each year, during which the stream would overflow its banks and acquire a depth of ten to fifteen feet, which it would retain for several weeks. In earlier years it afforded an outlet for rafts and flat-boats, but of late, owing to the long-continued drouths, the water has been very low. Its bottoms are very broad and rich, and at several localities the valley presents scenes rarely excelled in quiet beauty.

Aside from that on the bottoms, the soil is usually poor. As this county lies beyond the limit of drift action, its soil is derived chiefly from the underlying rocks. These are chiefly shales and sandstones, with but little limestones; so that, except on the eastern border, where the limestones at the base of the Upper Coal Group are reached, the soil is thin and loose. In some localities it affords barely hold for grasses on the hill-sides, and during heavy rains is washed out, forming deep gullies, which continue to increase in size, notwithstanding heaps of logs and brush thrown in to impede the erosion. Little of the land remains uncultivated, and even the hill-sides are put in corn—a wasteful operation where they are so steep and the soil so thin. Much attention is paid to sheep-raising, which is thought to be the only pursuit yielding a fair interest on the value of the land. It is probable, however, that eventually Guernsey county will become important as a dairy district, for it possesses many springs of cool, soft water, and its hill sides are fitted only for pasture.

The outlets are the Central Ohio Railroad, running east and west through the southern portion of the county, and the Cleveland, Pittsburgh and Marietta Railroad, which passes through the western portion, while another road will probably be built in the east. The county seat is Cambridge, on the Central Ohio Railroad, which is rapidly increasing in population and business importance. Throughout the county the inhabitants are industrious and, notwithstanding the comparative poverty of the soil, prosperous.

GENERAL GEOLOGY.

The consolidated rocks belong wholly to the Coal Measures. In the eastern portion, the lower strata of the Upper Coal Group are exposed, and in the north-western corner some are seen belonging to the Lower Coal Group. The main portion of the county shows nothing but rocks belonging to the Lower Barren Group, which are chiefly sandstones and shales, with a few thin limestones and several uncertain beds of coal.

In this county we find two anticlinals. The more important one seems to be closely related to that already described in the report on Harrison county, and has a north-eastern and south-western direction through Londonderry, Madison, Center, Cambridge, and Adams townships. Its synclinal axis passes through Monroe, Liberty, and Adams. Near Antrim the north-westward dip is nearly one hundred feet to the mile, but towards Cambridge it apparently decreases. In that township it evidently throws off a spur of small dimensions to the south. The eastern slope has been more eroded than the western, and several small areas of Coal No. 8 are found on the latter, separated from six to ten miles from the western outcrop of that coal. Along the southern prolongation of the axis erosion has been so active as to render the phenomena very obscure.

The other anticlinal crosses the Muskingum line into Guernsey county not far from the junction of Knox township, Guernsey county, and Linton township, Coshocton county, and is identical for some distance with the "Irish Ridge" of the former township. It is quite abrupt to the east, and causes an elevation of not less than one hundred and thirty feet. The direction is east of north and west of south, so that the trough between it and the axis already referred to becomes very narrow toward the railroad.

An approximate section of the county is as follows:

		FT.	IN.
1.	Sandstone	30	0
2.	Coal No 10	3	0
3.	Fire-clay	3	0
4.	Sandstone	45	0
5.	Coal No. 9	2 (?)	0
6.	Sandstone	50	0
7.	Coal No. 8	4	0
8.	Fire-clay, with iron	12	0
9.	Limestone	6	0
10.	Shales, semi-argillaceous	25	0
11.	Sandstone	25	0
12.	Limestone	3	0
13.	Sandstone and shale	85	0
14.	Crinoidal limestone	2–5	0
15.	Shales	2–10	0
16.	Coal No. 7*b*	3	0
17.	Fire-clay	2	0
18.	Sandstone and shale	75	0
19.	Shale	10	0
20.	Coal No. 7*a*	2	0
21.	Fire-clay	1	6
22.	Sandstone	45	0
23.	Shales	10	0
24.	Coal No. 7	5 to	8
25.	Fire-clay	2	0
26.	Sandstone	80	0
27.	Shales	10	0
28.	Coal No. 6	3	0
29.	Fire-clay	4	0
30.	Shale	20–40	0
31.	Gray limestone	2	0
32.	Coal No. 4	2–5	0
33.	Fire-clay	15	0
34.	Shale	20–46	0
35.	Blue limestone	3	0
36.	Coal No. 3, cannel	2	6

Coal No 10 is found only along the eastern margin of the county, and is not worked. The same is true of Coal No. 9.

Coal No. 8, though of economical importance only in Millwood and portions of Oxford and Londonderry townships, is of interest, as here we find its western limit, and with it that of the Upper Coal Group, north of the Central Ohio Railroad. The line begins at the railroad, in Millwood township, near Belmont county, and runs west through the township to and one mile north of the road to section 32, where it turns abruptly northward through sections 33 and 34, into Oxford township. There it follows a tortuous course through sections 35, 36, 37, 25, 20, 21, and 27, into sections 28 and 35 of Londonderry. In this latter section the direction, previously north-west, is changed to south-east, through 35, 29, and 22, into 15, 8, and 2 of Oxford, where the course becomes north-east through 3 of Oxford into 4 and 5 of Londonderry, from which it crosses into 35 of Kirkwood township, Belmont county. Isolated patches are found on the western side of the anticlinal in sections 20 and 25 of Londonderry, 13 and 17 of Madison, and very probably in 10 and 17 of Jefferson, though in this latter case the coal was not observed. In Guernsey county the roof of Coal No. 8 is usually sandstone, sometimes separated by a few inches of shale, and the roof-coal is rarely present. Sandstone "horsebacks," of considerable extent, and "clay veins" are of frequent occurrence, and have a direction rudely north-east and south-west. The thickness of the coal varies little from four feet, and the quality is inferior to that of coal brought from the river. The strata below this coal to a depth of about one hundred and fifty feet are subject to great and sudden variations, sometimes consisting almost entirely of sandstone, while at others they are almost wholly shales.

The Crinoidal limestone, though thin, is an exceedingly important stratum. In the Barren Group, where the coals vary abruptly and the accompanying strata are for the most part characterless shales and sandstones, the geologist would be frequently at a loss unless some well-characterized stratum were found marking a definite horizon. Such a guide is found in this little limestone, which lies almost midway between Coals Nos. 7 and 8, being ordinarily one hundred and fifty feet above the former and one hundred and fifty to one hundred and sixty feet below the latter. It is usually very hard and impure, weathering into blocks dull gray outside, and dingy brown, or light gray, on the freshly fractured surface. The weathered exterior is covered with plates and spines of crinoids, together with many spines of mollusca. The specimens frequently weather entirely free from the rock, and several species common throughout the Ohio Coal Measures can be obtained in good condition from this stratum alone. Fossils can be collected at Quaker City, at Salesville, at several points along the road from Salesville to Washington, as well as between Birmingham and Londonderry. The rock is well exposed in Millwood, Wills, Center, Knox, Madison, Washington, and Londonderry townships. The following is a list of its fossils:

1. Crinoidal plates.
2. Crinoidal columns.
3. Zeacrinus mucrospinus .... M'C.
4. Lophophyllum proliferum .... M'C., Sp.

5. Lophophyllum. Sp. undetermined.
6. Productus semi-reticulatus .... Martin, Sp.
7. Productus Prattenanus .... Norwood.
8. Productus Nebrascensis .... Owen.
9. Productus punctatus.
10. Productus longispinus .... Sow.
11. Productus. Sp. undetermined.
12. Chonetes granulifera .... Owen.
13. Chonetes Smithii .... N. and P.
14. Ortbis carbonaria .... Swallow.
15. Hemipronites crassus .... M. and H.
16. Rhynchonella Osagensis .... Swallow.
17. Spirifer cameratus .... Morton.
18. Spirifer planoconvexus .... Shumard.
19. Spirifer lineatus .... Sowerby.
20. Spiriferina Kentuckensis .... Shum., Sp.
21. Retzia punctilifera .... Shum.
22. Athyris subtilita .... Hall, Sp.
23. Discina nitida ?
24. Nucula (like Nucula ventricosa, H.).
25. Yoldia (like Yoldia carbonaria, Meek).
26. Euomphalus rugosus .... Hall.

27–28. Bellerophon. 2 sp. undetermined.

29. Pleurotomaria. Sp. undetermined.
30. Macrocheilus primogenius .... Conrad.
31. Macrocheilus. Sp. undetermined.
32. Cyrtoceras. Sp. undetermined.
33. Phillipsia. Sp. undetermined.
34. Petalodus destructor .... Newberry.

The shales immediately above the limestone frequently contain numerous specimens of *Spirifer cameratus*, and it is more than probable that the *Nucula* and *Yoldia* of the list are from the shales. In some portions of the county a slaty coal or bituminous shale is found ten or twelve feet above the limestone, but it is of no value at any point where seen.

Coal No. 7*b* is worked at various localities in Madison, Jefferson, Center, and Cambridge townships. It is variable in thickness—four feet in Madison to ten inches in Knox—but is persistent, having been traced from Carroll county, through Harrison and Guernsey, to within three miles of the Muskingum River, in Muskingum county. It is seldom of economical value, being usually a cannel coal of low grade.

The interval between the Crinoidal limestone and Coal No. 7*a* seems to increase southwardly, for in Adams township a peculiar buff limestone is found seventy-five feet above the coal and from fifty to seventy feet below the crinoidal. Above this limestone, which is fossiliferous, there is a thin streak of coal, which, however, is of no value in this county. In no other portion of the county was this limestone observed.

Coal No. 7*a* is of value only in Liberty, Jefferson, and Monroe townships, where it is between three and four feet thick, and in these townships is used only because no other coal is accessible. Usually it is of poor quality. Overlying it is a heavy sandstone, containing many vegetable remains, and apt to be conglomerate. As in Harrison county, iron ore is not unfrequently found above this bed, but, as far as observed, the quantity is unimportant. Occasionally, blackband is found over No. 7*b*, and that may prove to be an ore horizon of some local value.

Coal No. 7 is of little importance north of the Central Ohio Railroad, and its variations are exceedingly perplexing. At one locality it is five feet thick; two miles north-west it is eight inches; three miles farther north it is three feet; after which to the north it varies from ten to eighteen inches. It can be traced through Cambridge, Center, Liberty, Monroe, and Adams townships, but is worked only in Center and Cambridge. South of the railroad it is of considerable value. The sandstone above this bed is very massive, and apt to be conglomerate. The shales resting on the coal are dark-colored, and occasionally become true blackband.

Coal No. 6 was observed only in Liberty, Wheeling, and Knox townships, in each of which it is extensively worked for domestic use. It varies from thirty-three inches in Liberty to four feet in Knox. The coal is usually of good quality. The shales overlying it are full of ferruginous nodules, having fragments of zinc blende as their nuclei. At the junction of the shales with the sandstone above a large quantity of nodular iron ore occurs, but it is so intimately associated with the sandstone as to be practically worthless.

Coal No. 4 was seen at several localities in Liberty and Wheeling townships. The gray limestone above it contains great numbers of *Spirifer lineatus*, and is not persistent. The coal varies from eighteen inches to five feet, and is worked only in Liberty township. The distance between this bed and No. 6 is very variable in this county, and equally so in Muskingum county, as will be seen by reference to that report. In south-east Liberty No. 4 is only twenty-eight feet below No. 6. Five miles to the north-west the distance is somewhat more than forty feet; while five miles farther to the north-west it is one hundred and five feet. This evidently shows that the subsidence which put a stop to the formation of a coal-bed bore no fixed relation in its local extent to the length of time intervening before the formation of the next bed above.

Coal No. 3 was seen only in Wheeling township, the blue limestone resting upon it, and only twenty feet below Coal No. 4. At Liberty the limestone has been struck fifty-nine feet below Coal No. 4. The coal is cannel, and of good quality. The limestone is shaly below, and of a deep blue color. It contains numerous specimens of *Productus longispinus*, *Chonetes mesoloba*, and *Athyris subtilita*.

LOCAL GEOLOGY.

Millwood Township.—The section of this township is as follows:

		FT.	IN.
1.	Sandstone	30	0
2.	Coal No. 10	3	6
3.	Fire-clay	3	0
4.	Sandstone	55	0
5.	Coal No. 9	2	0
6.	Limestone	5	0
7.	Sandstone	50	0
8.	Coal No. 8	4	2
9.	Shale and fire-clay	12	0
10.	Limestone	6	0
11.	Shale, arenaceous	50	0
12.	Limestone	3	0
13.	Shales and sandstones	80	0
14.	Crinoidal limestone	2	0
15.	Shales (seen)	5	0

Coals Nos. 9 and 10 are not worked, and No. 9 is seen only in the south-eastern portion of the township. The limestone below No. 9 is also confined to the same locality.

Along the Central Ohio Railroad Coal No. 8 is worked to some extent near Bailey's Mills, near Spencer's by Mr. Flood, near Quaker City by Mr. Gildow, and near Salesville by Mr. Brill. At all of these openings the sandstone comes down upon the coal, usually without any intervening shale, and occasionally cutting out the coal so as to form sandstone horsebacks. In an opening made by Mr. Webster, just west of Quaker City, one of these was encountered, and is so extensive that the opening was deserted. The quality of the coal is fair, doing well enough for domestic use, but containing too much pyrites to be of commercial value.

The limestone below No. 8 makes a good, strong lime. The Crinoidal limestone is well exposed in railroad cuts, both east and west of Quaker City, as well as at Salesville.

Wills Township.—This township lies wholly in the peculiarly barren portion between No. 7*a* and No. 8. At no point are the hills high enough to catch No. 8, nor are the valleys excavated deeply enough to reach No.

7*a*, except, perhaps, in the north-western corner. The section, as obtained from Salesville to Washington, is as follows:

		FT.	IN.
1.	Shales	50	0
2.	Limestone	2	0
3.	Shales	55	0
4.	Crinoidal limestone	4	0
5.	Shales	12	0
6.	Sandstone	50	0
7.	Limestone	2	0
8.	Shales (seen)	10	0

South-east of a line running north-east and south-west through Washington No. 7*b* is not seen, but north-west of such a line it sometimes appears. Mr. Alexander Barton works it a short distance north of the village. The coal is two feet four inches thick, and is of very fair quality.

Oxford Township.—Just east from Middletown Coal No. 8 is worked by Mr. Thomas Ford in section 31. There the following section was obtained:

		FT.	IN.
1.	Coal	1	0
2.	Shale	1	0
3.	Coal	4	2
4.	Fire-clay	1	6
5.	Sandstones and shales	147	0
6.	Crinoidal limestone	3	0
7.	Shales and sandstone to creek	40	0

The coal is of good quality, but of rather less specific gravity than that from other banks in the neighborhood. Mr. Boyd Forbes's bank in section 25 has the same characteristics. The strata above the coal are altogether sandstone for a distance of one hundred feet, and no signs of Nos. 9 or 10 were seen. Nodules of limestone occur on top of the hill.

Following the National Road from Middletown east, Coal No. 8 is first seen in a deserted opening in section 20, belonging to Nancy Yurkle. Near the Antrim road Mr. Bailey has made several openings. Here the coal averages four feet, with one foot of roof-coal. The pyrites band in the upper bench and the slate partings are well marked and persistent. The coal is compact, of good quality, and generally free from pyrites. Two and one-half miles east of Middletown Mr. McCullough has opened the same coal by means of a shaft. The coal is three feet six inches thick, and is regarded as of excellent quality. It contains many films of carbonate of lime. This bed continues accessible to the county line, and is worked at several localities along the National Road. The rocks above are sandstone for seventy feet, excepting a thin shale midway, containing a few nodules of limestone.

On the Antrim road, in section 21, openings were seen belonging to Mr. Lyon and Mr. Newell. In neither of these was the roof-coal seen. They show—

		FT.	IN.
1.	Clay	0	0
2.	Coal	4	2
3.	Fire-clay and iron ore	3	0
4.	Shale	9	0
5.	Limestone	6	0

In each of these openings the coal is of good quality.

Londonderry Township.—Along the road from Antrim to the National Road the openings in Coal No. 8 are quite numerous. Mr. Dallas McPeak, in section 27, has it varying from three feet six inches to four feet. The pyrites band in the upper bench is two inches thick. The coal is good, but the bed is much broken up by "horsebacks," both from above and from below, as well as by "clay veins" of considerable size. In openings belonging to Messrs. Mack & Barrett, in sections 28 and 29, there is a sandstone "horseback" running north-east and south-west thirty-five feet through, and resembling the sandstone above. The coal is about four feet thick. At Mr. Campbell's bank, in section 28, the coal is cut by several "clay veins," averaging one foot thick. Mr. Enoch McPeak's opening, in section 35, is almost the last exposure of the coal to the west. From all of these banks coal of good quality is obtained for the supply of an extensive district at the west.

In the south-eastern portion of the township Nos. 8 and 10 are well exposed but little worked. Mr. John Dunbar has made an opening on No. 7*b*, but found it worthless. On the Stillwater Mr. Smith has opened No. 7*a*, and found it nearly four feet thick. The upper two feet yield very poor coal, but that from the bottom is of moderately good quality.

Washington Township.—Like Wills township, this lies wholly in the barren interval between Nos. 7*a* and 8. The only coal here is No. 7*b*, which is very thin, and consequently not worked to any extent. The single opening seen is near the school-house on the Birmingham and Freeport road, not far from its junction with the Antrim road. The Crinoidal limestone was observed at several points, where its fossils weather out in good condition.

Monroe Township.—Coals Nos. 7 and 7*a* are seen here, and the latter is worked to some extent in the eastern portion. At New Birmingham the following section was obtained:

		FT.	IN.
1.	Sandstone	55	0
2.	Crinoidal limestone	4	0
3.	Shale	9	0

		FT.	IN.
4.	Coal No. 7*b*	2	6
5.	Fire-clay	1	8
6.	Limestone	1	0
7.	Sandstone	55	0
8.	Shale	12	0
9.	Coal No. 7*a*	2	6
10.	Fire-clay	1	0

The shales resting on the coal are dark and contain a small quantity of blackband, but insufficient to prove of economical value. The coal is fairly compact and free from impurities, and is used in the village. It varies in thickness from two feet six inches to two feet nine inches. The sandstone of the section is exceedingly hard, and at times becomes conglomerate.

Madison Township.—In this township No. 7*a* is seen in the "bottom" just east from Antrim, and there has been worked by stripping. It is seen also in the bed of the run in section 11, at the township line. A small amount of kidney ore is seen over it. At Antrim the Crinoidal limestone lies at the level of the village, but no coal is seen under it. Near Winchester, on top of a ridge south of the village, Coal No. 8 has been struck in wells. It showed a thickness of three feet, but is rotten. No. 7*a* is not seen here, owing to the sharpness of the westward dip, which carries it at least thirty feet under the creek at Winchester.

No. 7*b* is better developed here than in any other portion of the county, and is worked to considerable extent. In the neighborhood of Winchester it has been opened by G. W. Burson, J. H. Carlisle, Eli Titerick, and others, and at a short distance south by P. Weyer and G. Yeo. At these openings the coal lies at an average of five feet below the Crinoidal limestone, and has a limestone not far below it. At Mr. Burson's opening the following section was obtained:

		FT.	IN.
1.	Crinoidal limestone	3	0
2.	Shale	4	0
3.	Cannel coal	0	11
4.	Bituminous coal	2	6
5.	Fire-clay	4	0
6.	Limestone	1	0
7.	Sandstone (seen)	20	0

The cannel coal varies from eight to eleven inches, and is full of aviculoid shells, which are so flattened and distorted that identification is almost impossible. This material burns well and makes a good fire, but leaves nearly half its weight of white, powdery ash. The bituminous portion not infrequently attains a thickness of three feet four inches.

The coal is slaty, but makes a hot fire, and is an excellent fuel if nothing better can be obtained. It contains a considerable proportion of pyrites, generally distributed.

This bed is badly cut up by horsebacks of a somewhat peculiar type. In one of Mr. Burson's openings the coal in the main entry suddenly changed into a curious mixture of very base iron ore and prismatic coal. This displaced the coal for twenty yards, and made it necessary to enter the bed in another direction. A thin streak of iron ore is found a few feet below the coal. It is of fair quality, but too small in quantity to be of any value.

On the farm of Mr. J. H. Carlisle, in section 15, is a chalybeate spring issuing thirty-five feet below the coal, and pouring out a strong stream two and one-half inches in diameter. Directly below it is a bed of iron ore perhaps fifteen inches thick, though this could not be accurately determined. The spring is unfailing, and yields so large a quantity of water that when the annual camp-meeting is held on this property, several thousand persons being present, all the people and horses are supplied from this spring without lessening the amount of water in the reservoir.

Center Township.—On the National Road, about two miles from Washington, Mr. Alex. Eagleston works No. 7*b* It is here two feet six inches thick, and appears to be topped directly by a heavy sandstone, the Crinoidal limestone being nowhere exposed. The coal is handsome and said to be very good. The result of analysis is as follows:

Specific gravity	1.300
Moisture	2.30
Volatile combustible matter	36.30
Fixed carbon	53.00
Ash	8.40
Total	100.00
Sulphur	4.44
Sulphur remaining in coke	1.92
Sulphur forming of the coke	3.13
Fixed gas per pound, in cubic feet	3.72
Character of coke	Compact.
Color of ash	Gray.

Two miles farther west this coal is only one foot thick, and about sixty feet below it is a two-inch coal, which is probably No. 7*a*. One hundred and forty feet below No. 7*b*, Coal No. 7 is seen at Mr. Ed. Nyce's, on the

National Road. At this opening the coal shows in the entry as follows:

		IN.
1.	Coal	12
2.	Slate	1
3.	Coal	19
4.	Slate	½
5.	Coal	18
6.	Fire-clay	8

The coal is said to be five feet thick in the chambers, but these were full of water, and no opportunity was afforded for measurement. A specimen from this bank yields the following on analysis:

Specific gravity	1.281
Moisture	3.30
Volatile combustible matter	32.30
Fixed carbon	60.30
Ash	4.10
Total	100.00
Sulphur	2.80
Sulphur remaining in coke	1.40
Sulphur forming of the coke	2.17
Fixed gas per pound, in cubic feet	3.80
Character of the coke	Compact.
Color of ash	Fawn.

The same coal is worked extensively on the Central Ohio Railroad by Mr. H. L. Williams, who opens it by means of a shaft. The coal is shipped to various markets, and commands a ready sale at a fair price.

Jefferson Township.—Though the soil here is very thin, yet the subsoil is so thick as to conceal the rocks, and exposures are very few. The Crinoidal limestone and Coal No. 7*b* were nowhere observed in the northern portion, though both appear on the Salt Fork, where the latter is worked. The hills are high enough in the north-eastern portion to catch Coal No. 8, but it was not opened. At one or two localities along Salt Fork it appears and is worked.

On the property of Thomas Adams, in section 4, three miles from Salem, Coal No. 7*a* is worked, and there we have the following section:

		FT.	IN.
1.	Sandstone	10	0
2.	Shales	8	0
3.	Coal	0	3½
4.	Clay	0	5
5.	Coal	2	4
6.	Bituminous shale	0	4
7.	Fire-clay	1	3
8.	Sandstone	60	0

The top coal is a poor cannel; the other is slaty, and contains much pyrites throughout. The sandstones are coarse, and in some layers conglomerate, with pebbles as large as peas. Coal No. 7*a* is worked also by Mr. G. Beal in section 2. It there shows the same characters as at Mr. Ford's.

Liberty Township.—In this township the succession is as follows:

		FT.	IN.
1.	Sandstone	50	0
2.	Crinoidal limestone	?	0
3.	Sandstone	70	0
4.	Shales	10	0
5.	Coal No. 7*a*	3	0
6.	Fire-clay	1	6
7.	Sandstone	45	0
8.	Coal No. 7	2	0
9.	Sandstone	80	0
10.	Shale	12	0
11.	Coal No. 6	3	0
12.	Shale	20 to 40	0
13.	Limestone	2	0
14.	Coal No. 4	2	0
15.	Fire-clay	13	0

Near the village of Liberty Mr. T. S. Luccock has made a boring to ascertain whether any available coal exists below the surface at that locality. He obtained the following section, beginning about twenty feet below Coal No. 6:

		FT.	IN.
1.	Débris and shale	17	0
2.	Coal	2	6
3.	Fire-clay	13	0
4.	Shale	46	0
5.	Limestone, reddish blue	3	0

Coal No. 2 of the boring is Coal No. 4 of the general section, and is seen in the bank of Wills Creek about one mile west of the village, on property belonging to Mr. T. S. Forsyth. It there shows a thickness of one foot at the outcrop, but becomes two feet at a short distance in the hill. The gray limestone rests on it, two feet thick, and full of *Spirifer lineatus.* It is missing in the boring, but as it occurs in separated blocks the drill may have passed through a crevice. It is not, however, persistent, for on the property of Mr. R. R. Miller, four miles north-east from Liberty, the coal is found twenty-eight feet below Coal No. 6, and separated from it by lead-colored shales, no limestone being present. At Mr. Miller's shaft the coal is five feet thick, and there, as well as at Mr.

Luccock's boring, appears to be of excellent quality. An analysis of a specimen from Mr. Miller's opening gives the following:

Specific gravity	1.267
Moisture	3.00
Volatile combustible matter	36.20
Fixed carbon	58.00
Ash	2.80
Total	100.00
Sulphur	1.97
Sulphur remaining in coke	0.90
Sulphur forming of the coke	1.68
Fixed gas per pound, in cubic feet	3.88
Character of the coke	Compact.
Color of ash	Dull white.

Coal No. 6 is worked near Liberty by Messrs T. S. & S. W. Luccock, section 23, and by Mr. James Gibson, section 22. At these openings the coal varies little from three feet in thickness, and is of very good quality. It is also worked by Mr. G. B. Leeper, section 8, who has it thirty-five inches, and by Mr. Miller, just above his shaft upon Coal No. 4, where it is only thirty-three inches thick. It shows no well-defined parting, and varies in character considerably. At one of Mr. T. S. Luccock's banks it is very soft and clean, with but little pyrites visible, while in several of the others it is hard, irised, and containing no inconsiderable amount of sulphur. A specimen from Mr. T. S. Luccock's bank gives the following upon analysis:

Specific gravity	1.253
Moisture	3.20
Volatile combustible matter	35.40
Fixed carbon	58.40
Ash	3.00
Total	100.00
Sulphur	2.60
Sulphur remaining in coke	1.18
Sulphur forming of the coke	1.92
Fixed gas per pound, in cubic feet	3.36
Character of the coke	Compact.
Color of ash	Brown.

On the property of Mr. W. Ralston, section 17, is the most southerly exposure of Coal No. 6. The section is:

		FT.	IN.
1.	Lead-colored shale	8	0
2.	Black fissile shale	0	4
3.	Coal, "bone"	0	4

		FT.	IN.
4.	Coal parting	0	2
5.	Coal	3	0
6.	Fire-clay	0	0

The coal, No. 5, varies in thickness from two feet four inches to three feet two inches.

Coal No. 7 is nowhere of any value. On Mr. J. Proctor's property section 22, it is a cannel coal of low grade, seventeen inches thick. On Mr. G. B. Leeper's property, section 8, it is a rotten coal ten inches thick, and on Mr. Miller's property it is poor and eighteen inches thick.

Coal No. 7*a* is quite as variable as Coal No. 7, but has the advantage of occasionally becoming workable. At Mr. Miller's it is ten inches thick, at Mr. Leeper's fifteen inches, and at Mr. Proctor's, in section 22, it is of workable thickness. At this latter locality we get the following section:

		FT.	IN.
1.	Sandstone	30	0
2.	Shale	3	0
3.	Cannel coal	0	9
4.	Bituminous coal	2	2
5.	Fire-clay	1	8
6.	Sandstone	0	0

The shale above the coal contains some thin streaks of blackband, but so interstratified with barren shale as to be worthless. The layers of shale immediately above the coal bear many vegetable impressions, some of which are very beautifully preserved. The coal, No. 4 of section, is of very fair quality.

In sections 18 and 19 salt is manufactured. The wells are four hundred and fifty feet deep, beginning at the level of Coal No. 6. No definite information could be obtained respecting the records. In section 18 Mr. J. Warden makes six barrels per diem, and in section 19 Messrs. Alexander & Ferbrache make five barrels. The brine averages five per cent., and the salt is of good quality, selling for two dollars per barrel.

Cambridge Township.—Here the changes in the structure of the rocks are more marked than in any other township. Every thing seems to thin out excepting shale, which takes the place of coal, limestone, and sandstone almost exclusively.

On Mr. Ford's property, near the road from Liberty to Cambridge, and four miles north of the latter place, Coal No. 8 is worked to some extent in the winter. As the opening was full of water no examination was made, but Mr. Ford gave the following section of the coal:

		FT	IN.
1.	Clay	0	0
2.	Coal	2	6
3.	Slate parting	0	2
4.	Coal	0	6
	Fire-clay	1	6

The popular belief is that about two feet below No. 4 there is another coal eighteen inches thick, but Mr. Ford states that this is erroneous, as the drain is much deeper than two feet. The coal is of good quality and in good repute for domestic use.

About a mile nearer Cambridge Mr. William Garey has made an examination of the bed and finds it only eighteen inches, roofed by fifteen inches of shale, upon which rests a heavy sandstone.

About a mile north of Cambridge the coal is seen in the road-side eight inches thick, with nodular limestone below it. To the east the coal and limestone become much thicker, the former reaching four feet along the National Road, where there are numerous deserted openings. West and north-west of Cambridge the coal varies so in thickness as to be traceable with great difficulty.

Coal No. 7*a* was observed at a few points, but at no place does it exceed eighteen inches.

Coal No. 7*b* was observed at only one locality. It is worked by Mr. G. W. Fiester, section 1, above five miles north-east of Cambridge. No good opportunity was afforded to obtain measurements, but the section is about as follows:

		FT.	IN.
1.	Crinoidal limestone	0	8
2.	Shale	15	0
3.	Coal	0	4
5.	Black shale	0	6
6.	Coal	1	6

The Crinoidal limestone here is very thin, but it retains its fossils in considerablt numbers.

Knox Township.—In this township we find no workable coal except No. 6, which is very nicely displayed along Indian Camp Creek, where it has been opened by T. Wells and J. Zimmerman, in section 19; J. Ingraham, section 9; the heirs of Jacob Lawrence, in section 2, and by several others. In all of these the coal varies little from three feet six inches, and is of very good quality. The sandstone above the coal contains numerous impressions of *Lepidodendron* and *Sigillaria.*

Coal No. 7 was nowhere observed. Coal No. 7*b* was frequently seen on top of the Irish Ridge, having a thickness of about ten inches, and lying a few feet below the Crinoidal limestone.

Adams Township contains several thin coals, rarely workable. Nos. 7, 7*a*, and 7*b* are frequently seen, but rarely exceed a foot in thickness. In the south-western portion a coal between two and three feet thick, containing some cannel, and lying forty-five feet below No. 7*b*, is worked by Messrs. Kerr, Gallagher & Wiley.

SUMMARY.

Coal.—Situated for the most part on the Barren Group, Guernsey county is, compared with the counties adjoining it, poorly supplied with coal. Along the eastern border Nos. 8 and 10 occur, and the former yields an abundance. In the remaining portion there is no bed of much value, except in the deeply excavated valleys of Indian Camp and Wills Creeks, where No. 6 is reached, and in the vicinity of Cambridge, where No. 7 is of sufficient thickness to repay working.

Coal No. 8 has not been analyzed. Specimens were procured for this purpose, but they seem not to have reached Prof. Wormley, as no analyses have been reported. The coal, however, bears great resemblance physically to that obtained from the same bed in Belmont county, and doubtless would show no material difference on analysis, as the variations in composition are very slight.

Coal No. 7*b*, underlying the Crinoidal limestone, was found of workable thickness only in Center township, and near Winchester, though it is very persistent. It is of no value. The only analysis shows it to be rich in gas, but to contain 8.44 per cent. of ash and 4.44 per cent. of sulphur.

Coal No. 7 in its characteristics is more essentially a Barren Measure coal than any of the others, and shows many sudden variations in thickness, leaping, in one case, from six inches to as many feet within two miles. In the vicinity of Cambridge it is important, but elsewhere is of no value. The coal is of excellent quality for fuel, makes a fine coke, and is rich in fixed gas. Sulphur is present to 2.8 per cent., much less than the average found in the Pittsburgh. So excellent is this coal that in most of the central townships of the county the residents show much anxiety to learn at what depth it can be reached. There is little satisfaction in stating that this is one of the most persistent beds in the series, being rarely absent, for it is so variable in thickness that any explorations involving much expenditure of time or means are not justifiable. For the benefit of those who may desire to bore for it, we state that this coal, in the greater portion of the county, lies from one hundred and forty to one hundred and sixty feet below the gray fossiliferous limestone, which I have termed the Crinoidal limestone. Toward the railroad the interval is somewhat more, while between them comes a blue fossiliferous limestone, weathering buff. Explorers should remember, also, that at from forty to fifty feet above the Cambridge coal they will be apt to strike No. 7*a*, which is nearly as persistent as the one below it. Should any one bore for this coal he should not be disappointed if he find it only a few inches thick.

Coal No. 6. In Liberty, Knox, and Wheeling townships this coal is exposed and worked along Wills and Indian Camp Creeks. In this vicinity it is now available, as the Marietta and Pittsburgh Railroad affords means of transportation. The bed, it is true, is rarely more than three feet thick, but the quality is superior. The ash is only 3 per cent., and the sulphur 2.6 per cent., along Wills Creek. This is an excellent fuel and a good gas coal, though not so rich as the Cambridge coal.

Coal No. 4 is available only on Wills Creek, in Liberty township. A specimen from the only bank in operation shows it to be a very excellent coal, containing only 2.8 per cent. of ash and 1.97 per cent. of sulphur.

Iron. The presence of iron in really valuable quantity is somewhat questionable. Associated with the Cambridge coal there is usually found more or less of nodular iron ore in the roof shales, and occasionally, no doubt, this may be locally of some importance. The same may be said of No. 7*a*. In Tuscarawas county there are well-marked horizons of ore. Extensive explorations were making in Wheeling township at the time of our examination, but we have not ascertained the result.

Lime, for building purposes, can not be obtained easily. The Crinoidal limestone does not burn well. The limestone over Coal No. 4 is occasionally good. The best rock is the stratum under Coal No. 8, in the eastern portion of the county.

Water.—The county is well supplied with water for all purposes.

CHAPTER LXIII.

REPORT ON THE GEOLOGY OF MUSKINGUM COUNTY, NORTH OF THE CENTRAL OHIO RAILROAD.

BY JNO. J. STEVENSON.

Muskingum county is bounded on the north by Coshocton, on the east by Guernsey and Noble, on the south by Morgan and Perry, and on the west by Perry and Licking. It has twenty-five townships, with an area of more than eight hundred square miles. The portion of the county referred to in this report embraces eight townships, with parts of four others.

This may be regarded as a valley, having the Muskingum River as its lowest line. A few dividing ridges are seen, but they are of limited extent, and the streams, after following a more or less tortuous course, empty into the river. The surface of the county is much broken and affords easy drainage. Thus, White Eyes Creek, with its many forks and tributaries, drains Monroe and Highland, emptying into Wills Creek at the north. Symmes Creek drains Madison and Adams; Salt Creek, Union, Perry, Salem, and Washington; Michaelachpesink Creek, Licking, Hopewell, Muskingum, and Falls; Waukatomaka Creek, Jackson and Cass. Wills Creek, on the north, uniting with the river a few miles north from Dresden, is fed by numerous small streams from Monroe and Adams, and frequent tributaries of the river are seen in Madison, Washington, Muskingum, and Cass. This drainage system is complete, freeing the county from malarial influence and affording a constant supply of water for stock, while innumerable springs yield more than enough for household purposes.

Wills Creek and the Muskingum River, above Zanesville, are not constantly to be depended on as commercial outlets. The fall in these streams is slight, and slack-water navigation is perfectly feasible. Many years ago a survey of Wills Creek was made, with a view to this improvement, and the fall was found to be a little more than ten inches per mile. In former times the creek was subject to very extensive freshets, giving from fourteen to eighteen feet of water, overflowing the country for miles, and, owing to the sluggishness of the stream, lasting for several weeks. During later years such freshets have been of rare occurrence, as, temporarily at least, the climate has become much dryer than previously. At certain seasons of the year there is sufficient water to admit of floating out rafts of timber. In the Muskingum the supply is more regular, and though now, during the greater part of the year, not sufficient for commercial purposes, a comparatively small outlay would render it navigable most of the time, and so afford a cheap outlet for the bulky iron and coal.

The limestone beds of the Lower Coal Measures lie near the surface over a large portion of the county, and disintegrating readily, render the soil "strong," so that it yields excellent crops of grass and good crops of grain. While the hills are usually sharp and somewhat steep, the valleys are numerous, broad, and fertile.

The Central Ohio Railroad and the Pittsburgh, Columbus and St. Louis Railway cross the county and are connected by a branch road running along the Muskingum from Zanesville to Dresden Station. The Ohio Canal passes through the north-western portion of the county. Zanesville, the county-seat, is a flourishing city of about twenty thousand inhabitants, and an important manufacturing center. Almost every township contains one or more cheerful and prosperous villages. A reasonable amount of attention is paid to educational matters, and the county contains one institution empowered to grant collegiate degrees.

GENERAL GEOLOGY.

The consolidated rocks of the county all belong to the Carboniferous age, and, for the most part, to the Coal Measures. The following is an approximate section:

		FT.	IN.
1.	Shale	100	0
2.	Coal	2 to 10	
3.	Clay	3	0
4.	Limestone	1–3	0
5.	Shale	60	0
6.	Crinoidal limestone	2–4	0
7.	Shale	1–35	0
8.	Coal No. 7*b*	1–2	9
9.	Fire-clay	2	0
10.	Sandstone	45–75	0
11.	Shale	3	0
12.	Coal, "Norwich"	0–2	0
13.	Fire-clay	9	0
14.	Limestone	8	0
15.	Sandstone and shale	100	0
16.	Coal No. 7	1–6	0

		FT.	IN.
17.	Fire-clay	2	0
18.	Sandstone	50–70	0
19.	Shale	10–25	0
20.	Coal No. 6	$2\frac{1}{2}$–$4\frac{1}{4}$	0
21.	Shale and clay	25	0
22.	Sandstone	30	0
23.	Coal No. 5	4 to	4
24.	Shale and sandstone	55	0
25.	Iron ore	3	0
26.	Limestone	1–3	0
27.	Coal No. 4	4 to	7
28.	Fire-clay	1	0
29.	Sandstone and shale	20	0
30.	Limestone, flint, or iron ore	2–3	0
31.	Coal No. 3*a*	2 to	10
32.	Sandstone	10	0
33.	Limestone	1	0
34.	Coal No. 3	1	0
35.	Fire-clay	0	6
36.	Sandstone	75	0
37.	Coal No. 2	$2\frac{1}{2}$ to	4
38.	Shale and sandstone	45–50	0
39.	Coal No. 1	1–4	0
40.	Shale	40	0
41.	Iron ore	2	0
42.	Shale	5–10	0
43.	Conglomerate	28	0
44.	Waverly rocks	102	0

The dip is somewhat irregular. In the north-western portion of the county, especially in Jackson township, it is quite sharp to the north-east, but before reaching the Muskingum River it changes to south-east. Along a line running south-west from near Johnson's Mills, in Monroe township, to near Sonora, in Perry township, the dip is reversed, and is north-westward until a line is reached passing east of north and south of west through a point about one-half mile east of Norwich, in Union township. There it again becomes south-eastward, and so continues until another line is reached passing just east of New Concord in a north-east and south-west direction, where the dip is once more reversed, and so continues almost to Cambridge, in Guernsey county. The anticlinal passing east of Norwich is regarded as a spur of the main anticlinal passing through Guernsey county, and described in the report on that county. The Norwich anticlinal is somewhat interesting, in that its eastern slope is much more abrupt than its western, the dip per mile being almost three times as great.

of section was observed only in Union township, between New Concord and Norwich. The limestone underlying it is more or less fossiliferous. I was at one time inclined to regard this as perhaps the western prolongation of the Pittsburgh, but no proof has been found to substantiate the conjecture. The coal is of no value.

The Crinoidal limestone is fully described in the report on Guernsey county. In Muskingum it is shaly and coarse-grained, wanting the compactness and flintiness characteristic of it in Guernsey, Harrison, and Carroll. It is well exposed in Highland, Monroe, Adams, and Salem townships, and runs out in the hills of Madison, about three miles east of the river. The only species found here, aside from those given in the list from Guernsey, is *Ctenoptychius semicircularis*, of which a single specimen was obtained in Salem township.

Coal No. 7*b* is seen at a distance of from one to thirty-five feet below the limestone. It appears to be of economical importance only in the vicinity of Norwich, in Union township, where it is thirty-four inches thick. Toward the north it becomes thinner, and averages only ten inches through Salem, Adams, Monroe, and the greater part of Highland. Where of available thickness, it appears to be a very good coal.

The coal which I have termed the "Norwich" coal is quite circumscribed in area. Both it and the underlying limestone disappear northward. It is worked in Highland and Union townships to a slight extent. The limestone under it is blue, weathering buff, very tough, and contains many fossils, among them *Productus costatus,? P. punctatus, P. longispinus, P. Prattenanus, Athyris subtilita*, and *Chonetes granulifera*.

Coal No. 7 is as variable here as in the adjoining county of Guernsey. South of the Central Ohio Railroad it attains great importance, but thins out abruptly northward, being seldom more than one foot thick, and usually a cannel of poor quality. At one or two points it suddenly expands to nearly six feet, but yields an inferior coal. It was seen in Monroe, Adams, Madison, Washington, and Muskingum townships.

Coal No. 6 is the important bed of the county. It is the upper coal at Coaldale, near Zanesville, and is mined extensively in Monroe, Adams, Madison, Washington, and Muskingum. The thickness varies from three to four feet. The upper part of the bed usually consists of hard, slaty coal, four to six inches thick, burning well, making a hot fire, but leaving much ash. Six to ten inches from the bottom is a very persistent clay parting about two inches thick. Other partings are sometimes seen, but they are not persistent. Ordinarily the coal is of excellent quality, containing little sulphur and yielding a very superior coke. In some localities in Washington township a bed of iron ore is seen about fifteen feet below this coal. Its area is not extensive.

Coal No. 5 is local in its development, appearing only in Washington township, and exhibiting great variations in thickness. It is most important near the Central Ohio Railroad, and thins out rapidly northward, disappearing about twelve miles north of Zanesville.

Coal No. 4 is a persistent coal, though varying greatly in thickness. Wherever seen in Monroe, Adams, Cass, Jackson, Muskingum, and Madison townships it is a cannel, but is of no value, except at one locality in Jackson township. It is interesting, especially because of its relations to No. 6. In Monroe township it may be traced along White Eyes Creek from near Otsego to Johnson's Mill, twenty inches thick, and about forty feet below No. 6. It is every where known as the "limestone coal," but the limestone is not persistent along the outcrop. Tracing it down Wills Creek, the interval between the coals is seen to increase, until, at Frew's Mills, it becomes ninety feet. At the salt works, near the Coshocton line, it is the same; near Dresden, one hundred feet; on the north branch of Symmes Creek, eighty feet; and near Morton's coal works, on the Muskingum, one hundred and ten feet. In Liberty township, Guernsey county, it becomes twenty feet. These variations afford an excellent illustration of the doctrine, long since established, of unequal subsidence. The gray limestone overlying this coal is coarse-grained, sometimes shaly, but usually compact, having a fracture like sandstone. It contains great numbers of *Spirifer lineatus.*

Coal No. 3 and its associate limestone are duplicated in this portion of the county. The coals are thin and of no value. The limestone is variable, in some places pure and ringing when struck, at others quite earthy. The fossils are ordinarily perfect, and are very numerous. With the upper limestone is a flint, gray to black in color, and very irregular in quantity and mode of deposition. It occasionally replaces the limestone and becomes three feet thick. In Jackson township it is associated with an important bed of iron ore. It contains numerous remains of mollusca, which, for the most part, are badly preserved.

Coal No. 2 is thin and of no economical value.

Coal No. 1 was seen only in Licking and Jackson townships. It is variable in thickness, but yields a coal of very superior quality, apparently free from sulphur. Where accessible it is too thin to be of much economical value, but in some almost inaccessible localities it expands to four feet.

The strata below this coal were observed only in Jackson township, and will be found fully described under that head.

LOCAL GEOLOGY.

Jackson Township.—In this township the section is as follows:

		FT.	IN.
1.	Shale	35	0
2.	Limestone	4	0
3.	Shale	8–10	0
4.	Coal No. 4	4 to 8	
5	Clay	12	0
	Limestone	2	0
7.	Flint and iron ore	3	0
8.	Coal No. 3	2	9
9.	Sandstone	75	0
10.	Coal No. 2	1–2	0
11.	Sandstone and shale	50	0
12.	Coal No. 1	2–4	0
13.	Fire-clay	5	0
14.	Shale	30	0
15.	Iron ore	2	0
16.	Shale	5–10	0
17.	Conglomerate	28	0
18.	Calcareous iron ore	4	0
19.	Nodular iron ore	2	0
20.	Sandstone	27	0

Coal No. 4 is here of economical thickness, and in the neighborhood of Frazeysburg is worked at several openings. At Mr. Samuel McCann's bank the section is:

	FT.	IN.
Coal	0	2
Shale	0	4
Coal	2	5
Fire-clay	1	0

At the end of the entry the thickness is only eighteen inches. The coal is cannel, containing many thin seams of bitumen, and near the top, one of bituminous coal, two and one-half inches thick. It burns beautifully, but leaves a very bulky ash. A specimen forwarded for analysis gives the following result:

Specific gravity	1.305
Moisture	2.60
Volatile combustible matter	37.00
Fixed carbon	54.95
Ash	5.45
Total	100.00

Sulphur	1.73
Sulphur left in coke	0.99
Sulphur forming of the coke	1.68
Gas per pound, in cubic feet	3.32
Ash	White.
Coke	Pulverulent.

This bed runs out in the hills to the north and west of Frazeysburg. Towards the north-east it rapidly thins out, and along Irish Ridge can be traced only as a black streak under the limestone.

Coal No. 3 is nowhere of any value, and is seldom more than ten inches thick.

Coal No. 2 shows itself near Mr. William Morgan's house, on the West Carlisle road. An opening was made here and pushed for some distance into the hill without finding good coal. The bed was found thirty inches thick. At another opening by the road-side the thickness is only eighteen inches.

Coal No. 1 has been worked at various points along Waukatomaka Creek, in the north-western portion of the township. It is thickest on Mr. Joseph Willey's property, in section 8, where the following section was obtained:

		FT.	IN.
1.	Sandstone	15	0
2.	Clay	4	0
3.	Coal, bituminous	0	9
4.	Clay parting	0	4
5.	Cannel coal	0	8
6.	Clay parting	0	4
7.	Bituminous coal	2	4
8.	Fire-clay	5	0

The coal from Nos. 3 and 7 is said to be of most excellent quality. Mr. L. W. Doane, who superintended the oil-boring near by, asserts that it is entirely free from sulphur, and is the best blacksmiths' coal he ever saw. The cannel is very poor and little better than bituminous shale. It abounds in vegetable remains, some of which are exceedingly fine. Mr. Doane has obtained slabs of *Lepidodendron* and *Sigillaria* two to three feet square. The dip eastward here is quite sharp, being five feet in one hundred yards. At none of the other openings in this neighborhood does the coal exceed two and one-half feet in thickness, and sometimes is less than two feet. Unfortunately all the banks have been deserted for one or two years, so that it was found impossible to obtain specimens for analysis.

The ore beds of importance here are two. The lower rests almost directly upon the Conglomerate, while the upper is always more or less intimately connected with the flint above Coal No. 3. Between these, and about twenty-five feet below Coal No. 2, is a thick bed which may prove to be of some value, if one can judge from road-side exposures. It has never been tested, and no satisfactory specimens could be obtained for analysis.

The upper bed is worked to some extent near Frazeysburg, on property belonging to Mr. Abram Adams, and on that of Mr. E. Lemmert, as well as at several other localities nearer the village. It lies near the surface, and is obtained by stripping from three to twelve feet of superficial deposits. It varies in thickness from eighteen inches to three feet, but is much injured by its association with the flint, which, though usually very thin, sometimes replaces the ore entirely. This ore occurs in plates and is obtained with considerable ease, each digger averaging about two tons a day. It frequently contains well-preserved casts of *Productus* and *Spirifer*.

Specimens of this ore yield the following on analysis. No. 1 is from Mr. Abram Adams and No. 2 from Mr. Lemmert, the latter converted into limonite by exposure :

	No. 1.	No. 2.
Specific gravity	3.152	3.464
Water combined	2.40	10.05
Silicic acid	26.72	3.66
Iron, sesquioxide	13.57	79.07
Iron, carbonate	43.08	.....
Manganese	0.60	1.70
Alumina	2.00	2.60
Lime, phosphate	2.64	1.13
Lime, carbonate	4.18	.....
Magnesia, carbonate	4.24	0.65
Magnesia, phosphate	.....	0.70
Sulphur	0.53	0.23
	99.96	91.79
Metallic iron	30.28	54.65
Phosphoric acid	1.21	0.89

This bed is not persistent to the north-east of Frazeysburg. On the West Carlisle road the flint is found of a beautiful bluish-black color, and containing many fossils. Upon it rests a thin seam of iron ore, capped by a grayish limestone. Three miles from Frazeysburg both flint and ore have disappeared and the limestone has become double, with three feet of coarse sandstone between the layers.

The lower ore bed was worked thirty-five years ago on Mr. Jackson Blizzard's property, but the workings have fallen in, and so concealed all exposures. The revival of mining has called attention to this bed, and a number of loads have been hauled to Frazeysburg. It is found at many localities along Waukatomaka Creek, and is doubtless persistent along the whole course of that stream above the point where the Conglomerate first shows itself. It is somewhat interesting to observe that this horizon is an ore-bearing one in West Virginia and Pennsylvania.

Just below the Conglomerate is found a bed of calcareous ore yielding eighteen per cent. of iron. Though too poor to be worked alone, it has proved useful as a flux. Underlying it is a bed of nodular ore in sandstone, the nodules containing casts of the shells which served as nuclei.

Though the amount of available ore here is considerable, the inducements to mine, as matters now stand, are very slight. The laborer receives one dollar and twenty-five cents for mining, and the teamster the same amount for hauling. The price per ton, delivered on the car, is only three dollars, which leaves only fifty cents gross profit to the shipper. This margin is too small, considering the uncertainties here. The ease with which lumps of flint can be made to resemble ore is a continual temptation to the miner, especially when the flint cuts out much of the ore. Even under any circumstances it is difficult to sort out the ore perfectly, so that the shipper is at the mercy of a dishonest consignee. The business has not been a good one. There is no reason, however, why this ore should not be a source of great profit to the community. The furnace to work it should be erected at Frazeysburg. The ore can be mined at seventy-five cents a ton, and should be mined for less. The price of hauling is excessive, and the ore, delivered at Frazeysburg should not cost more than one dollar and seventy-five cents. Situated on a railroad and the canal, the furnace could be easily supplied with richer ores, and good coke, at low rates, could be obtained by the canal from some one of the numerous openings into Coal No. 6 along the Muskingum River. Under such circumstances a furnace at Frazeysburg could not fail to be successful.

Some years ago a number of gentlemen residing in Toledo, and represented here by Mr. L. W. Doane, bored 764 feet in search of oil. Their property lies in section 8, about two and one-half miles north-west from Frazeysburg, and is divided by Waukatomaka Creek. The boring was begun eighteen feet below the top of the Conglomerate and on the bank of the creek. The record has been lost, but Mr. Doane gives the following section:

		FT.
1.	Gravel	63
2.	Conglomerate	59
3.	Blue core	8
4.	Sandstone and shale (about two-thirds sandstone)	523

		FT.
5.	Blue mud	12
6.	Black material, exceedingly hard, but without grit	4
7.	White sandstone, yielding salt water in large quantity	33
8.	Shales, dark brown or bluish, with nodular pyrites	62
		764

The gravel, of course, is detritus brought down by the stream. The interval represented by it is partly filled by exposures up the stream, as follows:

		FT.
1.	Conglomerate	28
2.	Calcareous ore	4
3.	Nodular ore	2
4.	Fine-grained sandstone	15
5.	Brown sandstone	12

Leaving twenty feet, not seen, necessary to make the section in the oil well complete. There is no reason to doubt that Nos. 2, 3, 4, and 5 of this section, as well as No. 2 of the oil well section, belong to the Waverly series, which, therefore, includes all down to No. 8, the Huron shales.

The Carboniferous conglomerate is here quite coarse, and contains many pebbles two-thirds of an inch in diameter. The sandstone, No. 4 of the second section, is fine-grained, without pebbles, and works nicely under the chisel. No. 5 is scarcely inferior to it.

At the depth of 671 feet salt water was found in large quantity, and is said by Mr. Doane to average nine or ten per cent. of salt. Under such circumstances there can be no doubt that were there suitable means of transportation the manufacture could be carried on here to profit.

Licking Township.—Coal No. 2 has been worked by Mr. L. Stump near Nashport, and is said to be somewhat more than two feet thick, and to yield a coal of fair quality. Coal No. 1 undoubtedly exists west from Nashport, but is probably very thin, as no openings, or even exposures, were observed. The outcrop of Coal No. 4 was seen at several localities, but it is very thin. Near the Muskingum line the flint ore bed has been worked by stripping. Coal is not mined to any extent here, as it can be brought more cheaply by canal from Coshocton county.

In the western portion of the township the Conglomerate and the Waverly series are exposed.

Cass Township.—About one mile west from Dresden a number of deserted openings upon Coal No. 6 mark its western outcrop. On the road from these banks to Dresden the following section was obtained:

		FT.	IN.
1.	Coal No. 6	0	0
2.	Fire-clay and shale	60	0
3.	Sandstone	40	0

		FT.	IN.
4.	Coal No. 4	0	0
5.	Fire-clay	8	0
6.	Chert	0	6
7.	Coal No. 3*a*	0	0
8.	Sandstone	4	0
9.	Fire-clay	3	0
10.	Limestone	4	0
11.	Coal No. 3	0	0
12.	Shale	2	0

No measurement of the coals was attempted, owing to the character of the exposures. The interval between Nos. 4 and 6 includes the gray limestone, slabs of which were seen about ten feet above No. 4.

On Waukatomaka Creek Coal No. 4 was formerly worked. It is there a cannel two feet thick, as measured at the outcrop, the opening having fallen in. The section there is:

		FT.
1.	Limestone, bluish-gray	4
2.	Sandstone	6
3.	Shales	8
4.	Coal, cannel	2
5.	Concealed	65
6.	Sandstone	5
7.	Shales	10

The concealed portion includes the flint and blue limestone which are seen in the road a mile farther up the creek. At its base is a thin coal four inches thick, not satisfactorily shown in the section, but well exposed at two points farther down the creek. This is Coal No. 2. Coal No. 3 was nowhere observed. Coal No. 6 is worked near Adams's Mills, in the north-eastern portion of the township, and is there four feet thick.

Muskingum Township.—Here Coals Nos. 4 and 6 are exposed at many localities, but openings are few and for the most part confined to the eastern portion of the township. Near the Dresden road to Zanesville Coal No. 6 is worked by Messrs. E. Bland and J. Beatty. These openings are adjacent, and give the following section:

		IN.
1.	Slaty coal	5
2.	Parting	1
3.	Coal	2
4.	Parting	2
5.	Coal	23½
6.	Parting	2
7.	Coal	2
8.	Parting	1½
9.	Coal	2
		41

No. 1 is really a bituminous shale. It will burn, but is not equal to the poorest cannel. Below No. 6 the coal is very bad and contains much pyrites in nodules, while above the same parting there are numerous streaks of the same. The coal here is by no means equal to that obtained east of the Muskingum River. The same coal is worked by Mr. C. Mattingly and by Mr. Lane, at whose banks it is said tò be four feet thick. A specimen from Mr. Bland's bank gives the following:

Specific gravity	1.308
Moisture	3.00
Volatile combustible matter	38.40
Fixed carbon	56.70
Ash	1.90
Total	100.00
Sulphur	1.83
Sulphur remaining in coke	0.79
Sulphur forming of the coke	1.34
Fixed gas per pound, in cubic feet	3.80
Character of coke	Compact.
Color of ash	Yellow.

A cannel coal, probably No. 4, was formerly worked on the old Blunt farm, near the line between Cass and Muskingum. It was found impossible to determine accurately whether it is No. 4 or No. 3*a*, as there is no satisfactory exposure of the accompanying strata. The thickness is variable, ranging from four to seven feet. It was mined to a considerable extent by a Newark company for distillation. The discovery of petroleum rendered the manufacture unprofitable, and the works have fallen into decay.

The limestones here are three in number, each with a coal bed under it. The ore bed can be traced into this township, but has never been worked, and there are no means of determining its thickness or value, as the exposures are very bad.

Madison Township.—At Mr. J. Closen's salt works, in the northern portion of the township, Coal No. 6 is worked. It is about four feet thick, and yields a good coal throughout, though the upper portion is the better. Near the works Coal No. 4 is seen by its smut, accompanied by the gray limestone above. The salt well is 408 feet deep, beginning about 120 feet below Coal No. 6. No record of the boring could be found. The brine contains from five to six per cent. of salt, and the average weekly manufacture is about fifty barrels. A specimen of Coal No. 6, obtained here, gives as follows

Specific gravity	1.287
Moisture	2.90
Volatile combustible matter	36.70
Fixed carbon	58.80
Ash	1.60
Total	100.00
Sulphur	1.59
Sulphur remaining in coke	0.82
Sulphur forming of the coke	1.35
Fixed gas per pound, in cubic feet	3.72
Character of coke	Compact.
Color of ash	Light gray.

At Mr. Geo. King's, due south of the salt works about four miles, Coal No. 6 is worked, and shows a thickness of three and one-half feet. Seventy-five feet below it, and directly under the gray limestone, Coal No. 4 has been worked, but is not now exposed. Ten feet lower Coal No. 3 is found in the run under its limestone, which is here of a very light blue color and full of flattened specimens of *Spirifer lineatus.* The coal is said to be three feet thick. A specimen gives as follows:

Specific gravity	1.343
Moisture	2.80
Volatile combustible matter	35.60
Fixed carbon	47.20
Ash	14.40
Total	100.00
Sulphur	2.74
Gas per pound, in cubic feet	3.32
Ash	Gray.
Coke	Compact.

On the south fork of Symmes Creek the following section was obtained:

		FT.	IN.
1.	Coal No. 7	1	6
2.	Shale and sandstone	70	0
3.	Shale	12	0
4.	Coal No. 6	3	6
5.	Clay	15	0
6.	Sandstone	50	0
7.	Gray limestone	4	6
8.	Clay	6	0
9.	Coal No. 4	1	6
10.	Clay	8	0
11.	Flint and iron ore	4	6

		FT.	IN
12.	Coal No. 3*a*	1	0
13.	Clay	4	0
14.	Sandstone	6	0
15.	Limestone	3	0
16.	Coal No. 3	1	0
17.	Shale	9	0

Coal No. 6 is worked on this creek by Messrs. J. M. Garrett and Townsend Gore, at whose banks it is four feet thick. At Mr. Slack's bank it shows the following section:

		IN.
1.	Shale	4
2.	Coal	4
3.	Clay	1
4.	Coal	10
5.	Clay	1
6.	Coal	5
7.	Clay	2
8.	Coal	7
9.	Clay	2½
10.	Coal	8

The coal is of excellent quality and makes a good coke, as it does at Mr. Closen's bank, and also at Mr. Alex. Copland's, nearer the river.

The limestones of the section are strikingly alike in color and other features. They are gray in color, and weather into large and regular slabs about four feet square and one foot thick. They are fossiliferous, but the number of species is small and the specimens are badly preserved. The clay under the flint is manufactured into earthen-ware by Mr. Minner, on Symmes Creek, and appears to be a good article, as the ware commands a ready sale, not only in the immediate neighborhood, but also in Dresden. The ore bed is the same as that already referred to in Jackson township, and deserves to be carefully tested. The sandstone over Coal No. 6 is coarse and sometimes conglomerate. A heavy conglomerate appears, near Mr. George King's, one hundred feet above Coal No. 6.

Washington Township.—At Wharton's coal works, and at Coal Dale, about two and one-half miles from Zanesville, we have the following section exposed:

		FT.
1.	Sandstone	0
2.	Coal	1
3.	Sandstone	12
4.	Coal No. 6	4
5.	Sandstone	18–35
6.	Coal No. 5	3½–4
7.	Sandstone	50

Coal No. 6 only is mined here, as No. 5 yields a coal of too poor quality to be marketable. Near this locality a cannel coal, probably Coal No. 4, is seen in the bed of the creek, and is eighteen inches thick. The two beds, 6 and 5, are seen on the property of Moses Robinson, and on that of Messrs. Fisher and Mangold, near the Adamsville road. They are each three and one-half feet thick, but the upper one alone is now worked. No. 5 was formerly mined by stripping, on Mr. Moses Robinson's property, near the school-house. About eight miles north from Zanesville, Mr. David Matthews mines Coal No. 6, which shows —

		FT.	IN.
1.	Slaty coal	0	4–6
2.	Coal	3	4
3.	Clay	0	2
4.	Coal	0	4
		4	2

The coal above the parting is very pure and makes an excellent coke, very compact and handsome. Two coking ovens were in use at the time of examination, and two more were being built. Below the parting the coal is very poor, and often two-thirds of it is pyrites. Streaks of pyrites occur occasionally in the coal above, but are very thin and not extensive. Mr. Matthews ships about sixteen hundred tons per month. A specimen of his coal yields the following:

Specific gravity	1.318
Moisture	3.10
Volatile combustible matter	37.50
Fixed carbon	56.50
Ash	2.90
Total	100.00
Sulphur	3.02
Sulphur remaining in coke	1.48
Sulphur forming of the coke	2.49
Fixed gas per pound, in cubic feet	3.56
Character of coke	Compact.
Color of ash	Fawn.

A short distance further up the river, on the property of Mr. L. Menefee, the following section was obtained:

		FT.	IN.
1.	Shale and sandstone, partly concealed	60	0
2.	Coal No. 6	3	6
3.	Fire-clay and shale	15	0
4.	Iron ore	3	0
5.	Shale	7	0

		FT.	IN.
6.	Sandstone	30	0
7.	Coal No. 5	0	4
8.	Shale	30	0
9.	Sandstone	25	0
10.	Iron ore	3	0
11.	Gray limestone	1–4	0
12.	Coal No. 4	0	7
13.	Shale	25	0
14.	Blue cherty limestone	1	6
15.	Shale	0	2
16.	Coal No. 3*a*	1	10
17.	Sandstone	10	0
18.	Blue limestone	1	0
19.	Coal No. 3	0	10

Coal No. 6 shows the following section:

		FT.	IN.
1.	Cannel coal	0	6
2.	Coal	1	10
3.	Clay	0	2
4.	Coal	1	0
		3	6

Mr. Menefee claims that the bed is entirely free from pyrites, and that neither streaks nor nodules have ever been seen. The entry has been driven only forty feet and has hardly reached sound coal, so that it would be injudicious to speak positively in this connection. The coal is quite pure, shows little tendency to break up on exposure, and exhibits no incrustation of copperas on the outcrop. Fifteen feet below the coal is a bed of iron ore three feet thick, containing about eighteen inches of what has been pronounced a most excellent ore. A specimen was procured for analysis, but, unfortunately, has been mislaid. At the time this locality was visited Mr. Menefee was negotiating for the sale of this bed to a Zanesville firm, at a royalty of thirty cents per ton. The deposit is evidently extensive, as it was traced from this point east and north through the township to the opening in Coal No. 6, belonging to Mr. White, on the road to Adamsville. The horizon is one at which ore is found at numerous localities throughout the coal field in the State, and the deposit here merits careful investigation.

This is the most northerly point at which Coal No. 5 has been seen in the county, nor, indeed, has it been seen east or west of this township. Though identifying this bed with Coal No. 5 of the State section, I doubt the propriety of so doing, especially as there is no associated rock by which to prove its identity. It would seem more probable that it is an intercalated bed, if one may judge from its sudden origin and expansion. It is absent over the greater part of Muskingum and Guernsey counties in localities where both Nos. 6 and 4 can be recognized without doubt. Coal No. 4 is of no importance, and was observed at no other locality. Here it consists of cannel, three inches, bituminous coal, four inches. Coal No. 3*a*, though here only twenty-two inches thick, becomes thirty inches at another point about a mile east from Mr. Menefee's, where it is worked. It is highly esteemed by some, as it makes a cheerful fire. A layer of bituminous coal, three inches thick, is found at the bottom.

The limestones are all bluish. The gray limestone is apt to be shaly, is less tough, and more granular than those below. It has been used successfully as a flux. The middle limestone is cherty, with the flint irregularly distributed through it. Near Mr. Matthews's coal works the limestone is absent, being replaced by the flint. The ore, so well marked in Madison, Jackson, Licking, and Muskingum, is absent here, or rather is traceable only by means of a few scattered nodules accompanying the chert. The ore resting upon the gray limestone is of no value, being imbedded in sandstone. The sandstones of the section along the river, between Nos. 4 and 6, are compact, and would doubtless be excellent for building purposes.

Coal No. 7 was seen only at one point. It is seventy-five feet above No. 6, and is not more than nine inches thick. South of the Central Ohio Railroad it is mined extensively, and is four to five feet thick.

Adams Township.—The greater portion of Adams lies at such an elevation as to place it far above any available coal. The higher coals, which are worked at Norwich, Union township, thin out northward and become worthless. On Symmes Creek and Wills Creek Coal No. 6 is exposed. A section of the township is as follows:

		FT.	IN.
1.	Crinoidal limestone	2	0
2.	Shale	2–15	0
3.	Coal No. 7*b*	0	10
4.	Fire-clay	2	0
5.	Shale and sandstone	100	0
6.	Coal No. 7	0	6
7.	Shale and sandstone	80	0
8.	Coal No. 6	3	6
9.	Fire-clay	4	0
10.	Not well exposed	30–70	0
11.	Coal No. 4	2	0

Coal No. 6 is worked by Messrs. Keyes & Ridgway, on the north fork of Symmes Creek, in section 16. No opportunity was afforded for examining these banks, as they were full of water. The coal is said to be three and one-half feet thick, and of good quality. Along Wills Creek this coal is mined by J. Wilcox, C. Wilcox, and S. Voorhis, in section 2, and by H. Schmueser, in section 3. Being worked only for domestic use, and left untouched in summer, none of these banks were in condition to admit of satisfactory measurement, and no specimens could be obtained. Coal No. 4 is not reached on Symmes Creek, and is nowhere satisfactorily exposed along Wills Creek, though it can be recognized here and there, and, with some difficulty, can be traced from Johnson's Mills to Frew's Mills. Fragments of the gray limestone were occasionally seen, but it was not observed in place. Nodules of iron ore are common in the sandstone above Coal No. 6, but are not in quantity to be of economical value.

Salem Township.—Like Adams, this lies at such an elevation as to be without available coal. The Crinoidal limestone is seen on nearly all the roads, with Coal No. 7*b*, eight to ten inches thick, about twelve feet below it. In the southern portion, on Salt Creek, there are one or two openings upon the "Norwich" coal, which are worked irregularly during the winter. The coal used here is obtained chiefly from Madison and Monroe townships, where Coal No. 6 is mined.

Monroe Township.—Here we have the following section:

		FT.	IN.
1.	Crinoidal limestone	2	0
2.	Shale	3	0
3.	Coal No. 7*b*	0	8–10
4.	Shale and sandstone	120	0
5.	Coal No. 7	6	to 8
6.	Sandstone	60	0
7.	Shale	10–15	0
8.	Coal No. 6	4	0
9.	Fire-clay	3	0
10.	Shale	35	0
11.	Coal No. 4	2	0

Coal No. 7*b* is nowhere of any value, and is seen only occasionally with the Crinoidal limestone, and then on the tops of the highest hills. The limestone is very shaly, and contains few molluscan remains, being made up almost entirely of crinoidal fragments. Coal No. 7 is usually very thin, and can be traced only with the utmost difficulty; but one mile south from Otsego, on the farms of C. Buker and C. B. Painter, it is developed, locally, to a very considerable thickness. There it shows coal, four feet; clay, one foot; coal, one foot six inches. The upper coal is of only moderately good quality, as it contains much cannel of low grade, but the bottom coal is said to be very fair. No banks are now in operation. Coal No. 6 is the important bed, and is worked at and near Otsego by J. Walker, J. Smith, T. Rainey, J. M. Sprague, and J. Simmons. At Mr. Smith's opening we find:

		FT.	IN.
1.	Fissile shale	30	0
2.	Coal	3	0
3.	Clay	0	1
4.	Coal	1	0
5.	Fire-clay	5	0

No slaty coal is here seen on top. Streaks of pyrites are not uncommon in the upper bench, but they are thin and not persistent. The thickest is one foot and one-half below the roof, and one inch thick. The coal is regarded as exceedingly good, and some rude attempts have produced a coke of apparently fair quality. A specimen of the coal yields the following:

Specific gravity	1.287
Moisture	3.30
Volatile combustible matter	37.50
Fixed carbon	57.30
Ash	1.90
Total	100.00
Sulphur	1.97
Sulphur remaining in coke	0.87
Sulphur forming of the coke	1.46
Fixed gas per pound, in cubic feet	3.72
Character of coke	Compact.
Color of ash	Reddish.

At Johnson's Mills, in section 5, the same coal is worked. There it is badly cut up by partings, as follows:

		FT.	IN.
1.	Clay	0	0
2.	Black shale	0	4
3.	Coal	0	6½
4.	Coaly shale	0	½
5.	Coal	0	11
6.	Coaly shale	0	1
7.	Coal	1	2
8.	Clay	0	1
9.	Coal	1	0
10.	Fire-clay	3	0

The same bed is worked by Oscar Riney in section 8 and by Mr. Waters in section 9, also by Mr. Lawyer, near the road from Otsego to Liberty. Its thickness in these banks is nearly four feet.

Coal No. 4 is known, locally, as the "limestone coal," though the gray limestone is rarely seen. It is usually a cannel, of little value, and is not mined. Many years ago it was worked by stripping in section 8, on property now belonging to Mr. Oscar Riney. It may be seen in a run, near Johnson's Mill, where it seems to be about twenty inches thick.

At Johnson's Mill, as well as at Otsego, the lower layer of the sandstone over Coal No. 6 is, in the bottom two feet, a conglomerate of iron ore and sandstone. The ore is apparently of average quality, but its association with the sandstone is such as to render it worthless. It is referred to here only because some might be led to expend money in exploring it. Any money so spent will be wasted.

Highland Township.—On the Adamsville road from Norwich, Coal No. 7*b* is seen at several places, lying a few feet below the Crinoidal limestone, but is nowhere worked, as its thickness seldom exceeds sixteen inches. At Mr. Tait's, on this road, the Norwich coal is seen at the roadside, and is mined near by, by stripping. As nearly as could be ascertained, the thickness is two feet. The limestone is absent. About a mile north, Mr. John Cherry works the same bed, and finds it from two and one-half to three feet thick, with six inches of slaty coal. At both localities Coal No. 7*b* is seen, barely one foot thick.

Along Limestone Ridge, which coincides with the Norwich anticlinal, the Crinoidal limestone and the buff limestone, underlying the Norwich coal, are frequently exposed, and the interval between them varies from twenty to fifty feet. The latter disappears before reaching Bloomfield, where the Crinoidal limestone appears in the Otsego road. Near that village Mr. Oliver Rankin has an opening in the Norwich coal, which gives the following section:

	FT.	IN.
1. Shale	3	5
2. Coal	1	9
3. Clay	0	2
4. Coal	0	8
5. Fire-clay	6	0
6. Limestone	8	0

The coal is compact and hard, and meets with much favor. Blacksmiths use it, and pronounce it a very fair coal. Near the road from Bloomfield to New Concord, the Norwich coal is worked on the old Murphy farm. We there find:

	FT.	IN.
1. Sandstone	0	0
2. Dark shale	2	6
3. Coal	2	9
4. Fire-clay	0	0
5. Limestone	7	0

This bank was not in operation when visited, and the only coal seen had been exposed for several months. It seemed to be of very fair quality, and to have no great tendency to disintegrate on exposure.

Specimens were submitted to analysis, with the following results. No. 1 is from the Rankin bank and No. 2 from the Murphy bank:

	No. 1.	No. 2.
Specific gravity	1.305	1.314
Moisture	2.90	3.20
Volatile combustible matter	34.70	33.00
Fixed carbon	57.80	56.40
Ash	4.60	7.40
Total	100.00	100.00
Sulphur	2.60	2.96
Sulphur remaining in coke	1.09	1.37
Sulphur forming of the coke	1.74	2.14
Fixed gas per pound, in cubic feet	3.72	3.40
Character of coke	Compact.	Compact.
Color of ash	Light gray.	Reddish.

Union Township.—At New Concord we reach the bottom of the boat-shaped synclinal already referred to. The Norwich limestone and coal are exposed here, near the village. In a boring for oil, made here several years ago, the following section was obtained:

		FT.	IN.
1.	Soil	6	0
2.	Shale	16	0
3.	Coal No. 7*b*	1	6
4.	Not determined	20	0
5.	Sandstone	22	0
6.	Coal (Norwich)	0	6
7.	Shale	9	0
8.	Flint rock	8	0
9.	Fire-clay	0	10
10.	Blue sandstone	5	0
11.	Shale	4	0
12.	Shaly sandstone	4	0
13.	Sandstone	20	0
14.	Blue clay	2	0
15.	Sandstone	12	0
16.	Shale	4	0
17.	Black shale	13	0
18.	Sandstone	7	0
19.	Blue clay	5	0
20.	Shale	2	0
21.	Sandstone	20	0
22.	Black shale	11	0

		FT.	IN.
23.	Shale	10	0
24.	Sandstone	7	0
25.	Coal No. 7	3	0
26.	Sandstone	28	0
27.	Shale	14	0
28.	Sandstone	58	0
29.	Coaly shale	5	0
30.	Coal No. 6	6	0
31.	Shale	13	0
32.	Sandstone	20	0
33.	Shale	11	0
34.	Blue clay	8	0
35.	Shale	8	0
36.	Brown shale	4	0
37.	Not described	34	0

No. 3 of this section was at one time mined by Mr. Speer, under the dépôt at New Concord, by means of an incline. It is there thirty inches thick, and overlaid immediately by the Crinoidal limestone, five feet thick, and exceedingly hard. The coal obtained here was of excellent quality, but the bed is too thin to be profitably worked. The same coal is worked at Norwich quite extensively by Messrs. J. C. Wiley, William Tudor, John Morehead, and several others. It is about two feet thick, and of very fair quality. The Crinoidal limestone is there seventeen feet above it, and the interval is occupied by shaly sandstone.

The Norwich coal has been worked at Norwich, but the banks have long been deserted, and no measurement could be made there, but it is said to be two feet thick. In a run north of Norwich, crossed by the Adamsville road, it is seen twenty inches thick. The limestone, nine feet below it, is blue on the fractured surface, but weathers buff, is fossiliferous, and very tough. It is the "flint rock," No. 8, of the oil-boring.

The absence of Coal No. 7*a* in the boring renders somewhat uncertain the identification of Nos. 25 and 30 of the section; but the Norwich limestone is present in the western portion of Guernsey county at from one hundred to one hundred and fifteen feet above the Cambridge coal (No. 7). The interval in the boring between the limestone and No. 25 is only about one hundred and twenty-five feet, so that I am inclined to regard No. 25 as the Cambridge coal. The interval between Nos. 25 and 30 is one hundred and five feet, which is greater than is usually seen between Nos. 6 and 7 in Muskingum county, though about the same as in Guernsey and Tuscarawas counties. The intervals between the coals of the Barren Group, that portion of the series between Coals No. 6 and 8, seem to diminish westward and northward from a line running through Muskingum, Tuscarawas, and southern Carroll counties. The interval between the Crinoidal limestone and Coal No. 6 varies in Carroll county from two hundred and fifty to less than one hundred and fifty; in Guernsey, from two hundred and forty to two hundred; and in Muskingum, from two hundred and twenty-five to one hundred and eighty. The opposite statement is true respecting the relations of the lower coals, as has already been shown respecting Coals Nos. 4 and 6 in the report upon Guernsey county.

The coals in Union township are not much esteemed for manufacturing purposes, and supplies are obtained mostly from Coal No. 8, in Belmont county.

SUMMARY.

Coal is found in sufficient abundance for domestic use in nearly every portion of the county north from the railroad, but of the numerous seams mentioned in the general section only Coal No. 6 is of persistent importance. Each of the others is workable at some point, but is liable to such variations in thickness as to render it unworthy of general note. Coal No. 6 is fully available along Wills Creek and the Muskingum River, where it is within reach of transportation. Analyses from three townships show the percentage of ash to vary from 1.6 to 1.9 per cent.; of sulphur, from 1.59 to 1.97 per cent.; and the yield of fixed gas per pound from 3.7 to 3.8 cubic feet, while the coke in all cases is compact. One analysis from Washington township shows a somewhat inferior coal, containing 3.02 per cent. of sulphur and an increase of ash. The coal throughout is an excellent fuel, and the low proportion of sulphur makes its coke comparatively good for use in smelting iron. The gas from this coal is said to be somewhat inferior in point of brilliancy.

Iron.—The ores of this county are likely to prove of importance. They are of excellent quality, and are made the more available by the proximity of good coking coal. It is not improbable that Coal No. 4, in Jackson township, may be employed raw, as it does not cake, and contains less than two per cent. of sulphur. In Washington township good ore is found fifteen feet below Coal No. 6. In Jackson, Licking, and Muskingum townships an ore bed is seen in conjunction with the chert above Coal No. 3, and the same was observed in Madison township. This is the horizon to which belongs analysis No. 2, in Jackson township. Another bed rests almost upon the Conglomerate in Jackson and Licking townships. Analysis No. 1, in Jackson township, is of ore from this deposit. These ores should be smelted at Frazeysburg and Irville or Nashport, as those places are upon the Ohio Canal, by which coke and the richer ores could be transported without difficulty.

Clays.—Under Coal No. 3 there is a fire-clay which seems to be of excellent quality. On Symmes Creek it is manufactured into pottery-ware, which is held in high esteem. The other beds of fire clay are sometimes quite thick, but usually they contain too much iron to be of any use. The heavy subsoil furnishes excellent material for bricks, and there are few farmers who can not make all the bricks they need from clay found on their own property.

Building Stone.—In the townships along the Muskingum, a sandstone below Coal No. 6 affords an excellent building stone, and is extensively quarried for this purpose. In other townships, east from the river, sandstones belonging to the Barren Group are occasionally employed, but they are too soft for any thing but coarse work. The Waverly sandstones, in the western portion of the county, will doubtless yield a first-class rock, but at present they are not available.

Limestone.—None of the limestones give a lime sufficiently white for inside work. In the eastern portion of the county the strata are usually too impure to be burned. The blue and gray limestones yield a strong lime, which is used for all ordinary purposes. As exposed along the Muskingum River, these are good enough to be used as a flux.

Water.—The supply is abundant every where.

CHAPTER LXIV.

REPORT ON THE GEOLOGY OF BELMONT COUNTY, NORTH OF THE CENTRAL OHIO RAILROAD.

BY JNO. J. STEVENSON.

Belmont county is bounded on the north by Harrison and Jefferson counties, on the east by the Ohio River, on the south by Monroe county, and on the west by Guernsey county. It contains sixteen townships, with a total area of not far from six hundred square miles.

The surface of that portion of the county which lies north from the Central Ohio Railroad is much diversified, the streams being very numerous, and some of them quite large. In the west, Stillwater Creek drains Warren, Kirkwood, and Flushing townships, while Wheeling Creek and its many tributaries drain Union, Wheeling, Richland, Colerain, and Pease townships. The soil for the most part is excellent, owing to the large proportion of limestone in the rocks whence it is derived, but the steepness of the hills renders extensive farming operations somewhat unsatisfactory. The inhabitants have expended much strength upon wool-raising, which has proved to be, in the main, quite profitable. In several townships stock-raising has been attended with success. In the western portion of the county tobacco is an important crop, there being shipped from Barnesville alone upwards of two millions of pounds per annum. The steep hills along the Ohio are covered with deep, rich soil, which is admirably adapted to grape culture.

The county seat is St. Clairsville, a prosperous village of several hundred inhabitants. The principal villages are Bellair, Bridgeport, Barnesville, and Flushing. The community throughout seems to be prosperous. Much attention has been bestowed upon the roads, many of which are macadamized. Schools and churches are numerous, and, for the most part, of such a character as to reflect credit upon the taste and intelligence of the people.

GEOLOGICAL STRUCTURE.

This portion of Belmont county exhibits no satisfactory evidence of glacial action. A few water-worn fragments were obtained on some of the higher hills, but they had been transported for but a short distance, if, indeed, they had been transported at all. In structure they are the same with rocks in the immediate vicinity. Along the river the gravel terraces are beautifully defined, and rise to more than fifty feet above the stream. This deposit extends to at least seventy feet below the present bed at Bellair, as has been proved by borings. How much deeper the original bed of the river lies can not be ascertained from any records of borings now accessible.

The rock formations of the country belong altogether to the epoch of the Coal Measures, and exhibit portions of the Lower Barren Group and Upper Coal Group of Rogers. An approximate section of the western part is as follows:

		FT.	IN.
1.	Débris, with fragments of limestone	15	0
2.	Sandstone	45	0
3.	Coal No. 13	1	6
4.	Fire-clay	0	8
5.	Black shale	7	0
6.	Sandstone	60	0
7.	Coal No. 12	1–2	0
8.	Fire-clay	0	10
9.	Sandstone and shale	20–35	0
10.	Coal No. 11 (Waynesburg)	1–6	0
11.	Sandstone and shale	50	0
12.	Limestone	6	0
13.	Sandstone	45	0
14.	Coal No. 10	4	0
15.	Fire-clay	3	0
16.	Sandstone	35	0
17.	Coal No. 9	2	6
18.	Fire-clay	0	2
19.	Limestone	45	0
20.	Black shale	3	0
21.	Coal No. 8 (Pittsburgh)	4	2
22.	Fire-clay	3	0
23.	Shales	0–12	0
24.	Limestone	4–30	0
25.	Sandstone	110	0
26.	Shale	10	0
27.	Crinoidal limestone	4	0

In the eastern portion of the county the section differs materially between Coals Nos. 8 and 10. As obtained there it is as follows:

		FT.	IN.
14.	Coal No. 10	3	0
15.	Fire-clay	2	0
16.	Sandstone	35	0
17.	Coal No. 9	2	6
18.	Fire-clay	1	0
19.	Limestone	70	0
20.	Shale	3	0

		FT.	IN.
21.	Coal No. 8*c*	3–4	0
22.	Sandstone	18–35	0
23.	Coal No. 8*b* and shale (Sewickly)	1	6
24.	Limestone	20	0
25.	Coal No. 8*a* and shale (Redstone)	1	6
26.	Limestone	18–25	0
27.	Shale	12	0
28.	Coal No. 8 (Pittsburgh)	6–7	0
29.	Fire-clay	0	6
30.	Limestone	3	0
31.	Shale	7	0
32.	Fire-clay	7	0
33.	Limestone	4	0
34.	Sandstone	50	0
35.	Shale	10	0
36.	Sandstone	40	0
	Level of Ohio River.		

In no other portion of the First Geological District, excepting the southern portion of Jefferson county, is so long a section of upper coals seen, though it is by no means probable that we have reached the summit of the series. The rocks dip south-eastwardly, so that in the southern portion of the county rocks much higher than any given in the section must occur. The Upper Barren Group of Rogers, which, according to J. C. White, has a thickness of nearly eight hundred and fifty feet in south-western Pennsylvania, beginning with the sandstone above our Coal No. 11, is shown here only partially, the total thickness seen in northern Belmont county being only about one hundred and sixty feet. In another place* I have shown the relations of the Ohio upper coals to those of Pennsylvania and West Virginia, and the parallelism there given has recently been confirmed by the exceedingly careful section made by Mr. J. C. White, from the Monongahela to the Ohio at Wheeling, and published in the Annals Lyc. Nat. Hist. N. Y., vol. XI. The equivalence of the coals thus determined is as follows:

OHIO.	PENNSYLVANIA AND WEST VIRGINIA.
Coal No. 13	Top coal at Waynesburg, Pa.
Coal No. 12	"Brownsville" of White, W. Va. and Pa.
Coal No. 11	"Waynesburg."
Coal No. 10	Wanting.
Coal No. 9	Absent.
Coal No. 8*c*	Absent (east side of basin).
Coal No. 8*b*	"Sewickly."
Coal No. 8*a*	"Redstone."
Coal No. 8	"Pittsburgh."

* Annals of the Lyceum of Natural History of New York. Vol. X, pp. 226 et seq.

It is impossible to trace the top coals into West Virginia and Pennsy - vania so as to determine the exact equivalence at distant localities. They are found over a large area, but only in small and widely separated patches, so that we are forced to rely only upon relative position, which, owing to the rapid variations in interval between beds, is at best an exceedingly unsafe basis on which to reason. The other beds, from 8 to 11 inclusive, those of the Upper Coal Group, are traceable without difficulty, and the identifications are certain.

Owing to the extensive operations of erosive forces in this county, Coal No. 13 is seen at but few localities. It is well exposed at the summit cut of the Central Ohio Railroad, being there one foot thick, and imbedded in dark shale. It occurs also about a mile north from this cut, but, as is ordinarily the case, it is exposed at the road-side. Near Morristown it should occur, but there its place is covered by débris. At no point is it of any economical value.

Coal No. 12, lying at a lower elevation and protected by the overlying sandstone, is visible at a much greater number of localities than the last. Along the Central Ohio Railroad it is exposed in cuts east and west from Burr's Mills, and in the tunnel at Barnesville. The exposures are quite numerous in Goshen, Warren, Union, and Richland townships, and in the latter it has been worked to a slight extent. The thickness rarely exceeds eighteen inches.

Coal No. 11 is worthy of note, chiefly because of the suddenness and extent of its changes, which seem to be as characteristic of it here as in its eastern extension, the "Waynesburg" of Pennsylvania and West Virginia. In the second cut west from Barnesville, on the Central Ohio Railroad, it varies from six inches to nearly six feet within one hundred yards. In this portion of the county it is known as the "Jumping six-foot seam. It is readily traceable through Warren, Goshen, Kirkwood, Flushing, Richland, and Pease townships. It is rarely of any economical value, and at no locality does it yield good coal.

Coal No. 10 is second in importance only to the Pittsburgh (No. 8), and is mined extensively to supply local demand in Warren, Goshen, Union, and Flushing townships. At the west it is rarely less than four feet thick, but steadily diminishes until at the Ohio it has entirely disappeared. In the western townships it is very much like the Pittsburgh structure, being a double bed, and, sometimes, still farther divided. The coal is variable in quality, and, as a whole, is inferior to that of the Pittsburgh.

Coal No. 9 is a very persistent bed, seldom less than thirty inches thick, though at one locality it is only eighteen. It is every where double, being divided midway by a clay parting six inches thick. The only locality at which it appears to be altogether absent is near Sewellsville, where an eroding current has removed the coal and the whole of the limestone between it and the Pittsburgh below, replacing them with sandstone.

The removal of these rocks presents some interesting features. In the greater part of the county the interval between Coal No. 9 and the coal next below is occupied by a massive limestone, varying in thickness from forty to seventy feet within Belmont county. West from a line beginning in Harrison county, and reaching Belmont at section 12 of Flushing township, thence passing south of west to section 23 of Kirkwood township, thence southerly to the National Road, thence irregularly southward to the Central Ohio Railroad, passing between Barnesville and the Hendrysburg pike, we find the limestone removed, and replaced by sandstone. The following sections illustrate the conditions: No. 1, from Barnesville, Belmont county; No. 2, from Sewellsville, Belmont county; No. 3, from Moorefield, Harrison county; No. 4, from Deersville, Harrison county; No. 5, from New Egypt, Belmont county, to show the normal condition.

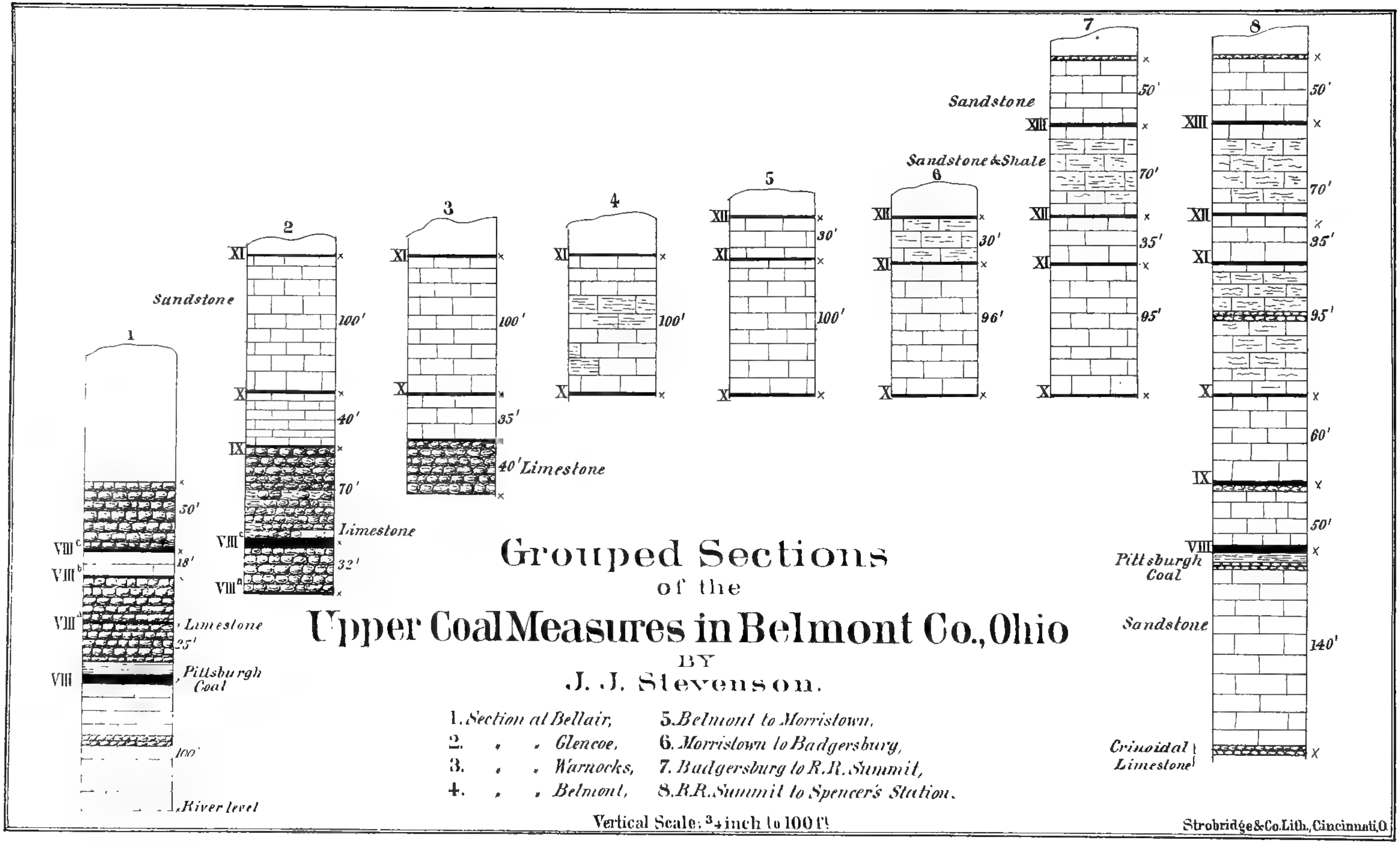
1.	2.	3.	4.	5.
1. Coal No. 10.	1. Coal No. 10.	1. Sandstone, 40′.	1. Sandstone, 70′.	1. Coal No. 10.
2. Sandstone, 55′.	2. Sandst'e, 105′.	2. Limestone, 4′.	2. Coal No. 8.	2. Sandstone, 35′.
3. Coal No. 9.	3. Coal No. 8.	3. Shale, 5′.		3. Coal No. 9.
4. Limestone, 5½′.		4. Coal No. 8.		4. Limestone, 70′.
5. Sandstone, 40′.				5. Shale, 5.′
6. Coal No. 8.				6. Coal No. 8.

A comparison of these sections shows that the limestone of section 5 has been removed to be replaced by sandstone. That the entire removal shown in No. 2 was not the work of a single current is shown by No. 1. The first or earlier current exerted its force before the close of the limestone-making time, and before the deposition of Coal No. 9. The limestone of No. 1 yields a hydraulic cement equal to any manufactured in our country. The upper layer of the limestone in No. 5 possesses hydraulic properties where exposed in the eastern townships, as well as in Harrison county, so that we can not doubt that it is synchronous with that at Barnesville. The force of this earlier current must have been exerted irregularly, for at Deersville it removed both limestone and shale without touching the coal below; at Moorefield it spared the lower portion of the limestone; while at Sewellsville and Barnesville it removed every thing above the lower division of Coal No. 8, and trenched that deeply from these points westward to the final outcrop. The second current did not exist until after the formation of Coal No. 9, and seems to have acted more energetically at the north than at the south. At Barnesville it spared the coal and its underlying limestone, while northward both have been removed. The two currents must have been due to similar causes, as their courses coincide.

Coal No. 8*c* is found only in the eastern portion of the county, and is known locally as the Glenco coal, having been worked somewhat extensively near Glenco, on the Central Ohio Railroad. Northward from the railroad it diminishes in thickness, but is easily traced to its final disappearance in Jefferson county. On the Virginia side it is frequently exposed from the Bellair bridge northward to Wheeling, beyond which it thins out. In Belmont county it is locally of some importance.

Coals Nos. 8*b* and 8*a* are of no importance, and thin out westward, disappearing entirely at less than fifteen miles west from the Ohio within the county. The limestones between these beds and Coal No. 8 are coextensive with Coal No. 8*c*.

Coal No. 8, the "Pittsburgh," is the important bed of the county. It is opened at many places along the Ohio River; is exposed and worked for eight miles along the Central Ohio Railroad; is readily accessible for nearly twenty miles along Wheeling Creek, in the runs on each side of the creek, and at many localities west from the divide running through the middle of the county. It is mined in Pultney, Pease, Colerain, Richland, Wheeling, Flushing, Kirkwood, and Warren townships. In the greater portion of the county it is overlaid by limestone, and shows the characteristic double bedding. Where overlaid by sandstone, in the western townships, only the main or lower division remains. In many openings one may see that the eroding current has torn away not only the upper divisions, but has made deep trenches in the main coal, which are now filled with great "horsebacks" of sandstone, which have a rudely east of north and west of south trend. Where clay seams and horsebacks occur in the eastern townships the trend is in the same direction. The general anatomy of the main or lower division seems to be the same throughout the county. About ten inches from the top there is a band of pyrites varying from one-half inch to two inches in thickness; in the middle there are two slate partings, pyritous, each about one inch thick, and separated by about three inches of coal, while at a distance of eight


Grouped Sections
of the
Upper Coal Measures in Belmont Co., Ohio
BY
J. J. Stevenson.
1. Section at Bellair, 5. Belmont to Morristown.
2. " " Glencoe, 6. Morristown to Badgersburg,
3. " " Warnocks, 7. Badgersburg to R.R. Summit,
4. " " Belmont, 8. R.R. Summit to Spencer's Station.
Vertical Scale: 3/4 inch to 100 ft.
Strobridge & Co. Lith., Cincinnati, O.
Sandstone
Sandstone & Shale
Limestone
40' Limestone
Pittsburgh Coal
Crinoidal Limestone
River level

to ten inches from the bottom there is frequently a thin streak of pyrites about one-fourth of an inch thick. Throughout the bed, at distances varying from four to six inches, there occur charcoal seams, rarely more than one-eighth of an inch thick, and with difficulty traceable in the solid coal, though very distinct near the outcrop. Nodules of pyrites occur in many banks, but are easily separated. Excepting in Warren township, the coal appears to be of excellent quality, and, aside from the portions referred to, comparatively free from pyrites.

The relations of the Pittsburgh bed to those above it are of no little interest. The three beds, marked No. 8*a*, No. 8*b*, No. 8*c*, are found only in the eastern portion of Belmont, and are absent in western Belmont as well as in Harrison and Guernsey, while they are only doubtfully present in southern Jefferson. It is observed that in the eastern portion No. 8*c* is about one hundred feet below Coal No. 10, while in the west No. 8 occupies that position. From Bellair to the summit of the Central Ohio Railroad nine coals are seen, beginning with the Pittsburgh, while from the summit westward only six coals appear in the section. In both sections the succession is the same from the top to Coal No. 9, below which the sections differ, as shown on a previous page. That the lower coal worked at Barnesville is the Pittsburgh there is no room for doubt, and that the upper coal is No. 10 is equally certain, for that coal can be traced, without any difficulty, from Barnesville round the divide back to the railroad at Belmont, and thence along the road to Glenco; thus giving indisputable evidence that it is not the Glenco coal (No 8*c*), as has been maintained by some. The accompanying plate of grouped sections, arranged with Coal No. 10 as the base, shows the matter very clearly. The sections are as follows: No. 1, from Bellaire; No. 2, from Glenco; No. 3, from Warnocks; No. 4, from Belmont; No. 5, from Belmont to Morristown, three miles; No. 6, from Morristown to Badgersburg, two miles; No. 7, from Badgersburg to Railroad summit, two miles; No. 8, from Railroad summit to Spencer's, along the railroad.

A reference to the map will show at once the relative geographical positions of these localities.

In order, however, to remove all doubts respecting the identity of the coal at Barnesville the following sections were compared:

No. 1.—Bellaire to railroad summit.			No. 2.—Railroad summit to Spencer's.		
1.	Coal No. 13.		1.	Coal No. 13.	
2.	Interval	70′	2.	Interval	70′
3.	Coal No. 12.		3.	Coal No. 12.	
4.	Interval	40′	4.	Interval	30′
5.	Coal No. 11.		5.	Coal No. 11.	
6.	Interval	98′	6.	Interval	100′

No. 1.—Bellaire to railroad summit.

7.	Coal No. 10.	
8.	Interval	35′
9.	Coal No. 9.	
10.	Interval	70′
11.	Coal No. 8*c*.	
12.	Interval	0′–35′
13.	Coal No. 8*b*.	
14.	Interval	20′
15.	Coal No. 8*a*.	
16.	Interval	25′–30′
17.	Coal No. 8.	
18.	Interval to river	130′

No. 2.—Railroad summit to Spencer's.

7.	Coal No. 10.	
8.	Interval	60′
9.	Coal No. 9.	
10.	Interval	45′–50′
11.	Coal No. 8.	
12.	Interval	140–150′
13.	Crinoidal limestone.	

A comparison of these sections certainly seems to prove that No. 11 of the second is the same as No. 17 of the first. The anatomy of the bed is the same, for while the upper division has been removed by the eroding current already referred to, we find in the lower division, which remains, the characteristic pyrites band and the clay partings. But to render the matter absolutely certain, this bed was traced, in connection with the Crinoidal limestone, all round the western and northern outcrop to Steubenville, on the Ohio, and thence down to the river to Portland, whence the bed itself was followed to Bellair, where it proved to be the No. 17 of section 1. It is evident, then, that the rocks filling the interval between Coal No. 8 and the massive limestone underlying Coal No. 9 have disappeared, bringing Coals Nos. 8 and 9 eighty feet nearer together at the west than at the east, so that at the west Coal No. 8 holds the same relative position to Coal No. 10 that No. 8*c* does at the east. Followed still further north and north-west, the limestone between Nos. 8 and 9 thins out until, at the extreme north-west outcrop in Harrison county, the interval is almost nothing. Further reference to this matter is made in the reports on Harrison and Jefferson counties.

As, however, this whole matter has been fully discussed by me in my memoir upon the Upper Coal Measures,* it is unnecessary to make any further reference to it here, beyond stating that I have as yet found no reason to doubt the accuracy of the conclusions announced in that memoir in December, 1872.

LOCAL GEOLOGY.

Warren Township.—In this township the soil is quite thick, and, for the most part, so effectually covers the rocks that exposures are rare. Good crops of grass and grain are obtained, and much tobacco is raised. That portion which is north of the railroad lies almost wholly in the upper coals, and the hills are so high that, should one follow the ridge roads, he

* Ann. Lyc. Nat. Hist. N. Y. (loc. cit.).

would be altogether above the available coals, oscillating between Nos. 11 and 12. In the ravines, some of which are cut three hundred feet below the railroad station at Barnesville, Coals Nos. 8 and 10 are exposed and worked. Coal No. 9 is traceable with some difficulty, and varies from four to eighteen inches in thickness.

Along the railroad Coals Nos. 8 and 10 are extensively worked. The former has been opened by Mr. T. C. Parker, near Barnesville, to supply his cement works. Here this bed, locally known as the Laurel Vein, varies much in quality in different portions of the seam. The upper pyrites band is fifteen inches from the top, and is one inch thick. The coal from the bottom bench is very good for steam purposes, but is too impure to be of any commercial value. Mr. Parker has also opened No. 10, but the quality of the coal is much inferior to that from No. 8. Forty-five feet above No. 8 there is a limestone five feet five inches thick, from which Parker's cement is manufactured. An analysis of this is as follows:

Carbonic acid	39.40
Lime	40.10
Magnesia	5.30
Silica	8.50
Alumina	4.80
Peroxide of iron	1.50
Moisture and loss	0.40
Total	100.00

The firm of Parker & Sons began the manufacture of cement in 1858, and found a ready market for their product. At the outbreak of the war they shut up their establishment, as public works were stopped and the demand had ceased. In 1868 the manufacture was resumed. In 1869 this material was tested by the Atlantic and Great Western Railway Company, in competition with eleven other brands, the result being that Parker's cement was adopted. Eleven thousand barrels were supplied to the Baltimore and Ohio Railroad Company during the construction of the bridge at Bellair. Other tests made on government works, by request of Dr. Newberry, have proved, incontestably, the superior quality of this cement. The sandstone overlying this limestone contains some feldspathic sand and much mica—so large a proportion that it is believed, popularly, to be granite.

In section 35 Mr. John W. Campbell works Coal No. 8. His opening shows:

		FT.	IN.
1.	Sandstone	40	0
2.	Bluish shale	0	8
3.	Bituminous shale	0	8
4.	Coal	4	4

The bituminous shale contains numerous thin streaks of coal, which are occasionally aggregated so as to form a layer one inch. The coal is so superlatively bad throughout at this opening that no effort was made to trace the pyrites bands. Pyrites abounds in all parts, and the outcrop is incrusted with copperas. The coal burns well, and, according to Mr. Campbell, does not clinker. The sandstone frequently displaces the shales, and rests directly on the coal. At this locality No. 10 was worked at one time, but the opening is deserted.

Mr. John Gibson, in section 29, works Coal No. 10. His opening was so full of water when visited that no measurement could be made, but the coal is said to be three and one-half feet thick. It is hard to dig, and is regarded as inferior to that obtained from Mr. Campbell's bank. In the same section Mr. John Cheney also works Coal No. 10, and finds it three feet thick, and of fair quality for use in the grate. In sections 16 and 22 the same bed is worked. In section 16 Mr. Walter Davy has it only two feet ten inches, while at Mr. George Douglass's bank, in section 22, we find slaty coal one foot six inches, and coal seen three feet. At many localities this coal is so bad that it seems good for little else but the manufacture of copperas. Mr. Davy's bank is thought to yield better coal than the others, and the following is the result of an analysis:

Specific gravity	1.363
Moisture	1.60
Ash	8.00
Volatile combustible matter	34.40
Fixed carbon	56.00
Total	100.00
Sulphur	3.28
Sulphur left in coke	1.91
Sulphur forming of the coke	2.98
Fixed gas per pound, in cubic feet	3.25
Ash	Gray.
Coke	——

The peculiarities of Coal No. 11 are well shown in the second cut west of Barnesville, where it gives the following section:

	FT.	IN.
1. Coal	1	0
2. Shale	0	4
3. Coal	0	4
4. Shale	0	4
5. Coal	0	4
6. Shale	2	0
7. Coal	1	0
Total	5	4

One hundred yards away it is six feet thick.

Goshen Township.—Little of this township lies north of the railroad, but it is interesting as affording a good exhibition of Coal No. 10 fully developed, as well as showing the highest coal seen north of the railroad. Coal No. 13 appears in the summit cut of the railroad and at several other points, and No. 12 was struck in a well seventy feet below No. 13 by Mr. H. Rogers, on the Morristown road. In section 29 Mr. Harris has an opening into No. 10, which shows as follows:

		FT.	IN.
1.	Shale	8	0
2.	Coal	1	6
3.	Shale	1	4
4.	Coal	4	0
	Total	6	10

The coal is evidently uncertain in thickness; for, near the outcrop, a horseback from below cuts out twenty-two inches. The coal is fair in quality, with little pyrites, but the roof-coal is poor and slaty and white, with copperas at the exposure. At a short distance from his bank, Mr. Harris finds the bed about two feet below the surface, and is working it by stripping.

At Badgersburg, in section 24, the coal is extensively worked to supply the village of Belmont. Mr. John Walker's bank gives the following section:

		FT.	IN.
1.	Laminated shale	4	0
2.	Coal (slaty)	1	7
3.	Shale and clay	1	4
4.	Coal	3	6
5.	Fire-clay	1	0

Mr. Samuel Henkle's opening, directly opposite, shows in the entry shale and clay one foot eight inches, coal five feet to five feet six inches, fire-clay one foot three inches, the roof-coal not being exposed. The difference in the thickness is marked, those on the west side of the road resembling Mr. Walker's, and those on the east Mr. Henkle's. The value of all the banks is impaired, more or less, by clay horsebacks, but they are not extensive. Several clay seams cut the bed at an angle of 60°, and run north-east and south-west, having a thickness varying from six to eighteen inches. The pyrites streaks are few, and are found near the top. Nodules occur occasionally, but are easily separated.

The following is the result of an analysis of a specimen from Mr. Myer's bank at Badgersburg:

Specific gravity	1.343
Moisture	1.10
Ash	6.70
Volatile combustible matter	32.90
Fixed carbon	59.30
Total	100.00
Sulphur	2.47
Sulphur left in coke	1.37
Sulphur forming of the coke	2.07
Fixed gas per pound, in cubic feet	3.30
Ash (color)	Dull white.
Coke	Compact.

Kirkwood Township.—In the neighborhood of Hendrysburg, Coal No. 8 is quite extensively mined. In section 20 Mr. J. McCartney's opening gives the following section:

		FT.	IN.
1.	Coal	0	10
2.	Clay	0	4
3.	Hard shale	1	0
4.	Coal	4	8

No. 3 contains numerous thin streaks of coal. Mr. J. Whittle's opening, in the same neighborhood, shows the same section. The coal is handsome and quite compact. The limestone appears ten feet above the coal. Formerly, Coal No. 10 was mined to some extent, and deserted openings can be seen in the hills on both sides of Hendrysburg. The thickness varies little from three feet and a half, and the roof-coal is not persistent. Coal No. 9 was formerly opened, but the bank has fallen in, so that no measurement could be obtained. The bed is said to be three feet thick. Coals Nos. 10, 11, and 12 are frequently seen in the road-side, between Hendrysburg and Sewellsville, but are not opened. In sections 33 and 28 Coal No. 8 is worked, and has a thickness of five feet. In section 34 this coal is worked by Mr. William Armstrong, at whose opening the sandstone rests directly upon the coal, which is from five feet to five feet eight inches thick. About one foot from the bottom is a band three inches thick, and six inches higher is another of the same thickness—both strongly marked by pyrites. Near the top two thinner streaks of pyrites were observed.

At Sewellsville Nos. 8 and 10 are conspicuous, while No. 9 is absent. Coal No. 10 was opened many years ago, but the coal proved utterly worthless, burning much like rotten wood. It is likely, however, that no fair test was made, and that nothing was used excepting badly weathered crop-coal. The thickness of the bed is about three feet. The openings in Coal No. 8 are very numerous. At Mr. John Greenleaf's bank, section 29, the thickness averages four feet six inches, though it sometimes reaches five feet. The coal is very prettily irised, somewhat brittle, and quite bituminous. It contains thin films of carbonate of lime. In the upper six inches are several thin streaks of pyrites, and at a distance of ten inches from the top is the pyrites band, three-eighths of an inch thick. Below this, pyrites is in small quantity, and the coal appears to be exceedingly pure. The sandstone roof is somewhat irregular, but interferes little with the coal. The adjoining banks, belonging t Mrs. Williams and Mr. Frizzel, show no material differences, except that the sandstone occasionally cuts out the coal somewhat, but never becomes troublesome as a horseback. In the banks of Mr. A. Hunter, section 35, and Messrs. McCormick and S. Curtis, section 30, the sandstone cuts out the coal, forming a sandstone horseback, varying from sixteen to thirty feet in width, which is usually softer than the overlying rock.

Between Sewellsville and New Egypt the erosion is enormous, as appears from the fact that although the distance is only five miles, the whole section from Coal No. 12 to forty feet below Coal No. 8, about three hundred feet, can be measured four times without leaving the road.

Analyses of Coal No. 8 were made with specimens from Mr. J. McCartney's bank (No. 1), near Hendrysburg, and Mr. J. Greenleaf's bank (No. 2), near Sewellsville.

	No. 1.	No. 2.
Specific gravity	1.343	1.300
Moisture	1.30	1.10
Ash	6.20	5.00
Volatile combustible matter	32.70	37.90
Fixed carbon	59.80	56.00
Total	100.00	100.00
Sulphur	3.02	3.84
Sulphur left in coke	1.64	1.78
Sulphur forming of the coke	2.49	2.91
Fixed gas per pound, in cubic feet	3.27	3.39
Ash	Dull white.	Gray.
Coke	Compact.	Compact.

This coal crosses the Guernsey county line about one mile west from Sewellsville. The north-western outcrop passes from this point in section 35 through sections 29, 30, and 24, into Flushing township.

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Union Township.—Coal No. 8 was nowhere satisfactorily observed in this township, and the land rises so high that this is probably reached at few points, the more so as in its eastern portion No. 8*a* occupies the level of No. 8. The National Road here lies for the most part from one hundred and fifty to two hundred feet above Coal No. 10, which is the important bed. The section from near Morristown, on the National Road, to a branch of Spencer's Creek, the lowest point in the township, is as follows:

		FT.	IN.
1.	Concealed, principally sandstone	125	0
2.	Coal No. 12	2	0
3.	Sandstone	40	0
4.	Coal No. 11	1	3
5.	Sandstone and thin limestones	95	0
6.	Coal No. 10	4	6
7.	Concealed	30	0
8.	Coal No. 9	2	6
9.	Fire-clay	0	3
10.	Limestone	65	0
11.	Shale and clay	3	0
12.	Coal No. 8 in bed of creek	2′ seen.	

At Mr. J. Shepherd's bank, section 26, Coal No. 10 shows a thickness of four feet six inches, and the roof coal is not exposed. The coal is very hard and brilliant, frequently irised, and containing layers of semi-cannel. It burns freely, and is a good coal for domestic use. This coal is worked in section 22 by Mr. J. Crozier. At Mr. Isaiah Lee's bank, in section 25, the coal is largely worked to supply Morristown. It there gives the following section:

		FT.	IN.
1.	Coal	1	0
2.	Fire-clay	1	3
3.	Coal	4	6
4.	Shale	1	0
5.	Coal, slaty		8″

Mr. Lee works only the middle bench. It contains no clay veins, and the horsebacks are few and of limited extent. Near the top a few streaks of pyrites are seen, and nodules are not rare. A specimen furnishes the following upon upon analysis:

Specific gravity	1.304
Moisture	1.20
Ash	6.00
Volatile combustible matter	32.40
Fixed carbon	60.40
Total	100.00

Sulphur	2.47
Sulphur left in coke	1.09
Sulphur forming of the coke	1.64
Fixed gas per pound, in cubic feet	3.39
Ash	Yellow.
Coke	Compact.

Flushing Township.—That portion of the road from Sewellsville to Flushingtown which passes through sections 19 and 14 may be regarded as on the north-western outcrop of Coal No. 8. Before reaching the Stillwater this line is deflected to the south-east through section 13 of Flushing into sections 18 and 17 of Kirkwood. It returns northwardly through sections 11 and 12 of Kirkwood into section 7 of Flushing. It then passes through 14, 9, and 3, and enters Harrison county in section 10 of Moorefield township. On the Stillwater the Crinoidal limestone is seen, and toward the north-west corner of the township the valley is cut deeply enough to reach No. 7*a*, which, however, was not observed.

Between Rock Hill and Flushingtown, in section 26, Coal No. 8 has been worked in a small way for upwards of sixty years on property belonging to Mr. J. Hollingsworth. In section 25 it has been opened by Mr. Isaac Holloway, and in section 26 by Mr. Samuel Fisher. At these openings it lies barely above drainage, and the coal is mined only to a slight extent. It is about four feet ten inches thick, with a roof of black bituminous shale containing much coaly matter. At the outcrop the coal is marked by several thin streaks of pyrites, most of which disappear at a short distance in the entry. The upper bench is held in high repute among blacksmiths.

Flushingtown and the surrounding country depend upon Coal No. 10 for supply, and the openings are quite numerous. In section 20, at Mr. W. Johnson's opening, the following section was obtained:

		FT.	IN.
1.	Sandstone (not measured).		
2.	Coal	1	2
3.	Shale and clay	1	4
4.	Coal	3	0

In many of the other openings the thickness is four feet. The proportion of pyrites is variable. At Mr. W. Holloway's bank, in section 21, a portion of the bed yields a coal so admirably adapted to blacksmiths' use that charcoal is no longer employed in the vicinity, whereas at Mr. Wilson's bank, on the other side of the hill, no part of the bed is fitted for such use. An analysis of Mr. Holloway's coal gives the following result:

Specific gravity	1.307
Moisture	1.40
Ash	3.00
Volatile combustible matter	31.60
Fixed carbon	64.00
Total	100.00
Sulphur	1.56
Sulphur left in coke	1.07
Sulphur forming of coke	1.59
Fixed gas per pound, in cubic feet	3.30
Ash	Dull white.
Coke	Compact.

Throughout this township the limestone is found above Coal No. 8, and is about forty feet thick, with Coal No. 9 resting upon it. This limestone, and that below the coal, have been largely quarried, to be broken for roads. When so quarried it is always nodular. The color varies from light blue to dark gray. A specimen of the upper layer yields the following upon analysis:

Silicious matter	5.40
Alumina and oxide of iron	1.60
Carbonate of lime	89.00
Carbonate of magnesia	3.25
	99.25

Wheeling Township.—The general elevation of this township is about the same as that of Flushing.

Along Wheeling Creek, which passes through its southern tier of sections, the exposure is very fine, as the whole series from No. 8 to 12 can be observed without difficulty. Where the Cadiz road crosses the creek, near Mr. W. Ramage's house, in section 30, Coal No. 8 is first seen in the bed of the creek. From this point down, the openings are very numerous, and the lower division averages about five feet. It is worked principally to supply the neighborhood and the village of Uniontown. Coal No. 8c is seen on the Cadiz road, near Mr. Ramage's, at fifty-two feet above No. 8, and is said to be three feet thick. At the exposure in the road it appears to be thicker, but as it is not worked any where nothing definite can be said about it. Coal No. 9 is here of its usual thickness—two feet six inches—and has its characteristic parting in the middle. Coal No. 10 is much degraded, being only two feet eight inches thick, and not worked.

Richland Township.—The three rows of sections running east and west through the middle of the township lie for the most part at little less than one hundred feet above Coal No. 10, and are therefore almost without available coal. The sections lying on the north being cut by Wheeling Creek, and those on the south by McMahan's Creek, have ready access to Coal No. 8.

At the infirmary, in section 28, Coal No. 12 has been worked to some extent, probably to give employment to the paupers, as it is little more than eighteen inches thick. In sections 3, 33, and 34, Coal No. 11 is worked by Messrs. Young, Roscoe, and McKelvy. At their openings the following section is seen:

		FT.	IN.
1.	Sandstone	12	0
2.	Shale	0	2
3.	Coal	2	9
4.	Fire-clay	0	8
5.	Limestone	2	0

The coal has been opened rudely, and is worked only for domestic use. It is of very poor quality, containing much pyrites, and marked by numerous clay seams one-half to three-fourths of an inch thick and three to six inches apart. Coal No. 10 is worked at East Richland, where it is three feet thick.

Coal No. 8*c* is worked by Mr. W. Caldwell in section 29, near the point where the Uniontown road crosses Wheeling Creek. It is overlain and underlain by heavy limestone, which has been quarried for use on the roads. It lies about thirty-five feet above the creek, which soon rises above it in Union township. As the creek flows from the south-west, the coal lies but a short distance below the surface for a couple of miles, and is worked by stripping. No other opening was observed on Wheeling Creek or its tributaries.

On Jug Run, a tributary of Wheeling Creek, both No. 8 and No. 8*a* are well exposed. Near the crossing of the Athens road No. 8*a* lies in the bed of the run. Half a mile further down No. 8 has been rudely worked by stripping, and shortly beyond several openings are seen just above the level of the stream. The opening made in section 6 by Mr. W. Christie appears to be the most characteristic. The following is the section:

		FT.	IN.
1.	Clay shale	2	0
2.	Coal	0	6
3.	Clay	0	8
4.	Coal	1	0
5.	Clay	1	2
6.	Coal	5	0
7.	Fire-clay	5	0

Coal No 8*c* is here sixty feet above No. 8, separated by sandstone, eight feet; limestone, fifty feet; clay shale, two feet. The intimate structure of the lower divisiion of No. 8 is as follows:

		FT.	IN.
1.	"Bone" coal	0	2
2.	Coal	2	0
3.	Clay parting	0	$\frac{3}{4}$
4.	Coal	0	10
5.	Clay parting	0	$\frac{1}{2}$
6.	Coal	2	0
		5	$1\frac{1}{4}$

In No. 2 the pyrites band is found one foot from the top and one inch thick. No. 4 is highly prized by blacksmiths, and is said to be remarkably pure. Nodules of pyrites are not common. The coal on this run is mined to a considerable extent to supply St. Clairsville, but is not regarded as equal to the coal from the Wheeling Hill mines on the National Road. Specimens from the top, middle, and bottom benches were forwarded for analysis, and gave the following results:

	TOP.	MIDDLE.	BOTTOM.
Specific gravity	1.343	1.323	1.304
Moisture	1.10	1.20	1.00
Ash	8.00	5.00	5.70
Volatile combustible matter	33.90	30.00	32.00
Fixed carbon	57.00	63.80	61.30
Totals	100.00	100.00	100.00
Sulphur	4.53	2.47	1.92
Sulphur left in coke	2.19	1.09	0.82
Sulphur forming of the coke	3.37	1.58	1.22
Fixed gas per pound, in cubic feet	3.65	3.12	3.42
Ash	Gray.	Gray.	Gray.
Coke	Compact.	Compact.	Compact.

On McMahan's Creek Coal No. 8 is mined for domestic use. At Mr. Johnson's opening the lower coal is four feet eleven inches, and the roof-coal is single, fourteen inches thick. In Mr. Brown's opening, not thirty yards distant, the lower coal is four feet ten inches, while the roof-coal is double, five inches and twelve inches, separated by six inches of shale.

Colerain Township.—In the northern sections of the township the land lies at such an elevation that the ravines barely reach Coal No. 10, which here seems to be quite thin and is not worked. The runs which empty into Wheeling Creek show Coal No. 8 very finely for a mile or more above the point of confluence. Along Wheeling Creek the height of the coal above the stream varies from thirty to one hundred feet, as the creek falls more rapidly than the coal. The openings are very numerous, averaging one to almost every farm. On Barr's Run the coal is opened on Mr. G. Lost's land, section 31. The lower coal is five feet thick, while the roof-coal is double, five inches and ten inches, separated by two inches of shale. Further up the run, at Mr. J. Henderson's mill, section 32, the lower coal is five feet, and it there disappears in the hill. On Hughes's Run two openings are seen near the county bridge. On Mr. J. Harris's land, section 19, the coal is one hundred feet above the creek, and the lower division is five feet eight inches. On Fall Run it is opened at several localities, but shows no peculiarities, averaging about five feet.

On Flat Run are several openings. That of Mr. Boggs, section 17, shows a strange variation in the roof. The section is as follows:

		FT.	IN.
1.	Shale	12	0
2.	Black shale	0	3″
3.	Coal	0	3″
4.	Black shale	0	½
5.	Coal	0	1½
6.	Shale	0	½
7.	Coal	0	10
8.	Shale	0	1
9.	Coal	0	1½
10.	Shale	0	5
11.	Coal	0	1½
		14	3½

Below this is one foot of clay, resting on the lower division, of which four feet ten inches are seen. The pyrites band is fourteen inches from the top, and the upper bench is twenty-nine inches thick. The coal is irised, and so hard as to bear transportation well. At Mr. S. C. Wilson's bank, on same run, the roof-coal is not exposed, and the lower coal is five feet four inches. At Mr. J. Nolan's bank, in section 10, the lower coal is five feet four inches to five feet eight inches, and the roof-coal varies from nine to twelve inches. The intimate structure of the coal at the openings in this township is as follows:

		IN.
1.	Coal, with pyrites band	29–31
2.	Slate parting	1
3.	Coal	3–10
4.	Slate parting	1
5.	Coal	28–31

Samples of Coal No. 8 were forwarded for analysis, and the results are given below. No. 1 is from Mr. J. Henderson and No. 2 from Mr. Boggs:

	No. 1.	No. 2.
Specific gravity	1.304	1.308
Moisture	1.20	0.80
Ash	8.20	5.20
Volatile combustible matter	30.40	34.20
Fixed carbon	60.20	59.80
Total	100.00	100.00
Sulphur	2.19	4.81
Sulphur left in coke	1.37	2.05
Sulphur forming of the coke	2.00	3.15
Fixed gas per pound, in cubic feet	3.07	3.39
Ash	Gray.	Fawn.
Coke	Compact.	Compact.

Pease Township.—In this township Coal No. 8 is extensively worked along the Ohio River, on Wheeling Creek, and near Kirkwood. Coals Nos. 8*c*, 9, 10, and 11 thin out either altogether or so as to be traceable with the utmost difficulty, while Nos. 11 and 12 attain extraordinary thickness in the central portion of the township along the river.

In the deep cut, on the road leading from Martinsville, is a coal nearly six feet thick, containing much pyrites, and evidently a very inferior article. It is slaty in structure, and resembles the low-grade cannel so common in the Coal Measures in Ohio. At this locality it is three hundred and twenty feet above Coal No. 8. On the property of Mr. W. J. Rainey, in section 13, it is four feet thick, and lies about three hundred feet above Coal No. 8. On Captain R. Crawford's property, near Bridgeport, it is seen three hundred and forty feet above No. 8. It is evidently of no economical value, and is Coal No. 12.

On Captain Crawford's place, at two hundred and forty-five feet above Coal No. 8, a bed three feet six inches thick is worked. The immediate section is:

		FT.	IN.
1.	Sandstone	15	0
2.	Limestone	3	0
3.	Shale	6	0
4.	Iron ore, very impure	0	6
5.	Coal	3	6
6.	Fire-clay	2	0
7.	Limestone	1	0

The development of this coal, No. 11, is local. The ore overlying the coal is worthless, owing to the large proportion of sulphur. The coal itself is handsome, and yields a very compact and beautiful coke. There is evidently an open burning layer, as some of the coke retains the form and appearance of the coal.

Coal No. 10 is only fifteen inches thick on Captain Crawford's property, and has not been observed elsewhere. No. 9 was not seen in Pease township. Coal No. *8b* is one foot six inches at Captain Crawford's, and lies fifty-six feet above No. 8. On Glen's Run, about two miles from its mouth and opposite the mill, this coal is only six inches thick, and lies fifty feet above No. 8. Back of Kirkwood No. *8c* is worked, and shows a thickness of three feet.

Coal No. 8 is mined for shipment by Mr. W. J. Rainey in section 13. The coal here shows:

		FT.	IN.
1.	Coal	2	0
2.	Clay	2 to	6
3.	Coal	6–4	4

The roof-coal has not been worked, but where it has fallen down and so been exposed it appears to be of good quality. The clay varies considerably at the expense of the coal below, but averages about ten inches, and at one spot contains a two-inch seam of coal. The coal of the lower bed varies in quality; six inches at the bottom is usually worthless, and the lower bench is apt to contain an undue percentage of pyrites. Mr. Rainey mines 30,000 tons per annum, the quantity being limited only by the opportunity to ship. He states that the coal is in demand for gas manufacture, and brings within thirty cents per ton of as much as the Connellsville coal.

On Glen's Run there are several deserted openings in which the main coal averages five feet ten inches. At Mr. Sedgwick's the bed shows:

		FT.	IN.
1.	Shale	7	0
2.	Coal	1	3
3.	Clay	1	2
4.	Coal	5	4

The roof-coal is poor and slaty. In No. 4 the upper bench is a good, clean coal, with little pyrites; the middle bench is poor and usually cast away; and the lower bench is slaty, though it burns well, and evidently contains much volatile combustible matter. For six inches at the bottom it is worthless.

At Mr. McConaghy's opening the section is the same, excepting that the lower coal is five feet seven inches. At Mr. Koehnlein's works, near Bridgeport, the coal sometimes becomes seven feet. On the National

Road, in section 15, Mr. D. Brown's opening gives the following section:

		FT.	IN.
1.	Coal	1	6
2.	Shale	0	8
3.	Coal	1	6
4.	Clay	0	8
5.	Coal	5	8

This shows a greater development of the roof-coal than any other opening. The lower division is, upper bench, twenty-nine inches, parting, one inch; middle bench, three inches, parting one inch; lower bench, thirty-six to forty-two inches. South of the National Road the coal is worked by Messrs. Allen, Nicholson & Thompson. A heavy horseback, closely connected with a thick "clay vein" and ten yards wide, crosses their openings.

Of the following analyses Nos. 1, 2, 3, and 4 are of Coal No. 8, and No. 5 of Coal No. 11; 1, 2, and 3 are from roof, upper and bottom of Mr. Brown's bank, No. 4 from Mr. R. Lyle's, and No. 5 from Captain Crawford's coal:

	No. 1.	No. 2.	No. 3.	No. 4.	No. 5.
Specific gravity	1.338	1.300	1.281	1.358	1.348
Moisture	1.00	0.90	1.10	1.20	1.10
Ash	14.00	4.60	6.20	6.50	2.90
Volatile combustible matter	31.00	34.10	34.30	31.60	32.50
Fixed carbon	54.00	60.40	58.40	60.70	63.50
Totals	100.00	100.00	100.00	100.00	100.00
Sulphur	6.31	2.74	2.52	4.11	0.68
Sulphur left in coke	....	1.37	1.51	1.51	0.54
Sulphur forming of the coke	....	2.10	2.33	2.24	0.81
Fixed gas per pound, in cubic feet	3.22	3.35	3.35	3.30	3.46
Ash	Gray.	Gray.	Gray.	Gray.	Yellow.
Coke	Compact.	Compact.	Compact.	Compact.	Pulv.

Iron ore has been found in some localities over Coal No. 13, and was formerly taken out for use at the Martinsville furnace.

On property belonging to Mrs. H. Harrison, section 28, there is found, one hundred and twenty-five feet above Coal No. 8, a limestone which seems to disintegrate readily on exposure, for at this elevation a similarly disintegrated rock is found on nearly every farm in the vicinity. It has a yellowish color, and can be taken out with a pick. Some persons have employed it as a marl, and found it very beneficial. The following analyses show it to be merely a disintegrated limestone, but they are obviously made from samples in very different stages of weathering. No. 1 was made at the Agricultural Department, in Washington, and No. 2 by Dr. Wormley:

	No. 1.	No. 2.
Water	1.18	10.00
Organic matter	1.54	....
Peroxide of iron and alumina	4.40	10.65
Lime	....	8.19
Carbonate of lime	65.06	7.29
Carbonate of magnesia	1.17	13.35
Sulphuric acid	Trace.	......
Phosphoric acid	....	Trace.
Silica and insoluble matter	26.65	50.50
	100.00	99.98

On Mr. D. Allen's property, section 17, there is a fire-clay ten feet below Coal No. 8. Samples of this clay were sent to New Cumberland, West Virginia, to be tested. The brick which was made is an excellent one, and the clay proved itself very refractory. The bed is seven feet thick, and may be traced without difficulty. The result of analysis is as follows:

Silicic acid	58.85
Alumina	24.48
Iron, peroxide	3.72
Lime	2.05
Magnesia	1.08
Potash and soda	2.32
Water, combined	6.95
	99.45

In the extreme north-western portion of the township Coal No. 8 is again seen beyond the divide upon Little Short Creek. On Mr. McKin's property it has been opened by Bracken and Lomax. It is there about four feet below the bed of the creek, and shows the following section:

	FT.	IN.
1. Coal	1	2
2. Clay	1 to	8
3. Coal	5	10

At this opening sound coal had hardly been reached at the time of examination, but the upper pyrites band is measurably persistent four inches from the top, and there appears to be much pyrites throughout the bed, as far as tested. In the tunnel a "clay vein" occurs, covering the bed in a north-west and south-east direction, and dipping north-east. It is somewhat more than three feet thick.

A short distance further down the creek the same bed is worked by Mr. A. H. Handel. The full section at this opening is as follows:

		IN.
1.	Roof-coal	15
2.	Clay	6–20
3.	Coal	31
4.	Parting	2
5.	Coal	17
6.	Parting	¼
7.	Coal	15
		67¼

Here the upper pyrites band is from eight to twelve inches below the clay, and is sometimes triple. It is persistent. The clay, No. 2, contains many thin streaks of coal, and, where thickest, usually contains a layer from two to four inches thick. The coal, as exhibited here, is of very fair quality, but when exposed to the weather it, in many portions, becomes covered with streaks of copperas, and, for the most part, shows a decided tendency to slack. Near the outcrop the coal is beautifully irised.

Half a mile further on, and very near the Jefferson county line, we find Mr. M. F. Sterling's opening. At this we obtain the following section:

		FT.	IN.
1.	Limestone	0	0
2.	Shales	5–8	0
3.	Coal	1	1
4.	Clay	0	4–6
5.	Coal	2	4
6.	Parting	0	½
7.	Coal	1	3
8.	Parting	0	¼
9.	Coal	1	4½
10.	Parting	0	⅛
11.	Coal	1	0
12.	Fire-clay	3	0
13.	Limestone	3	0
14.	Shales and sandstone	65	0
15.	Limestone and shale	5	0
16.	Shales	20	0

Thickness of main coal, six feet to six feet two inches.

The roof-coal is quite good, though somewhat bony. It burns down to a loose, white ash, which is bulky. The pyrites band occurs eight inches below the clay, No. 4 of the section, but through the bed pyrites is not of frequent occurrence. At all of these openings we find in the center of the bed, both above and below the "bearing-in bench," especially in the portion below, known as the "brick-coal," a very free-burning coal, which, on the grate, shows no tendency to cake. It is very clean, and suits well for blacksmithing. The lowest portion of the bed, usually one foot thick, is always somewhat inferior, and generally contains a thin band of pyrites, together with many nodules of the same.

Near where the old plank road leading from Wheeling to Mt. Pleasant crosses Little Short Creek, we find exposures above Coal No. 8 which are of some interest. We find there Coals Nos. 8*a* and 8*c*, but Coals Nos. 8*b* and 9 have disappeared, though their associated rocks are all present.

Pultney Township.—The openings in Coal No. 8 are quite numerous in this township, but for the most part those in operation lie south from the railroad. Near Neff's Siding we find Kidd's mines, where much coal is extracted. Here the bed is slightly faulted in two places—in one, eighteen inches, and in the other, three feet. At three hundred feet from the entrance it is crossed east and west by a "clay vein" six feet thick, which is struck again in a breasting three hundred and twenty-five feet from the main entry. The coal is from five to eight feet thick, and roofed by badly slickensided fire-clay, which is apt to fall. The roof-coal is thin. At the bottom there is a layer of cannel four inches thick, crowded with crushed specimens of *Pleurophorus.*

The coal is dry and quite clean, containing little sulphur. It is a good gas coal, burns freely, but does not yield a good coke, and in portions is apt to clinker. An analysis of this coal shows it to consist of—

Free carbon	61.525
Volatile combustible matter	37.280
Ashes	1.655
Coke	65.180

At Franklin the same coal is worked at the Stewart, Ball & Meehan mine. Here the average thickness is five feet ten inches. On top is a three-inch layer of cannel, which is not persistent. The coal is very good, and finds a ready market at from five to six cents per bushel.

SUMMARY.

Coal.—In this county there are three seams of coal of economical importance. Coal No. 10 is a thick bed, finely exposed in Warren, Goshen, Union, and Flushing townships. Coal No. 8*c* is of value along the Central Ohio Railroad, from the river to where it disappears under the hill, about eleven miles along the railroad, while Coal No. 8 is available in nearly every township within the northern portion of the county. The amount of coal thus exposed is almost incredible.

Along Wheeling Creek, for nineteen miles from the river, the Pittsburgh (No 8) coal lies above water-level, and its average thickness is more than five feet. Throughout this distance it is readily accessible on both sides of the creek for a mile or more, and the ravines, except in the immediate vicinity of the cut, are rarely cut down to the bed, so that the amount of "crop," or rotten coal, is comparatively small. As the dip is toward the south-east, the available area north from the creek reaches quite into Harrison and Jefferson counties. After making all allowance for waste of every kind, and assuming the thickness of the bed to be only five feet, we find available for transportation, within one mile north and south from Wheeling Creek, more than one hundred and twenty millions of tons of coal. Along the Central Ohio Railroad, within eight miles from the river, there are, on the north side of the road, calculated in the same way, twenty-five millions of tons. On these two lines the coal can be easily reached. In the western portion of the county transportation can not be obtained readily, except along the Central Ohio Railroad, where the coal is exposed for about three miles.

It is somewhat unfortunate that, where this coal is present in such vast quantity, it contains impurities which unfit it for direct use in the important manufactures of gas and iron. The ash varies from 4.6 to 8.2 per cent., and the sulphur from 2.19 to 4.11 per cent. Of the sulphur, a very large part remains in the coke, so that it is present, in combination with iron, as pyrites. The coke is so compact that the experiment of washing the coal previous to coking might prove profitable. This bed shows little variation in purity throughout the county.

Of Coal No. 8*c* we have no analyses. At the time of examination no opening was in operation, so that no specimens could be obtained except from the outcrop. It is rarely worked north from the railroad, as Coal No. 8 is generally reached with ease.

Coal No. 10, as a whole, seems to be somewhat superior to Coal No. 8, though, judging from physical characters alone, one would be led to the opposite conclusion. The ash varies from three to eight per cent., while the sulphur in no case exceeds 3.2 per cent., and in one instance falls to 1.56 per cent. The coke every where is compact. This coal is quite as rich in gas as No. 8, and, owing to its lower percentage of sulphur, might be made available as a gas coal if facilities for transportation were afforded.

Coal No. 11 is rarely of economical importance, but near Bridgeport, in Pease township, it yields an open-burning coal of great purity. There it shows only 2.9 per cent. of ash, and 0.68 per cent. of sulphur. This coal should prove valuable, as it can be used raw in smelting iron.

Iron.—No deposit of iron ore, economically important, was observed in the county. Here and there are shales containing many nodules, but the quantity is nowhere sufficient to be of any value.

Cement.—The layer of limestone immediately underlying Coal No. 9 every where yields a lime possessing hydraulic properties. The Barnesville cement obtained from this rock has no superior among the cements manufactured in our country. This layer is present throughout the county, except in the north-west, and invariably presents the same physical character. Underlying Coal No. 8*b*, on the river, is a limestone which yields a good hydraulic lime.

Marl.—The calcareous shales interstratified with the limestones under Coals Nos. 8*b* and 9 will prove useful as marls. The analysis of one of these has been given (Pease township).

Fire-clay.—The clay from below the coals is usually too ferruginous to be of any value. The deposit in Pease township may prove valuable, but the analysis is not encouraging. Clay for bricks is obtained from the subsoil.

Water.—The county is well supplied with water for all purposes.

CHAPTER LXV.

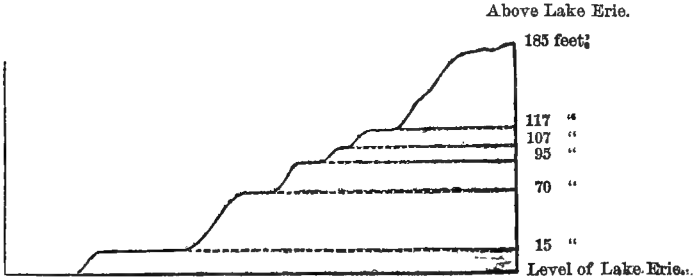
REPORT ON THE GEOLOGY OF HURON COUNTY.

BY M. C. READ.

TOPOGRAPHY.

The distinctive peculiarities of the topography of Huron county are apparent only after a somewhat minute and careful observation. Commencing at the north-west corner of the county, a broad and level surface of prairie, with peaty soil, modified in places by sand dunes and valleys of recent erosion, is a marked characteristic. This is followed on the north and east by other broad and higher terraces reaching to the irregular undulations of the clay Drift of the divide. The outlines of these successive terraces are very irregular, and the ascent from one to the other so gradual, that the changes of level are often unnoticed; the attention of the observer being attracted only to the large areas which mark the old water-levels, the difference in elevation of these being overlooked. The elevated land, extending from the northern divide through Townsend township, terminating at Berlin Heights, in Erie county, forms a high promontory, which reached far out into the Lake when the land to the west and north-west of it was covered with water. On the northern face of this promontory, the successive steps of the terraces which are read with difficulty in most other parts of the county, are brought into close proximity, the record of each successive stage in the depression of the waters of the Lake being plainly legible, as will be seen from the woodcut below.

TERRACES AT BERLIN HEIGHTS.



Each of these narrow terraces is represented in Huron county by broad expanses of level land, showing that they are old water plains, diversified by sand dunes and remains of old lake beaches, and by the various channels excavated by the present streams. In the eastern and southern parts of the county the surface rises to a level, geologically and topographically, above the summit at Berlin Heights, and is marked by irreggular undulating hills of the clay Drift.

The topography is also modified by the valleys of the Vermillion and Huron rivers and their tributaries; the valleys showing old flood plains, in places from one-half to three-fourths of a mile wide, with bluffs from fifty to sixty feet in height. Vermillion River has its source in Savannah Lake, Ashland county, where it connects with streams which are tributary to the Ohio; the valleys uniting at the divide in a continuous channel, now deeply filled with Drift, indicating that the drainage of both valleys was formerly southward. The connection of the head-waters of Huron River with the streams running south is not so distinctly marked, yet it can easily be traced between them and two valleys, one to the east and one to the west of Mansfield, in Richland county, where the drainage is also to the south. This is indeed a general characteristic of the streams in this part of the State, which have their origin near the divide, between the waters of the Lake and the Ohio River. They are not separated by a water-shed, and fed by springs flowing from opposite sides of it, but take their common origin in valleys having a northerly and southerly direction, and usually commence in marshes or small lakes, now occupying the summit of the pass. Here they receive the surface drainage from the higher lands on each side, which accumulates in the pond or marsh, and gives rise to streams flowing in opposite directions. The valleys of these streams are filled with alluvium, resting upon Drift deposits; and they have rocky beds only in places where obstructions have diverted the stream into new channels.

SURFACE DEPOSITS.

The surface deposits of Huron county afford a good illustration of the influence of recent geological changes in preparing a soil fitted for the work of the agriculturist. The underlying rocks are sandstone, argillaceous and bituminous shales, with a strip of lime rock in the northwestern border of the county. The disintegration of these rocks in place would have formed a narrow belt of calcareous soil on the western margin, next a broad, irregular surface of tenacious clay, and over the rest of the county a soil of comparatively barren sand. These rocks have been broken up and pulverized by Nature's vast ice-plow; the finely comminuted debris has been intimately mixed with that of the granite of the north, and of all the intervening rocks, and the whole spread out over the surface of the county. As the waters which covered the surface at the close of the glacial epoch receded, each of the terraces described above was formed, and each for a long period constituted a shore swamp, in which the decomposing vegetable material accumulated to form a soil of unsurpassed and permanent fertility.

The materials composing the upper terraces were long subjected to the action of shore waves, and in places the surface is occupied by sand dunes and assorted gravel. The lower terrace is a broad prairie, with swampy muck soil. When the country was first settled, some of this was not sufficiently reclaimed from the water to support forest trees, but the greater part of it is now remarkably fertile farming land, especially adapted to the cultivation of corn. In a few places the prairie soil rests upon the bed-rock, but generally upon a heavy deposit of boulder clay, containing the ordinary granitic and metamorphic boulders, and also a great profusion of fragments of limestone; and wherever gravels are found a large percentage of the pebbles is derived from the limestone. Indeed, the Drift deposits here all contain an unusual abundance of the debris of the limestones. In the bed of Huron River are many large boulders of the Corniferous limestone. In the sand hills the cavities left by decaying roots are often filled with calcareous tufa, and crumbled and broken layers of the Berea grit in the quarries are frequently cemented into a coarse breccia by the percolation of lime water from above. Also the beds of water-worn pebbles are here and there cemented into a conglomerate by the same cause. To these facts, together with the abundance of humus from the old swamps which once covered the surface, we must attribute the remarkable fertility of a large part of the county.

The general elevation of the level prairie land in Lyme township is one hundred and twenty-five feet above the lake. Here is a succession of remarkable sand dunes which rise to the height of thirty feet. The sand composing them is fine, shows irregular, waved lines of stratification, and rests upon peat. These sand hills were formed, as was much of the main sand ridge of the county, by wind and wave action along the lake shore, and on the margin of a shore swamp caused by this barrier, in which vegetable debris accumulated for a long time. The swamp soil in many places contains abundant remains of corniferous trees, and extends under the dunes and the sand ridge, because the sand was drifted back from the beach over it. The north and south bases of the ridge and sand hills have the same elevation above the lake. The north side of the ridge exhibits the irregular, winding outline of a lake beach, while on the south it is usually bordered by irregular, billowy dunes of sand—the ridge, apparently, formed by the waves, the dunes by the wind. Precisely the same results are now produced by the combined action of the waves and wind where low, swampy land extends to the lake, and the shore is bordered by a sand beach.

The following section, near the Norwalk water-works, will exhibit the relations of the same ridge to the underlying clays of the drift:

		FT.
1.	Sand	40
2.	Yellow clay, with irregular blocks of blue clay, surrounded with a yellow oxydized shell	20
3.	Sand, with a profusion of vertical columnar concretions, at the bottom, passing into yellow clay	10
4.	Blue clay, finely washed, compact, mingled with sharp, fine gravel, the whole cut by vertical, oblique, and horizontal seams—the greater part vertical—filled with yellow, silicious clay, cemented into rock	20

The partings in this blue clay vary in thickness, from that of paper to one-eighth of an inch, and are so finely cemented, that where the clay is washed away by the rains, they resist the erosion, and project from the bank from three-fourths of an inch to one and a half inches. The cementing material is iron, brought down from the clays above, and the fissures are apparently cleavage seams, produced by compression.

A few rods to the north of this locality, the well for the Norwalk water-works was sunk in the valley, and commences on a level with the bottom of the bluff, of which the section is given above. The materials passed through were—

		FT.
1.	Yellow drift clay, passing into blue clay	17
2.	Gravel to bottom	5

The fragments of rock thrown out in the excavation, were principally granite, green stone, corniferous limestone, and Huron shale. Near the bottom of the blue clay, in this well, was obtained the remarkable spherical concretion originally from the Huron shale, one side of which was planed off and striated by glacial action, which is figured and described by the Chief Geologist, Prof. Newberry, in the first chapter of volume one. It was obtained seventeen feet below the surface of the valley, and one hundred and seven feet below the base of the sand ridge at Norwalk.

There is ordinarily no such accumulation of drift material beneath the sand ridge, as is indicated above. West of Monroeville, the ridge is a regular, well marked beach line, rising about ten feet above the plain at the south of it, and fifteen feet above that at the north. On the south side, are the irregular dunes mentioned above, and on the north, a wide stretch of level prairie land.

The ridge is here largely composed of the debris of the Huron shale, which is often found in bed, a few feet beneath its base. The soil on each side is clay, mingled with a peaty, black mold, indicating a wide extent of shallow water resting upon the shales and their clay debris, which gradually passed into the condition of a swamp, ultimately filled with the swamp vegetation, and slowly drained by the subsidence of the lake. The most abundant forest trees on this soil, are yellow and swamp-oaks.

West of Monroeville, at "Four Corners," the ridge becomes less conspicuous, but maintains the same elevation, the marginal swamp of the old lake having been here quite shallow. Beyond this, to the limit of the county, the ridge has an elevation of only from ten to fifteen feet above the level plain, which stretches away to the north of it. At a point near where the Bellevue road crosses the county line, the limestone rock, in bed, may be seen cropping out of the sand ridge, indicating a low rock bluff, formerly the shore of the lake, which the waves have buried beneath the sand. Where the ridge does not rest upon the bed-rock, the materials below it are here fifteen to twenty feet of silicious, blue clay, with abundance of granite boulders and pebbles, and fragments of shale, with quicksand below, resting upon the rocks, and in which a supply of water is reached by wells.

While the great body of this level land, reclaimed from the old swamps, is exceedingly fertile, there is a remarkable exception in a large tract north of Monroeville, and extending into Erie county, to which my attention was called some years before the survey was authorized. The soil is a fine, black, peaty mold, presenting nothing to the eye to distinguish it from the productive corn lands surrounding it. It was cleared and put under cultivation, upon the supposition that it was of equal value with the adjacent lands; but it refused to tolerate grass, or corn, or any valuable crop. Here and there an apple tree sprang up, spontaneously seeded, and grew vigorously; but the principal crop was a small one—a light growth of weeds. The effort was made to ameliorate a part of it by more thorough drainage, and ditches were opened through it at considerable expense; yet the land was nothing bettered, but rather grew worse. The soil is comparatively thin, the bed rock coming near the surface; but equally thin soils, in other places in the neighborhood, are productive, and I am confident this is not the real cause of its infertility. A washing of the soil showed, with litmus-paper test, a decided acid reaction, and selected specimens gave the taste of acid when touched by the tongue. The vegetation, also, indicates the presence of acid. The soil has every element of fertility, and there can be little doubt that this deleterious substance is the sole cause of its sterility. If this is so, it only remains to inquire what is the origin of this acid, and how it can be removed from the soil, or have its injurious properties neutralized. The underlying rock is the Huron shale, which is filled with nodules and concretions of the bi-sulphide of iron. Wherever this is exposed to the joint action of air and water, it is decomposed, the sulphur set free, and, uniting with the oxygen of the air, produces sulphuric acid. These changes are facilitated by cultivation, and by more perfect drainage of the soil, so that the steps taken to improve the soil only aggravated the evil. If this is the cause of the difficulty, the remedy is easily found—a generous dressing of ashes, or of quicklime, will be sufficient. The lime, uniting with the acid, will form sulphate of lime, or "plaster," of itself a good fertilizer. The alkali must be well mixed with the soil, and the application may have to be repeated, until all the pyrites within reach of atmospheric influences, has decomposed, and yielded up its sulphur. In a similar case, in Trumbull county, a single application, made some ten or twelve years ago, was sufficient to neutralize the acid, and no repetition of the remedy has been required. The amount of lime needed can only be learned by experiment. As the railroad, from Sandusky, where there is an abundance of limestone, passes directly through these "bad lands," they can probably be rendered productive at comparatively little expense.

East of Norwalk the sand ridge has a gently waving contour on the north, and is bounded by a broad water plain, except as modified by recent erosion. On the south it is very irregular in its outline, the billowy round dunes being of varying height and form, and often extending a long distance from the ridge. The materials of the ridge are, at the top, finely washed sand, resting upon gravel, with a profusion of granite bowlders, and below this, bowlder-clay or bed-rock. This is the only well-marked and continuous sand ridge in the county, a winding highway, thrown up by the action of the waves, resting in places directly upon the bed-rock, in others upon the coarser materials of the Drift clays, sometimes burying beneath it the debris of the old shore swamps, and at others extending over chasms one hundred or more feet in depth, filled to the general level with drifted material. The deep ravines in the bed-rock, now filled with Drift, and the general contour of the rock surface here and in other parts of northern Ohio, indicate a peculiar topography before the period of the Drift, viz., a broad expanse of rock surface, disintegrated in places sufficiently to form a soil fitted for the support of forest trees, with a net-work of deep channels, which are now filled with Drift, but which largely determined the location of the present lake chains and river courses.

Granite bowlders of various sizes may be occasionally seen projecting through the sand of the ridge and through the peaty marsh soil between the ridge and the Lake, presenting an appearance of having been dropped from floating icebergs. About one mile south-west of Monroeville a granite bowlder eight and a half feet long and five feet in breadth projects four feet ten inches above the black mould of the prairie soil; others somewhat smaller are found here and there, and in places the surface is thickly dotted with them. Careful examination was made, to determine the question whether any or all of these were dropped after the surface had assumed its present form. Many bowlders were found on the sand ridge presenting such an appearance as suggested the inference that they had been dropped upon the ridge, but an examination in every case, where it was certain that they had not been moved by human agency, showed that they were still *resting upon the rock, or upon the clay or gravel underlying the ridge*, so that instead of resting upon the sand, they are only *partly buried* by it. All the well-marked terraces at Berlin Heights have bowlders scattered over them—the lower terraces showing them in the greatest abundance—indicating that they were all a part of the original Drift, cut away into terraces by the wave action, which would naturally leave the bowlders as they are now found. On the prairie soil, north of the ridge, bowlders are scattered here and there, and in places the surface is profusely set with them; but they protruded from the soil in the greatest abundance where the underlying rock or bowlder-clay came nearest to the surface. During a long search, prosecuted for the express purpose of settling this question, not a single bowlder was found in its original bed which was not resting upon the rock or the bowlder-clay. Every fact thus far observed tends to the conclusion that all of the bowlders were dropped before the sand ridge and the prairie soil was formed; but near the south-west corner of Berlin township, in a primitive forest, composed mainly of large oaks, a great number of bowlders was discovered *resting upon the undisturbed vegetable mould.*

Many of these were lifted out of their beds, and the soil explored to a considerable distance below them. It was found to be pure vegetable mould, extending apparently to the depth of several feet. Certainly every bowlder examined here, rested in and upon this black mould, and the inference seemed at first sight inevitable that they had in some manner been dropped upon it. A more careful study of their position and character, however, leads to the conclusion that these also originally constituted a part of the floor of the old swamp, and were deposited in or upon the bowlder-clay covered by it. They are now strictly superficial, resting on the soil, very slightly embedded in it! If they were dropped upon the surface of the swamp, this must have occurred when it was covered with a depth of water sufficient to float large icebergs loaded with the rock fragments, and when the muck bottom, long soaked with water, was a soft, oozy, carbonaceous mud, into which a rock, when falling, would be deeply buried. They are altogether too superficial to admit of the conclusion that they were thus deposited. They are also all of peculiar shape, none of them approaching a round or spherical form, but are comparatively thin, with broad, flat surfaces. My conclusion is, that they were lifted from the bottom of the old marsh by the growth of plants, and that the carbonaceous soil accumulated beneath them. The *modus operandi* was probably this: the roots and rootlets of trees and shrubs once spread in a complete net-work on the surface of the bowlder-clay, and insinuated themselves under all the *flat* rocks resting upon it. As they increased in size, these roots and rootlets slowly lifted the blocks of stone, making the intrusion of other roots more easy, all by their ultimate decay leaving a thin layer of humus between the rock and its old bed. No roots would pass over it to bind it to its place, but their combined growth and decay beneath it steadily lifted it upward, so that the accumulation of vegetable debris under it kept pace with that in other parts of the swamp. Spherical or rounded rocks were probably too deeply and firmly imbedded in the clay to permit the roots to insinuate beneath them, and so lift them from their beds, and no such forms are found upon the surface.

The brick and stone sidewalks in our cities and villages, when they surround trees, are lifted above the general level by the same means; and a tree planted upon a level lawn will in years become the center of a gentle mound, not by the accumulation of material upon the top of the soil, but by the roots lifting the turf upward through the steady pressure occasioned by their growth.

Since these observations were made, and this conclusion reached, my attention has been called to a brief notice of two papers by Mr. Thomas Mehan, read before the Philadelphia Academy of Sciences, on the "Influence of the Growth of the Roots," and the "Action of Frost in Elevating the Trunks of Trees." There can be little doubt that the trunk of a tree may be, and often is, lifted bodily upwards by the growth of the roots when they rest upon a rock surface, or any material as unyielding as bowlder clay, and that frost may aid somewhat in this elevation; but my observations do not tend to the conclusion that the top root serves in any respect as an anchor to resist or counteract the action of the frost, but that it aids very materially in its action. Seedling trees of the first year are often lifted entirely out of their beds by the action of the frost, and from this cause very many perish the first spring after planting.

When horizontal roots are well developed the tree is safely anchored, and is in no danger of being thrown out by the frost. So the stumps of dead trees remain undisturbed by the frost until the horizontal roots have rotted away. After that those having large top roots are rapidly lifted out of the soil by the action of the frost. I have repeatedly seen such swamps, with the remains of the horizontal roots two and three feet above the surface, and others that had fallen down, having been completely lifted out of the ground by the action of frost. In the elevation of these bowlders the frost may have had some influence, but it was probably slight. It is not necessary to assume that the trunks of the trees were here elevated by the growth of the roots, though it is probable that they were. If we may assume the fact that the horizontal roots would pass under these bowlders, and maintain their normal growth under the pressure, their slow and steady elevation would follow as a necessary result.

Remains of other sand ridges than that described can be detected in other parts of the county. Between Norwalk and Olena, on the line which separates Bronson and Hartland townships, the surface presents to the eye the appearance of a broad, level plain of rich sandy loam, but it rises imperceptibly to the height of two hundred and fifteen feet above the sand ridge at Norwalk, or three hundred and sixty feet above the Lake. This originally supported a dense forest of oak, hickory, black ash, elm, etc. About one mile east of Olena a long, sandy and gravelly ridge rises to the height of three hundred and ninety-five feet above the Lake. It has a nearly north and south direction, sloping on the west gradually to the general level of the plain, and descending abruptly to it on the east, the top being thirty-five feet above this general level. The materials here have been assorted by the waves and wind in the same way as those of the northern ridge.

Near the north-east corner of Hartland township there are also the remains of another sand ridge, fifty feet lower than the last, which has suffered much from erosion, and is cut up by very irregular valleys leading down to the west branch of Vermillion River, exposing the coarse Drift below, with many large striated bowlders.

In the western part of Fitchville township a long, sandy ridge, trending nearly north and south, rises in the highest parts to four hundred and twenty-five feet above the Lake, rising ten to fifteen feet above the level land to the east, and twenty to twenty-five feet above that on the west. The land to the north-west of this is a plain, diversified by irregular sand ridges and dunes descending gradually to a lower level, and marking the gradual descent of the waters of the old lake. On these ridges the timber is largely beech; on the lower land, oak, elm, black oak, etc.

The surface Drift in other parts of the county presents a great variety of features, a few of which may be briefly noticed. In Peru township the bed of Huron river is about one hundred and thirty feet above the Lake, the bluffs generally composed of modified Drift—a gravelly clay loam, with the debris of limestone rocks abundant. These bluffs rise to the height of from one hundred and eighty to two hundred feet above the Lake, and are much modified by surface erosion. Receding from the river, the surface rises to two hundred and twenty feet above the Lake, being undulating, much eroded and presenting no appearance of a water plain; soil rich in lime and humus.

At Greenfield Center the barometer marked an elevation of two hundred and ninety feet above the Lake. The surface of most of the township is covered with irregular undulating hills of gravel and Drift.

The following is a section of the Drift banks of the branch of Huron River, west of Steuben:

		FT.
1.	Modified Drift, composed of stratified sand and clay, with debris of granite, limestone, and local rocks	25
2.	Gravel	5 to 6
3.	Blue boulder clay, unstratified	12

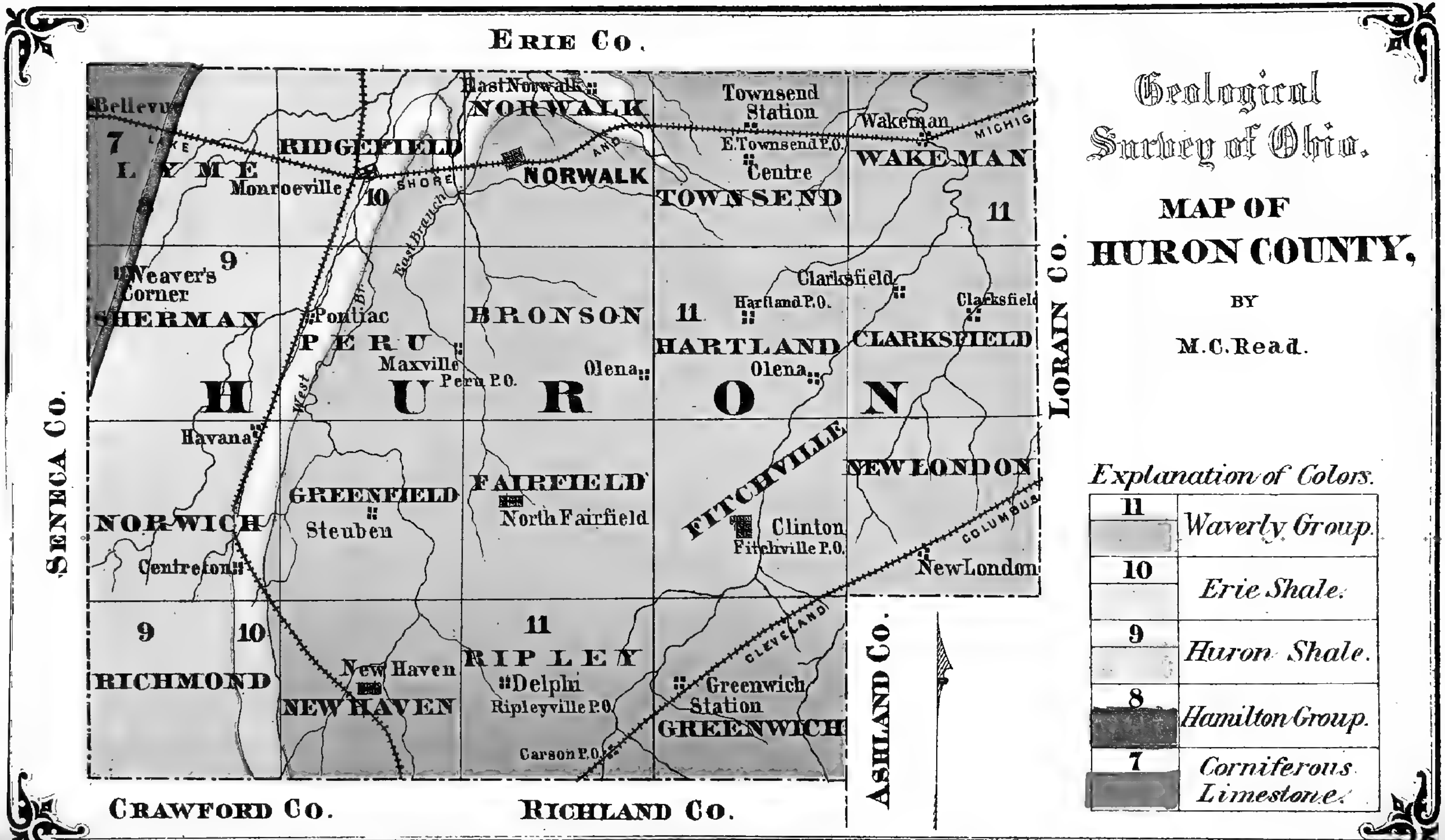
Westward the surface is a broad table-land, rising to the height of three hundred and forty feet above the Lake, with irregular valleys of erosion, and continuing to the west line of the county. The rock formation is deeply buried under the Drift.

Near the center of Townsend township, the following section of the Drift is disclosed in sinking wells:

		FT.
1.	Soil	2 to 3
2.	Boulder clay	4 to 12
3.	Laminated clay with thin layers of gravel	2 to 6
4.	Coarse water-bearing gravel, the thickness of which is not ordinarily ascertained.	

The lowest stratum yields an abundant supply of excellent water, which in places rises to the surface and flows in a steady stream from the mouth of the wells. Water obtained above this horizon is of poor quality, rendered impure by the minerals contained in the Huron shales, the debris of which are largely mingled with the Drift.

In Greenwich township the north and south center road, south of the Cleveland, Columbus, Cincinnati and Indianapolis Railroad, passes over level clay lands at an altitude of four hundred and eighty-five feet above the Lake, presenting the appearance of a broad water-plain, and resem-

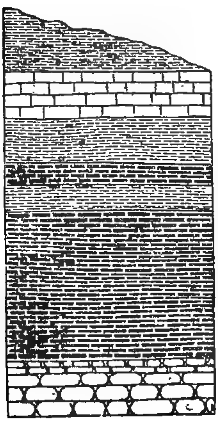


Strobridge & Co. Lith. Cin. O.

bling in all respects the heavy clay lands in north-eastern Ohio, which are underlain by the Cuyahoga shales. Large elms are also a characteristic of the forests here. This surface, though apparently level, slopes uniformly and somewhat rapidly to the north, so that at the northern part of the township it is only three hundred and eighty-five feet above the Lake. The indurated rocks are here deeply buried beneath the Drift which fills the broad, deep channel formerly connecting Vermillion River with the head waters of the Mohican, and Ashland county.

GEOLOGICAL STRUCTURE.

The geological structure of the county is easily made out, and comprises simply the Upper Devonian and the Lower Sub-Carboniferous rocks, of which the following is an approximate general section :



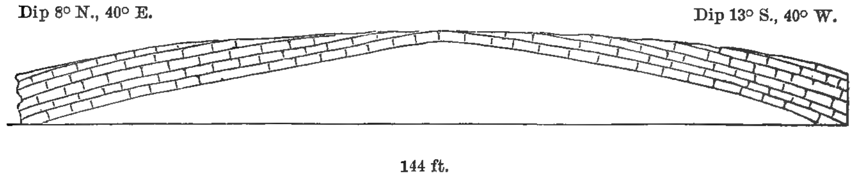
		Ft.
1.	Cuyahoga shale	100
2.	Berea Grit	50 to 75
3.	Bedford shale	40 to 50
4.	Cleveland shale	15 to 30
5.	Erie shale	15 to 32
6.	Huron shale	700
7.	Hamilton group	10 to 15
8.	Corniferous limestone	50

The exposed strata show evidences of much greater disturbance and displacement than I have observed elsewhere in the State. Sharp synclinal and anticlinal axes are visible in a majority of the rock exposures above the Huron shales. These are most conspicuous in the Berea grit, and will be more specifically described in connection with that deposit.

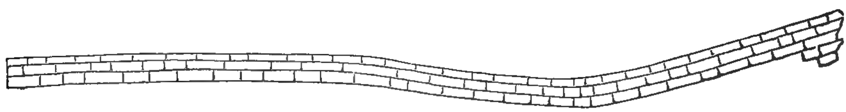
CUYAHOGA SHALES.

About one hundred feet of the lower part of the Cuyahoga shale underlie the south-eastern part of the county. This formation is frequently exposed in the banks of Vermillion River and its tributaries, where the harder layers are quarried for local use, and furnish building stone of fair quality. The rock is a compact, fine-grained sandstone in rather thin strata, containing what the quarrymen call *turtle-backs*. These show contorted lines of cleavage, which cause the rock to break up in rounded, flattish masses, bearing a rough resemblance to the animal which has given them this name. This peculiarity is more decidedly exhibited in the Bedford shales of the county, as some of the seotions hereafter given will show. The dip of the strata is irregular. At the quarry worked by W. R. Starr, south of Clarksfield village, along the line bearing south 60° east, the rock dips to the north 11°. Fifteen rods north the dip is 7° in the opposite direction. Half a mile west of this locality, in another branch of the Vermillion, the dip is as represented in the subjoined wood cut:

ANTICLINAL AND SYNCLINAL ARCHES IN BEREA GRIT.



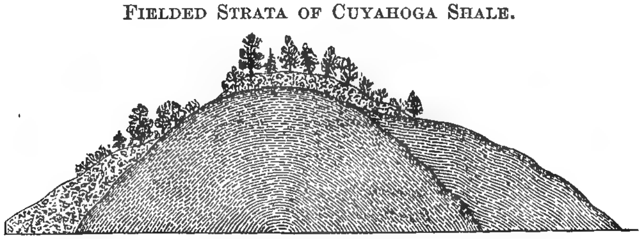
Following the above exposure toward the east, we find the flexure indicated below:



The lines of fracture are substantially parallel with the line of strike Here, as elsewhere in the county, this disturbance is superficial, not involving the deeply buried rocks, and is the result of lateral thrust, the action of that slowly moving, resistless force, which has broken up and displaced nearly all the surface rocks of the county, and has crushed to the center the high rock hills in the counties further north.

Just north of New London township, in Ashland county, this superficial disturbance of the strata is shown in an exposure of the Cuyahoga shales near the north and south center roads. There the soft, flexible shales are crowded up, as represented in the figure given below, until the strata incline at an angle of 45°. They were becoming level again however, at the west, and the disturbance evidently involves the superficial strata only.

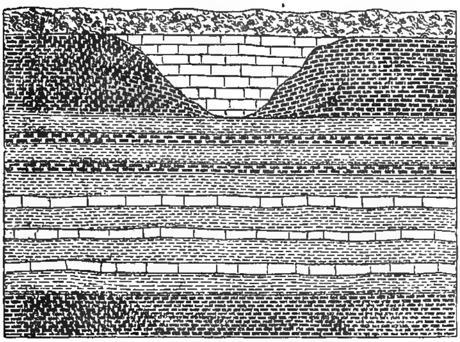
FIELDED STRATA OF CUYAHOGA SHALE.



BEREA GRIT.

This important quarry rock covers much of the county, but its value is greatly impaired by the local disturbances mentioned above.

At Rattlesnake Run, in Norwalk township, an exposure of the Berea and the rocks below gives the following sections:



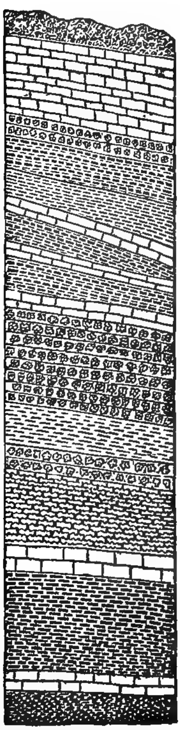
1. Drift, with fragments of Berea Grit.
2. Black shale, containing a mass of Berea Grit ...... 30 feet
3. Blue shale................ 6 " } Cleveland shale.
4. Black shale............... 2 " }
5. Blue shale................ 6 " }
6. Black shale............... 2 " }
7. Erie shale................ 32 "
8. Blue argil. shale, with hard bands.
9. Huron shale.

Here the Bedford shales are entirely wanting; the Berea grit is crushed and broken, and rests in a narrow trough of the Cleveland shales. This is not an old channel, cut out before the deposit of the Berea, but was excavated by a part of the Berea which in a measure resisted the crushing force of the ice, and was pushed forward by it, until it had excavated the channel in which it now rests, dipping southward 30°. The Cleveland shales on each side immediately adjoining the Berea, dip toward it, but at a short distance from it dip in the opposite direction, showing that they were pushed outward and "buckled" slightly upward by the lateral pressure.

At Jefferson's quarry, near the town line at the north-east corner of Townsend, on a long ridge running north and south, the surface of the Berea is two hundred and seventy-five feet above the Lake; the dip is south-westerly 17°; the line of strike north 67° west. The upper layers only are exposed; these are thin, but strong, and less broken than in most places in the county, indicating that here good quarries could be opened. A half mile further north, the dip is 15°; the surface marked with glacial striæ, bearing north-east and south-west At Mr. Milliman's quarry, near the north-west part of Townsend, the dip of the Berea is 20°. South and south by south-west the stone is of good quality; glacial striæ north-east and south-west. East of the last two exposures, and on the east bank of the Vermillion, the surface of the Berea is twenty-five feet below the last. Fifteen feet of the rock is exposed in large massive blocks, nearly horizontal, but dipping slightly in different directions. These blocks have been undermined and dropped below their proper horizon; glacial striæ on their surface south 35° east.

Near Plymouth village, the Berea crops out on the banks of the stream, showing massive rock about twelve feet in thickness, nearly horizontal, and of good quality. At Edgar Bovier's quarry, just east of the village, the rock is in thin horizontal layers, becoming thicker as the opening is carried downward; color, grayish blue, many of the layers affording a sharp grind-stone grit. Here, and at openings further north on the river, streaks of coaly matter, derived from plants, are not infrequent in the Berea. The rock is here unaffected by glacial action, but the disturbance becomes very marked further down the river. At G. Graham's quarry, in Greenfield township, the rock dips 13½° south-westerly, with the line of strike south 35° east, is in very even layers, all finely ripple-marked, some with that puzzling mammary surface, probably caused by the action of eddies where "two seas met" on the old ocean shore. Following down the stream the dip increases in fifty rods to 37½°, then diminishes to 10½°, increasing again till the layers become almost vertical (standing at an angle of 75°), with the line of strike south 29° east.

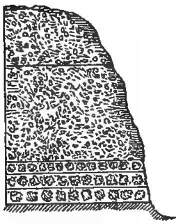
The following is a section of the Berea grit and the rocks exposed below it at this place:



		Ft.
1.	Drift.	
2.	Berea, evenly bedded	25 to 30
3.	Turtle-backs	3
4.	Sandy shale, alternating with argillaceous shale	6
5.	Evenly bedded sandy shale	8
6.	Argillaceous shale, with bands of hard rock	25
7.	Turtle-backs, in three layers	8 to 10
8.	Evenly bedded shale	8
9.	Turtle-backs, in soft argillaceous shale	3
10.	Shaly sandstone, waved and ripple-marked	20
11.	Hard sandstone, with thin layers of soft shale	5 to 6
12.	Blue black shale	20
13.	Shaly sandstone	2
14.	Argillaceous shale	15

For a few rods below this exposure the bed of the stream and bluffs are composed of Drift, mainly the debris of local rocks, the first rock seen beyond being that mentioned above, inclined at an angle of 75°, and standing like a dike directly across the bed of the stream.

The character of the Drift banks is indicated by the following section of the bluff at this dike:



		Ft.
	Yellow clay and gravel	8 to 12
	Blue clay and gravel	12
	Debris of the "turtle-back" rock with Drift pebbles	6

This "turtle-back," or pudding rock, is a very peculiar formation, composed of a mass of indurated mud-balls, sharply separated from the including strata with the internal structure of the slag of a smelting furnace. If a mass of thoroughly worked, tenacious clay could be slowly pushed forward over a gentle slope, constantly folding upon itself in the manner in which the slag flows from a furnace, a structure very similar to that found in these strata would be produced. Studied at this point alone, where their peculiarities are the most marked, an explanation of the mode of their formation is very difficult.*

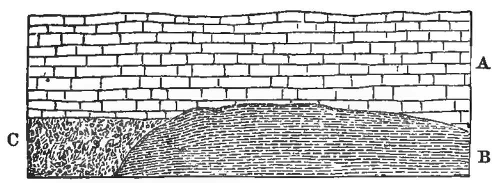
Following the stream still further downwards, the rock disappears both from the bed and bluffs of the stream, first reappearing near the little village of Maxville, where it has a slight dip to the north which soon increases to 19°. A little north of this, after passing a fissure in the rock, the dip is 13½° north 60° west. Still further north, near the west line of Bronson township, a rock exposure at the bridge, over Huron River, exhibits another phase of this general disturbance.

The following is a profile of part of the exposure:

A—Sandstone of Bedford shales.

B—Cleveland shales.

C—Clay and debris of Erie shales.

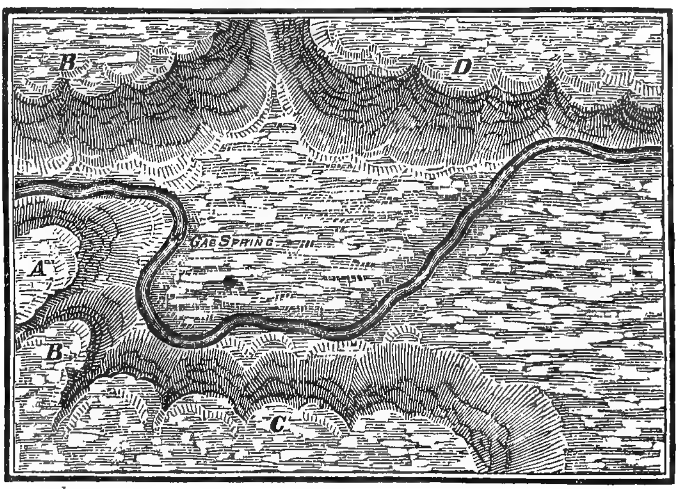


* In the valley of the Cuyahoga, on the same horizon, the rocks exhibit a slight approach to this structure, and it is there apparently due to sea weeds. It would seem that in this locality a mass of fucoid plants, rolled and tumbled by the waves, were spread upon the surface and buried under a deposit of clay and sand, which, when hardened into rock, has retained the irregular, distorted, internal structure thus given to it.

The sandrock A is but little broken, the layers all retaining their proper positions. The shales B are somewhat distorted, but the laminæ are nearly horizontal. C is the crushed and pulverized debris of shale, showing that the whole mass of the rock A has been pushed bodily from its position, grinding up the material beneath it, till it has taken on the appearance of glacial drift, but is composed wholly of the debris of the rocks below A. The mass A is some eight to ten feet thick, and is exposed for several rods in the bluff, with no indications that it has been moved from its native bed, except the character of the material beneath it.

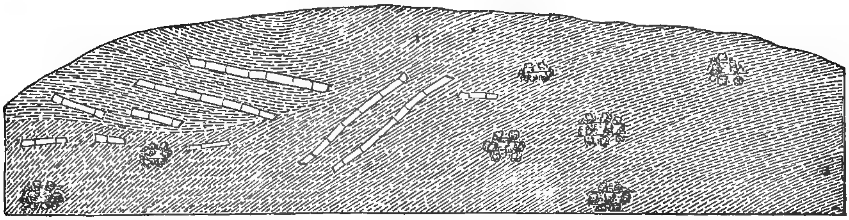
At Cole's quarry, one and a half miles south-east of Norwalk, the Berea is only two hundred and five feet above the Lake, and in its position and surroundings affords a remarkable illustration of the superficial disturbances which prevail over a large part of the county. The rock is in thin evenly-bedded layers, dipping 27° south-easterly, the line of strike being north 22° east. Directly north some fifteen or twenty rods, and on the opposite side of a small stream, the black shale is in position at the same level; the strata horizontal and undisturbed. About two rods north, and a little east of the quarry, the Bedford shales are exposed, dipping south about 27°. North from the last, and on the opposite side of the stream, a bluff, twenty-five feet high, shows a mixture of Erie and Bedford shales. The following sketch will show the relations of these different rocks:

BLUFFS AT COLE'S QUARRY, NORWALK.



A—Quarry in Berea grit, dip 27°.
B B—Black shale, horizontal.
C—Bedford shales, dip 27°.
D—Bluff of Erie shales much disturbed, dip irregular, with the "turtle-backs" of the Bedford shales as in the figure below.

Broken Strata of Erie and Bedford Shales.



Bed of Stream.

The mass of the bluff is of Erie shale, with the hard bands which it contains broken up and tilted, but not removed from their connection with the including strata with which they are still in contact. The irregular masses BB are "turtle-backs" of the Bedford shales buried in the mass of the Erie.

All these outcrops of rock occupy now substantially the same topographical level. The Erie shales alone are in their original beds. All the others have been disturbed and tilted, pushed out of their beds, and carried to a lower level by the ice.

In the immediate neighborhood, the Berea is exposed in several places dipping in various directions, and varying from 20° to 40°. These disturbances have left the Berea here resting on the Cleveland shales, and have so broken up and crushed the strata as to greatly impair the value of the quarries in the county. In a few places, even where the rock is tilted up to quite a sharp angle, the strata are still entire, and excellent rock can be quarried. At many of the openings, the broken, worthless rock largely exceeds that which is suitable for building purposes.

BEDFORD SHALES.

The section on page 303 exhibits the general character of the Bedford shales in this county. They are exposed only in the different branches of the Huron and Vermillion Rivers. Where undisturbed, they range from forty to seventy-five feet in thickness, and consist of hard, fine-grained sand-rock in their layers, alternating with thinner bands of argillaceous shales; the thicker strata of the sand-rock are frequently composed of a mass of the peculiar contorted rock called "turtle-back," rendering it quite worthless. Sometimes, however, this formation yields a fair building stone. In places where quite a heavy bed of the Berea constitutes the surface rock, these shales are entirely wanting, the Berea resting upon the Cleveland shales.

CLEVELAND SHALES.

These have the ordinary characteristics of this formation, as described in the reports of the north-eastern counties of the State, differing materially only in two particulars. The deposit is thinner here, varying from fifteen to thirty-two feet at the points where measurements could be obtained. It also contains less carbonaceous matter and more iron, passing into the red shale which gives its name to the Vermillion River, and furnished an inexhaustible supply of "war paint" to the native inhabiants of the region. The Cleveland shale rests upon the

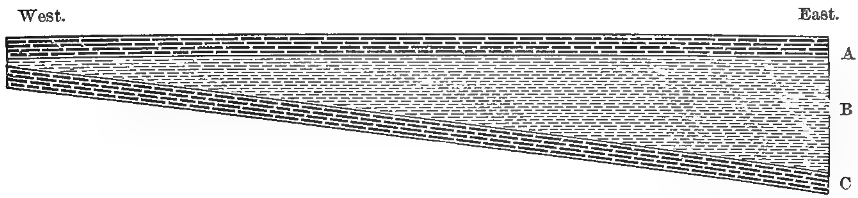
ERIE SHALES.

The largest measurement which I have obtained of these shales in the county is thirty-two feet. They present characters similar to those shown in the valley of the Cuyahoga, Chagrin, Grand and Ashtabula River, *i. e.*, are composed of soft, argillaceous, bluish shales with hard calcareo-silicious brands, a few inches in thickness.

The great changes in the thickness of this formation, and its position between the two beds of carbonaceous shales are of interest, as showing the topography of the region, and the changes of level at the time of the introduction of the carboniferous vegetation of the Coal Measures. These two deposits of carbonaceous shales are as well-defined, and as easily distinguished from the including strata, as beds of coal. They may in one sense be called coal, containing from eighty-five to ninety per cent. of ash, and having an origin similar to that of true cannel coal. Carbonaceous matter from the vegetation of shore swamp or the fucoids of a vast inland sea, finely comminuted, was deposited in still water and mingled with the argillaceous mud of the sea-bottom. The fine homogeneous material of which the shales are composed indicate their deposition from quiet water; and the wide range of the formation, as well as the remains of huge fishes which it contains, forbid the idea of its having accumulated in shallow swamps. Whatever may have been the conditions under which the Huron shales were formed, these conditions were abruptly changed; and the epoch was followed by long continued intervals, in which the growth and deposit of this carbonaceous matter was interrupted.

A section of these three formations extending from Huron to Lake and Ashtabula counties, where borings for gas wells have given accurate measurements of the Erie shale, would be as follows:

PROFILE SECTION SHOWING RELATIONS OF CLEVELAND, ERIE, AND HURON SHALES IN NORTHERN OHIO.



A—Cleveland shale.
B—Erie shale.
C—Huron shales.

The included Erie shales measure fully twelve hundred feet in Lake and Ashtabula, and not over thirty-two feet in Huron county. A similar thickening up of the strata between the Huron shale and the Coal Measures is shown as explorations are carried south-ward along the western margin of the coal fields, indicating a long continued and great subsidence to the south and east of Huron county, after the deposit of the Huron shales. This subsidence was so general and rapid as to prevent the growth of vegetation, except fucoids, and to afford deep water in which molluscous animals were abundant. This state of things continued until the ushering in of the true coal period.

HURON SHALE.

These are highly bituminous black shales having somewhat the appearance of impure cannel coal, containing in places the remains of plants accompanied with thin films of true coal. They also frequently include thin strata of blue argillaceous shales containing very little bituminous matter. Spheroid, and in the lower part of the Huron shales, elongated concretions are very abundant, varying in size from a half inch to fifteen feet in diameter. The smaller ones are composed almost entirely of pyrites, the larger one of impure carbonate of lime. These latter ordinarily show vertical lines of fracture and sometimes well-marked horizontal lines of stratification. Fissures in them are frequently filled with crystals of sulphate of strontia or of lime. A nucleus is ordinarily found at the center, sometime organic, but oftener mineral. The shales are so highly charged with sulphur and potash that in exposures protected from the rain an efflorescence of alum is sometimes seen three-fourths of an inch in thickness; and occasionally a nearly pure sulphur of equal thickness may be observed.

A satisfactory measurement of the thickness of the Huron shales could not be obtained in the county; but from the reported boring for water in the machine shops in Norwalk, I estimate it at not less than seven hundred feet above the top of the nearest exposure of the Cleveland shale. The tubing was driven at the machine shops ninety-nine feet through sand and clay before striking rock. The well was sunk to a depth of eight hundred feet from the surface without reaching limestone, and "most of the way in black shale." Near the bottom, a plentiful supply of clear sparkling water was obtained, but having an offensive odor. This is characteristic of all the water in the county which percolates through these shales, and I presume that from the Norwalk well was obtained from the bottom of the formation. Deducting one hundred feet for the aggregate thickness of the Cleveland and Erie shales, which is certainly enough, we have seven hundred and fifteen feet as the thickness of the Huron. This is much greater than the reported thickness, but is not too great, unless there is an error in the reports of the well-boring. I regret that no written record was kept of the drilling.

Since the field-work of the county was completed, specimens of so-called coal found in these shales have been sent me for examination. They consist of flat pieces of carbonaceous matter minutely fissured, and the fissures filled with thin plates of sulphate of Baryta. The nature and origin of these deposits are easily understood. The Huron shale is the great oil producing rock of eastern Ohio and western Pennsylvania. The slow distribution of the bituminous matter in it has resulted in the production of gas and petroleum, which along the outcrop of the strata have steadily escaped. The petroleum flowing into a fissure in the rocks where it was retained, has parted with its volatile matter, leaving a residuum of asphaltum or Albertite which by continued desiccation has become minutely cracked and the fissures have been gradually filled with barite. Such deposits afford no proof that "the geologists have been mistaken," and no encouragement whatever to the hope that a valuable deposit of coal may be found outside of the "Coal Measures." True coal in very thin laminæ is occasionally found in this shale, and in all the formations between it and the Coal Measures, land plants seem to have flourished under favorable conditions during the time of the deposit of all the upper Devonian, and the sub-carboniferous rocks. It has left its record in plant impressions, and in isolated thin films of coal which may be found on almost any horizon of these rocks; but if taken as indications of the presence of workable deposits of coal, they will unquestionably lead to disappointment.

HAMILTON GROUP.

This important group of limestones and shales of the New York geologists is here represented by a thin and unimportant deposit of bluish yellow marly limestone. This is quite soluble, and therefore much honeycombed and eroded at its points of exposure. Were it not for the profusion of Hamilton fossils contained in it, this would be regarded as the upper part of the Corniferous limestone, upon which it rests. It is apparently only from ten to fifteen feet in thickness, in thin layers, containing a profusion of crinoid stems, and its outcrops in this county afford no material for adding any thing to the description given by Prof. Newberry in the first volume of this report.

CORNIFEROUS LIMESTONE.

This formation contributes the surface rock at Bellevue, and a small territory adjacent in the north-west part of the county. Two and a half miles north of the village, and on the county line, it is covered with only from eighteen inches to two feet of soil, and has been exposed in a quarry to the depth of eight feet. The rock is in thin layers, hard, compact, highly fossiliferous, and presenting the ordinary characteristics of the upper layers of the Corniferous at Sandusky. Its surface is thirty feet above the railway at Bellevue. South from this point, and three-fourths of a mile north of the south line of Lyme township, it is struck as the first rock in sinking wells at a depth of 12 feet from the surface. Still further south, and west of Weaver's Corners, a ridge of limestone soil, filled with its debris, crosses the west line of the county at an elevation of fifty feet above Bellevue, making the thickness of this rock in the county approximately fifty feet. Near the north line of Sherman township, on the old Columbus and Sandusky turnpike, the Huron shale is struck in sinking wells, showing that the corniferous limestone covers only a small part of Lyme and a mere corner of Sherman townships. Exposures in the county afford very imperfect opportunities for the study of this formation, which is sufficiently described in the reports upon other counties.

CHAPTER LXVI.

REPORT ON THE GEOLOGY OF RICHLAND COUNTY.

BY M. C. READ.

Richland county is situated on the highest part of the divide between the waters of Lake Erie and the Ohio River. The surface on the north is comparatively level, but rises toward the south to the height, in places, of nearly one thousand feet above the Lake. In the south-east part of the county there are chains of high hills, separated by narrow valleys, and exhibiting almost a mountainous character. The Black Fork of Mohican River, rising in the north part of the county, and passing through the townships of Blooming Grove, Franklin, Weller, Mifflin and Monroe, and thence into Ashland county, flows in a deep channel which connects on the north with the channels of drainage into the Lake. A similar channel, having a similar northern connection, passes a little west of Mansfield, and, now filled with silt and gravel, forms the bed of Owl Creek. Between these valleys the hills rise in irregular chains, often quite abruptly, and in the southern and south-western parts of the county to an elevation of from two hundred to five hundred feet above the valleys. In Jefferson township a long "chestnut ridge," traversed by the road leading west from Independence, reaches an elevation of four hundred and fifty feet above the railroad at Independence. On my table of elevations this railroad station is given as six hundred and fifty-nine feet, but I suspect this to be excessive. If correct, the elevation of the ridge is ten hundred and fifty-nine feet above the Lake, and it is one of the highest points in the State. Two and a half miles north-east of Bellville, and near the north line of Jefferson township, the hills reach an elevation of nine hundred and fifty-two feet above the Lake. About two miles north, and on the direct road to Mansfield, the surface rises rapidly to an elevation of nine hundred and twelve feet, and at three and a half miles the summit between Bellville and Mansfield is nine hundred and thirty-two feet above the Lake, or three hundred and seventy feet above Mansfield.*

* The height of Mansfield above the Lake is, on the profile of the Atlantic and Great Western Railroad, 581 feet; on the profile of the Sandusky and Mansfield Railroad, 657 feet; and on the profile of the Pittsburgh, Ft. Wayne and Chicago Railroad, 592 feet; part of the difference being due to the different elevations of the localities passed by the railroads in the town.—J. S. N.

The descent from the top of this divide is much more gradual to the north than to the south, a characteristic of all parts of the watershed in this neighborhood; and one to which reference will be subsequently made when a few of the more prominent features of the surface geology of the neighboring counties are grouped together. The highest points to the north and towards Mansfield were, by the barometer, three hundred and twenty feet, three hundred feet, one hundred and ninety feet, etc., above Mansfield. About seven miles west of Mansfield, and near the western line of the county, is an isolated knob which is designated by residents in the vicinity as the highest land in the county and State. It is, however, by the barometer only two hundred and forty feet above Mansfield, or eight hundred and thirty-two feet above the Lake, while two and a half miles further east the surface rises by a more gentle inclination thirty feet higher.

SOIL.

The soil over the greater part of Richland county rests upon the unmodified Drift clays, and takes its general character from them. It contains a large quantity of lime, derived mainly from the corniferous limestone, fragments of which are every where mingled with the Drift. The clay in the soil is also modified and tempered by the debris of the local rocks, which is largely mingled with the Drift, and is mostly silicious. This character, combined with a high elevation and thorough surface drainage, furnishes a soil which renders the name of the county appropriate, and secures a great variety of agricultural products.

While all parts of the county are well adapted to grazing, the land is specially fitted for the growth of wheat and other cereals, and to the production of fruit. The profusion of rock fragments in the Drift render the soil pervious to water, and prevents washing, even in the steepest hills.

In the south-eastern part of the county the higher hills are, in places, capped with a coarse ferruginous conglomerate, and are so covered with its debris as not to be susceptible of tillage. Nature has designated a use to which these sand-rock hills should be appropriated, as they are generally covered with a dense second growth of chestnut. This timber prefers a soil filled with fragments of sand-rock, and the second growth is almost as valuable as red cedar for fence posts and other similar uses. If upon all similar rocky hills the inferior kinds of timber and the useless undergrowth were cut away, and the growth of the chestnut encouraged, these now worthless hill-tops would yield an annual harvest scarcely less valuable than that of the most fertile valleys. On the north side of the divide the slopes of the hills are covered by the debris of the local rocks and the soil is much less productive.

SURFACE DEPOSITS.

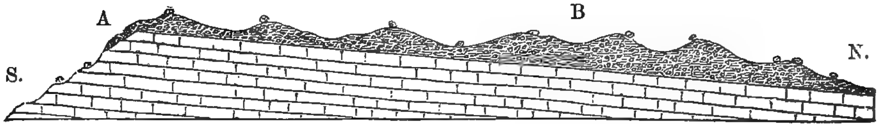
The greater part of the county is covered by a thick deposit of unmodified bowlder clay, which, in many of the northern townships, conceals from view all the underlying rocks. Except upon the margins of the streams, this bowlder clay, which is often very thick, is wholly unstratified. The clay near the surface is yellow; at the bottom, blue. Granitic bowlders and pebbles, and fragments of the local rocks, are very abundant through the whole mass. In some places the line of separation between the yellow and blue clay is sharply defined; but, aside from the difference in color, there is no distinction, except that the yellow is fissured by vertical, horizontal, and oblique seams, through which the water readily percolates, while the blue is generally quite impervious to it. On this account, springs frequently mark the junction of these clays. Many of them, however, which afforded an abundant supply of water when the country was first settled, have dried up. This is no indication of a diminished rain-fall, but may be explained partly by the more rapid surface drainage resulting from the removal of the forest, and partly by the deeper oxidization of the bowlder clay, which renders it porous, and depresses the junction between the yellow and blue clays, so as to change the line of drainage; or, from the deeper fissures of the clay, the water-bearing horizon has been carried below the outlets of the old springs.

The hard granitic and metamorphic bowlders and pebbles of this drift are well worn, and often striated with great uniformity along their greatest diameter. On the contrary, the soft and friable debris of the local rocks on the top of the hills is neither water-worn nor striated. The fragments are often as angular as if just broken up in a quarry. Away from the water-courses the surface of the land is undulating, consisting of irregular ridges, with frequent depressions and cavities having no outlet, and indicating that the present contour of the surface is not the result of recent erosion. The surface drainage is now filling up and obliterating these cavities, some of which are still swamps, and generally the wash from the hills is carrying silt and humus into these depressions, so that surface erosion is steadily diminishing, instead of increasing, the inequalities. Over large areas the clay includes such an abundance of rock fragments that wherever surface erosion is facilitated down the slopes of the hills by road-making or otherwise, the wash is arrested as soon as a shallow channel is formed by an accumulation of rock fragments on the surface. If erosion by rain-fall excavated the depressions and ravines, the water would have had force sufficient only to carry away the clay, sand, and finer gravels, and the surface would now be covered with bowlders and fragments of rocks; but such a condition of the surface is nowhere found. A comparatively few isolated bowlders are scattered over the surface as though dropped upon it. In the deeper ravines, which should be filled with a mass of these bowlders, they are very rarely found, and are no more abundant upon the slopes than upon the tops of the hills.

On the margins of the streams there is frequently at the bottom a deposit of laminated or finely stratified clay, with rudely stratified gravel and bowlders above. The fragments of the local rocks are here rounded and globular; no striated granitic fragments are found. In places, all the fragments of the local rocks have been ground to powder, and, with all the clay and finer gravels of the Drift, have been washed away, leaving only coarse, well rounded, granitic pebbles, with occasional bowlders of the corniferous limestone. In this material, also, cavities are occasionally found having no outlets, the character of the underlying rocks and the form of the surface indicating that they are not properly "sink holes," such as are often found in limestone regions. A little east of the railroad station at Lexington, two such cavities are quite conspicuous. They are on a long, billowy, ridge filled with coarse gravel and bowlders, and covered with a forest of hard maple. In the deepest cavity the depression is twenty-five feet, in the other fifteen feet. The slopes in each are smooth, without rock fragments, and covered with the native forest trees. In both there is accumulation of humus at the bottom, and the deeper one contains a little water. They afford a ready explanation of the origin of the small ponds having no outlet, found in other places along this divide, with dead forest trees standing in the water. In the original cavity the drainage through the porous bottom was free, and the forests occupied the bottom and the slopes. The wash of the slopes and the fine material of the decomposed vegetation gradually accumulated in the gravelly bottom, which, like a filter long used, gradually became impervious to the water, which encroached more and more upon the vegetation, ultimately destroying it, and the dry cavity became a pond. The accumulation of vegetable debris, and the growth of water plants upon the margin, will finally convert the pond into a marsh, which, in the end, will be filled up and obliterated.

A general section made north and south through the county, eliminating the water courses, would be substantially as represented on the subjoined wood cut:

PROFILE SECTION THROUGH RICHLAND COUNTY.



A—Abrupt slope to the south frequently without any Drift clay, the level rocks coming near to the surface, the significance of which will be more apparent after the description of the counties further south is given.

B—Undulating ridges of Drift such as have been described above, occasional granitic bowlders being scattered over the whole, with frequently a thin bed of stratified sand and gravel at bottom.

To account for these facts, an agency is required which shall bring from their home in the far north the granitic bowlders and pebbles, the Corniferous limestone, and other hard rocks intervening; shall pulverize to a clay the soft, argillaceous rocks; shall leave the hard rocks brought in from the north rounded and striated; shall mingle all this material intimately with the debris of the friable local rocks, which are neither water-worn nor striated, but are in sharp, angular fragments, and leave the whole entirely unassorted upon the high lands in undulating ridges; but upon the margins of the streams often washing away all the finer material, wearing to a sand the debris of the soft local rocks, assorting and depositing in different places the materials having different specific gravities. The question what that agency probably was, will be discussed when other facts bearing upon its full solution shall be accumulated.

GOLD.

One of the most interesting surface deposits of the county, and one intimately connected with the discussion of the Drift, is the gold found about Bellville and other places in the southern part of Richland county. The origin of the gold has been attributed to an ancient Drift agency which brought in the pebbles of the Waverly Conglomerate; but I am quite confident that it should be referred to the surface Drift, and was brought in by the same agency that transported the granitic pebbles and bowlders. If referred to the Waverly Conglomerate, it should be found at the base of this deposit. It is, in fact, found most abundantly about on the level of its upper surface, and in perceptible quantities on the slopes of the hills fifty to one hundred feet above it. If it came from the Waverly Conglomerate, it should be most abundant where the quartz pebbles of this Conglomerate are the most numerous, while at Belleville and the immediate neighborhood, this Waverly rock is comparatively free from pebbles. The gold is found in minute flakes, associated with black sand (magnetic iron ore), small garnets, and fragments of quartz. It is most abundant at the bottom of gorges opening to the south, rising rather rapidly toward the north, terminating in various branches which start from the top of the hills two or three hundred feet high. On the table land above, large quartz bowlders are occasionally seen, and angular fragments of quartz are abundantly obtained in washing for gold. Pieces of native copper are also found, some of them of considerable size, occasionally copper ore, and very rarely minute quantities of native silver. In the stone quarry near Bellville an angular and partially decomposed fragment of quartz was picked up, containing what the miners call "wire gold" interlaced through it. It had evidently fallen from the gravel bed at the top of the quarry, which contained quartz fragments, mingled with the other erratics. The most plausible theory of the origin of the gold is, that the transposing agencies which brought in and deposited the surface Drift, passed over veins of gold-bearing quartz which were crushed, broken up, and transported with the other foreign material, and scattered along a line extending through Richland, Knox, and Licking counties. Over what is now the southern slope of the divide between the waters of the Lake and the Ohio, a thick deposit of Drift has been washed away, the fragments of quartz broken up and disintegrated, the gold of the Drift concentrated probably a hundred thousand fold, so that in these protected coves the "color" of gold can be obtained from almost every panful of earth. The first discovery of this fact caused much local excitement, and experienced miners and others prospected the whole region, in the confident expectation that these indications would lead to rich placer mining. One returned California miner spent the whole of one summer and fall in prospecting, a part of the time with one, and the rest with three hired assistants. The gross amount of gold obtained was between twenty-five and thirty dollars. In the richest localities about one dollar per day can be obtained by steady work. As no gold-bearing rocks are to be found in the State, the occurrence of gold here can have only a scientific interest connected with the theories of the Drift.

IRON ORE.

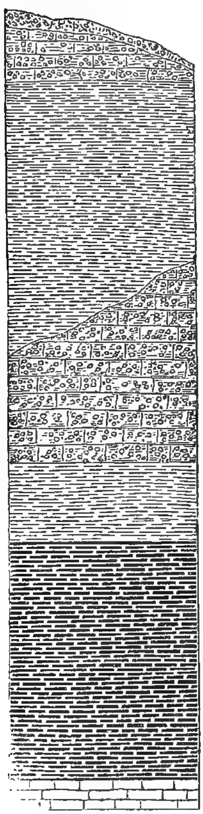
The rocks of Richland county include a few deposits of iron ore, generally of little value, and the surface accumulations of this mineral are rare. In Plymouth township, on a small stream near the center and west of the railroad, is quite an extensive bed of hydrated oxide of iron, containing large masses of calcareous tufa. No spring of water is apparent which could deposit these minerals, and they probably indicate the bed of an old, shallow swamp, now five or six feet above the present channel of the adjacent stream. The stratum is from two to three feet in thickness, but not of sufficient extent to be of any great value.

GEOLOGICAL STRUCTURE.

The geological structure of Richland county is easily read, and has little variety. No single exposure discloses all the rocks of the series, and as the dip is often quite considerable, and is without uniformity, the measurements of the different strata are only approximations.

The section here given is the result of many observations and measurements, and will illustrate the general character of the geological structure.

GENERAL SECTION OF THE ROCKS OF RICHLAND COUNTY.



The highest hills in the north-eastern parts of the county are capped with the Carboniferous Conglomerate, which is in general quite thin, rarely attaining a thickness of twenty feet. It frequently contains fragments of chert, and a large quantity of iron ore. In many places it is a silicious iron ore, and would be valuable if there were a local demand for it.

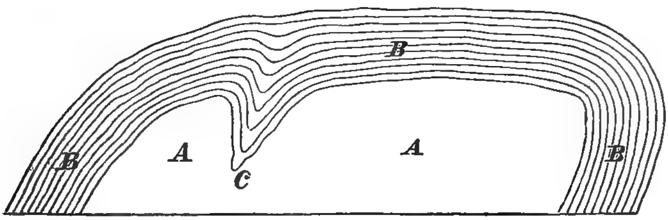
This Conglomerate contains in places a great profusion of calamites, lepidodendra, sigillaria, etc.

Below this is a series of shales corresponding to the Cuyahoga shales of the north-eastern counties, in part argillaceous, with fragments of crinoids and nodules of iron ore; and in part silicious, containing the ordinary sub-carboniferous fossils. The transition is here apparent through which the varied strata composing the Cuyahoga shales pass, in going southward into the homogeneous, sandy, olive shales of the Waverly; and this member of the series is here much more silicious than it is further north. It varies much in thickness, ranging from one hundred and ten to two hundred feet or over. In places the lower part of it becomes massive, and not distinguishable from the Waverly Conglomerate upon which it rests. Nowhere in it have I observed minerals of any economic value.

Waverly Conglomerate.—This is the characteristic rock formation of the county, and from its lithological character in many places might readily be mistaken for the ordinary Carboniferous Conglomerate, but its horizon can be definitely traced at a varying distance of from one hundred to two hundred and fifty feet below the true Conglomerate, and upon careful study can everywhere be readily distinguished from it. It is generally more thoroughly and evenly stratified than the Carboniferous Conglomerate, the pebbles are usually smaller; the grains of sand forming the mass of the rock are mostly globular and transparent. When colored by iron it is oftener in regular bands or layers, as the result of more perfect stratification, and pebbles and grains of jasper are more abundant.

The distinction between it and the Carboniferous Conglomerate of this immediate neighborhood is still more marked. The latter is quite coarse, containing large pebbles, some of them but little rounded fragments of fossiliferous cherty limestone, and many coal plants, including sigillaria, calamites, lepidodendra, cordaites, etc. The plants of the Waverly Conglomerate are mainly fucoids. The iron in the latter, shown only by the color of the rock, is magnetic, preventing the use of the compass in the vicinity of its massive outcrops.

In Plymouth township, about three miles southwest of Plymouth village, David Sissenger has a quarry in the Berea grit, showing something of a transition between this quarry rock and the coarse Conglomerate. About twelve feet in thickness of the rock is exposed, the upper layers yellow, thin, and much broken, the lower ones more massive, blue in color, and a grindstone grit. The dip of the rock is 5° north, and the quarry is twenty feet below an opening in the same rock at Plymouth village. The following illustration of the face of a broken rock of the lower strata, which at the time of my visit was lying in its natural bed, indicates the manner in which atmospheric agencies operating upon the cementing mineral of the rock change its color, and show how these may have produced the remarkable and beautifully colored bands so conspicuous in the quarry near Mansfield, and some other openings in the Center.



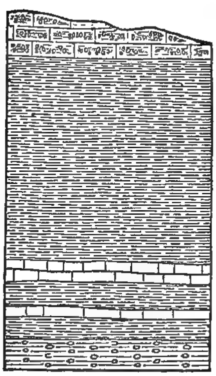
The mass of the rock marked A A has the ordinary bluish color of much of the Berea. The parts marked B B B are striped with black and yellow in regular layers, the changes evidently tending to involve the whole, and progressing more rapidly at the point C on account of a seam in the rock which is permeable to water.

This is the southern exposure in this neighborhood of unmistakable Berea, and there is great difficulty in tracing its connection with the outcrops of massive sandrock to the north-east, and in the central and eastern parts of the county. The surface rises to the north-east, is gently undulating, sometimes hilly, everywhere exhibiting a thick deposit of Drift, which conceals all the rocks, until a little north of Rome, in Blooming Grove township, on the banks of a small stream about fifteen feet of rocks are exposed, consisting of soft argillaceous shales, with hard blue tessellated bands which weather yellow, affording poor stone, but furnishing the only supply in this neighborhood. These present somewhat the appearance of the Bedford shales belonging below the Berea, while topographically they are by the barometer one hundred and seventy feet above the Berea last described. In Weller township, one-half mile north-west of Olivesburgh, a well was sunk passing through twenty-one feet of unstratified clay Drift, then striking a hard fine-grained blue sandstone, underlain with alternate bands of sandstone and argillaceous shales. These were penetrated to the depth of nineteen feet, when a small supply of water was obtained, and the explorations ceased. Four miles west, at Big Hill, the same sandstone is quarried. South of this and in the hills immediately north of Windsor station, in Weller town, ship, the Waverly Conglomerate is quarried and exposed by outcrops and bluffs in several places. It is here one hundred feet thick, and its surface by barometer is four hundred feet above the exposure of the Berea in Plymouth village. It is a coarse massive sandstone, in places white, in others colored with iron, containing many quartz pebbles, and presenting a strong resemblance to the ordinary Conglomerate. In James Mason's quarry about thirty feet of the structure of the ledge is exposed. It is much broken up, and except at the top has no regular stratification, and is all coarse. In places it is full of pebbles, and bears little resemblance to any of the northern exposures of the Berea. Glacial striæ were here observed, bearing south 32° east.

If this is a continuation of the Berea, its lithological characters here rapidly changed, and in the distance of about twenty miles it has risen between three hundred and four hundred feet. This may be the fact, but from a comparison of all the observations made, it is pretty certain that it has no connection with the Berea, but is simply an ancient shore deposit of coarse material, having no great horizontal range, and not always to be found on the same vertical horizon. The Waverly rocks in passing northward become much more silicious, and the sandy layers are generally composed of coarser materials. In places they consist entirely, so far as they are exposed, of thin fragile layers of sandy shale, constituting the typical olive shales of the Waverly. These, in places, pass into a compact quarry rock, similar to the Logan sandstone of Fairfield county, and often, at a distance of from one hundred and twenty to two hundred and fifty feet below the Coal Measure rocks, are succeeded by this coarse Waverly Conglomerate. This, it is true, is about the distance below the Coal Measures at which the Berea is found at the north. But there is a great thickening up southward of the Waverly rocks, and this Conglomerate has neither the persistence, nor any of the lithological characters of the Berea. Its base, where well defined in Knox county, is shown by borings to be over three hundred and fifty feet above the top of the red or chocolate shales, which is there a well-defined horizon, and appears to be identical with the Cleveland shales of the Cuyahoga valley, which are about seventy feet only below the Berea. These borings disclose the fact that the Huron, Erie, and Cleveland shales extend northward through these counties with little change in their lithological characters—the Erie greatly reduced in thickness; that above them there is a marked thickening of the Waverly rocks, and such a change in their mineral constituents and mode of deposition, as to make their subdivision into Cuyahoga shales, Berea grit, and Bedford shales, so clearly defined in the Cuyahoga, impossible. The interval between this rock and the Coal Measures also varies greatly, and it is evident that at different horizons the sandy shales of the Waverly pass into coarse Conglomerate, which form long, narrow ridges. with a northerly and southerly bearing, and nowhere extending in broad sheets in an easterly and westerly direction. The fact is of interest, in this connection, that the whole body of the Waverly here is composed of coarser material, and is generally more homogeneous than further north.

The following sections will show the general character of the upper members of the Waverly, and the local character of the Waverly Conglomerate:

Section from top of hill, near south-west corner of Washington township, to the "oil-well" on the banks of the Mohican, six miles south of Loudonville.



		FT.
1.	Coarse ferruginous, cherty Conglomerate.	
2.	Olive shales of Waverly	270
3.	Alternate bands of sandstone and argillaceous shales	100
4.	Argillaceous shales, with nodules of iron ore, many fragments of crinoids, spirifers, etc.	20

An exposure half a mile west of No. 3 of this section shows a coarse and more massive sandstone, approaching to the character of the Waverly Conglomerate.

SECTION THREE-FOURTHS OF A MILE NORTH-WEST OF LUCAS.

		FT.
1.	Red and yellow Conglomerate	10 to 18
2.	Hard white sand-rock in three layers	19
3.	Covered	160
4.	Sandy and argillaceous shales at bottom of valley.	

The upper part of the Waverly Conglomerate is represented by the upper part of this section. The rock shows occasional seams of pebbles, and in places colored bands, not as marked, but of the same character as at the Mansfield quarry. It is firm and strong, splitting easily in the lines of stratification, and furnishes very good quarry rock.

SECTION AT NEWVILLE.

		FT.
1.	Olive shales of Waverly	160
2.	White sand-rock	10 to 15
3.	Coarse sandstone, with pebbles and bands of gravel	80 to 100

The lower one hundred feet of this section compose the rock bluffs at Newville, which present a striking resemblance to some of the outcrops of the sub-carboniferous Conglomerate. It splits more readily into thin layers, and its true character as the Waverly Conglomerate is apparent from its mineral composition, as well as from its stratigraphical position.

SECTION AT DANIEL ZENT'S QUARRY, BELLVILLE.

		FT.
1.	Earth	2 to 4
2.	Coarse pebbles of Drift	8 to 10
3.	Sandstone in thin layers	15
4.	" massive layer	8
5.	" in layers of one to four feet	15

The rock of this exposure is much like the Logan sandstone, contains few pebbles, but is on the same horizon as the Waverly Conglomerate. It affords a large amount of excellent building stone, most of which is taken by the railroad company. This rock forms all the hills in this part of the county, which rise rapidly to the north to the height of thirty feet or more. It is in the coves and gorges cut down in this rock, and opening southward, that most of the gold of this county has been found, which is obtained not only at the bottom of the gorges, but from the earth which covers the slopes to the top. The fragment of gold-bearing quartz which was picked up in this quarry, unquestionably dropped from the layer of coarse pebbles at the top. These facts, coupled with that of finding many erratics of quartz in the tops of the hills to the north and north-west, indicate that this gold was brought in by the recent and not by the Waverly Drift.

Many layers in this quarry are conspicuously ripple-marked, and remains of fucoids are abundant. Northward from this locality, on the road toward Mansfield, the hills rise through the olive shales of the Waverly to the height of three hundred and fifty feet above the base of this quarry. The character of the rock is well shown in the hills, is a yellow, fine-grained, shelly sandstone, and valueless as a quarry rock. Approaching Mansfield it becomes coarser, more massive, and more highly colored with iron, and finally passes into a coarse, massive sand-rock, evidently the Waverly Conglomerate, the top of which is one hundred and forty-five feet above the base of the quarry at Bellville. Ninety-feet below this, in the bed of a stream, alternate layers of argillaceous and sandy shales are exposed.

The top of the quarry east from Mansfield is twenty feet below the tcp of this coarse sand-rock, and is a continuation of it, the town resting upon this formation, which crops out on all sides of it. About sixty feet of the rock is here exposed. It is all much broken; the upper thirty feet in thin layers, the lower thirty feet in layers of from one to six feet thick. Much of the rock is beautifully colored in waved bands and lines of black, yellow, and red, as delicately shaded as the best artificial graining of wood. Very beautiful specimens can be obtained, and if it were harder it would make a very ornamental building stone. It dresses smoothly and endures exposure well, but is soft and easily worn away by abrasion.

On Brushy Fork, near Millsborough, about six miles west of Mansfield, and thirty-five feet above the Mansfield quarry, is the outcrop of the same rock, of which the following is a section:

		FT.
1.	Coarse, shaly sandstone in broken layers	12
2.	Ferruginous sandstone, with waved lines of stratification	6 to 10
3.	Coarse, massive sandstone, with irregular veins of iron	6
4.	Shelly sandstone	8
5.	Blue argillaceous shale, with bands of hard, fine-grained sandstone to bottom of exposure.	

The upper numbers are the thinning out of the Mansfield rock, the equivalent of the Waverly Conglomerate.

On the opposite side of the stream, the yellow sand-rock on Newton Gilkinson's land is about thirty-five feet thick, coarse, ferruginous, with black iron streaks. There are about ten inches of light-colored and firm stone. All the rest, so far as exposed, is worthless for building purposes.

The rock at bottom is blue argillaceous shale, with hard blue bands, bearing a close resemblance to the Erie shales; no fossils discovered. In places, interstratified between the layers of the yellow sandstone, there is a layer of ten to twelve inches of white argillaceous shale, which, when disintegrated, bears a close resemblance to the fire-clays of the Coal Measures. Outcrops of this rock are to be seen northward, near Lexington, and between Lexington and Bellville, containing quartz pebbles and many nodules of soft iron ore; all the rock, in thin layers, extending to the tops of the hills, making the connection complete between the Mansfield and Bellville quarries. The Clear Fork here flows through a broad alluvial valley, bordered with heavy hills of modified Drift, generally sandy, in places composed of coarse, water-worn pebbles and bowlders, the stream occupying the raised bed of the old channel, which passes west of Mansfield, and connects the waters of the Lake with the Ohio.

Between the top of the argillaceous and silicious shales, which very generally underlie the horizon of the Waverly Conglomerate, there is an interval of something over three hundred feet, before the Berea, which is quarried in the extreme north-west corner of the county, is reached. The northern part of the county is comparatively level, the surface deeply covered with unmodified clay Drift, except along the lines of ancient erosion, where the sand-ridges equally mask the geological structure. Hence there are very few rock exposures, and these so isolated that the section cannot be constructed in detail. So far as seen, it is composed of alternate strata of argillaceous and silicious shales having little economic value, though some of the layers afford a fair stone for ordinary foundation purposes.

ECONOMIC GEOLOGY.

From what has already been written, it is apparent that the mineral deposits of the county are not of very great economic value.

The heavy beds of the Waverly afford an inexhaustible supply of stone of good quality for bridge and foundation purposes, which would also make a fair building stone, but not equal in value to the Berea north of it, or to the more homogeneous and finer-grained sandstones of the Waverly, further south. The peculiarly rich, but rather gaudy, coloring of the rock from the quarry near Mansfield and other places would, if properly selected, make highly ornamental window caps, sills, etc., and might be used for the entire fronts of buildings.

The Berea is too far beneath the surface to be accessible, except at the north-west corner of the county, and does not there present its best characteristics.

The iron ore of the county consists of the silicious ore occupying the horizon of the Conglomerate at the tops of the highest hills; nodules of clay-iron stone found here and there throughout the rock formations, and bog ore found in a few places on the surface. None of these are in sufficient quantity, or of sufficient purity, to pay for transportation to parts where they could be economically used.

Since the explorations of the county were made, considerable local interest has been manifested in the reported discovery of coal by deep borings in the immediate neighborhood of Mansfield. Coal is exhibited said to have been taken from the borings. It is a legitimate part of the work of a geological survey to expose and to prevent frauds of this kind so far as it can be done, but not to assert that any particular individual has attempted or practiced a fraud. This is the province of the courts, upon a proper case being presented to them. It is enough to say here that there is some mistake in regard to these pretended discoveries. Thin seams of carbonaceous matter or thick beds of bituminous shale may be reached by boring in this vicinity, but no coal seams will ever be found beneath the city of Mansfield or the adjacent country, and all pretended discoveries of them may at once be set down as either frauds or mistakes. The only place where coal can possibly be found in the county is near the tops of the hills of the north-eastern part. In none of the hills examined were Coal Measure rocks found; and the highest are capped with the Carboniferous Conglomerate, which is below the coal; so that the probabilities are that no coal will be found in any of the hills. Explorations in Holmes county have shown that hills of Waverly rock in places rose above the margin of the old coal swamps, and that coal is now found near them at a lower level. It is therefore barely possible that some outlying deposit may exist in this part of the county, and that these have not been discovered in making the Survey. It may be positively asserted, however, that no extensive and valuable deposits of coal will ever be found west of the Holmes county line in Richland.

CHAPTER LXVII.

REPORT ON THE GEOLOGY OF KNOX COUNTY.

BY M. C. READ.

LOCATION AND TOPOGRAPHY.

Knox county, situated directly south of Richland, is a continuation of the southern slope of the table land which separates the waters of Lake Erie from those of the Ohio River. Its surface presents a succession of hills, in part rugged and steep where influenced by the Coal Measure rocks and the Waverly Conglomerate; in part symmetrically rounded, and of very graceful outlines, where composed of the olive shales of the Waverly. These hills are all intersected by narrow ravines in which flow the tributaries of the larger streams, the latter uniformly occupying ancient valleys of erosion, and bordered by rich alluvial plains. This ancient river system of the county is very accurately defined. The main channel, commencing in the north-west corner of the county, is occupied by the head waters of Owl Creek, and is everywhere filled with coarse water-washed gravel capped with a thick deposit of alluvial soil The stream follows the line of this old channel, occasionally cutting through headlands which formerly projected into it. At Frederick, for a short distance it has a rock bottom, where a spur of the hills, extending out from the east side, is crossed by it, the old channel being easily traced a little to the west. An exposure of the rock here shows that it is much harder and more massive than usual, and had greater power of resisting erosion.

After the valley was filled up by the Drift, the modern stream found a shorter course across this space, and has cut its recent channel through the rock. This old channel extends to Mt. Vernon, where it divides, one branch continuing southward, and the other turning almost directly east, affording a fine illustration of the manner in which the topography of the country, before the Drift epoch, has controlled the course of modern streams, and in many places the location of our railroads. The engineers of the Valley Railway, running northward from Cleveland, have traced out such an old pre-glacial valley, and cross the divide in the swamp that marks its highest elevation in the north-eastern part of

Summit county. A similar channel, passing diagonally through Ashland county, having Savannah Lake as its Summit, invites the attention of railroad engineers. In Richland county, all the railroads for the greater part of their course follow the ancient valleys. In Knox county, Owl Creek and the Sandusky branch of the Baltimore and Ohio Railroad occupy the channel to Mt. Vernon, where the stream takes the eastern branch of the pre-glacial valley to Coshocton county, and the railroad the southern branch into Licking county. For a part of the distance below Mt. Vernon and Gambier, the stream has made for itself an independent channel through rock spurs projecting from the north, but the course of the old river can easily be traced a little to the north of it. At Gambier it is in the ancient bed which here divided a channel extending northward toward Martinsburg, now filled with gravel and sand hills, and occupied by Big Run, which flows northward, a direction opposite to that of the old stream, and becomes a tributary to Owl Creek. At Millwood, also, the channel of Owl Creek is narrow, rock-bound, and recent, but the old channel is easily traced to the south of the massive bluffs of the Waverly Conglomerate, where it is now filled with modified Drift hills of gravel and sand.

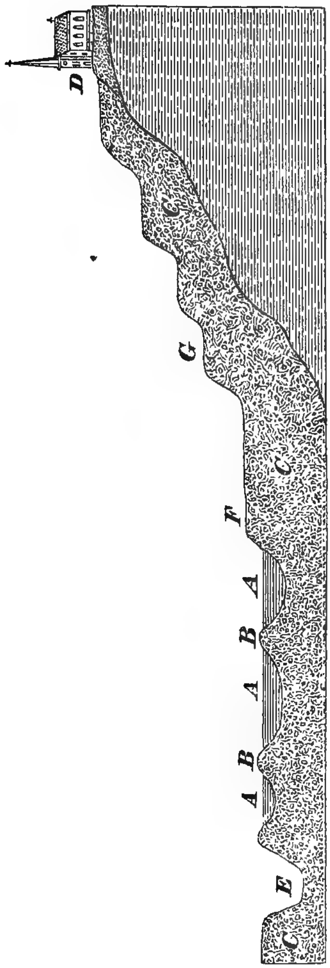
Coming down from the divide between the waters of Owl Creek and the Killbuck, the engineers who surveyed the route of the Cleveland, Mt. Vernon and Coshocton Railroad, and who had followed one of these old channels most of the way from Akron to Oxford, turned into this ancient valley, finding a level surface, no rock cuts, easy material to excavate, and abundance of gravel.

A railroaa from Mt. Vernon to Coshocton could be built only by following this old pre-glacial channel.

These old valleys have been filled by glacial Drift to the summit of the adjacent hills, and probably nearly if not quite to the top of the highest hills in the county; the immense erosion which accompanied the retreat of the glacier sweeping away the great bulk of the Drift, taking all the finer materials, and leaving a residuum of sand and gravel.

The following section from Zion's church east of Gambier, to the bed of Owl Creek, indicates very clearly a chapter of this old history.

DRIFT IN OWL CREEK VALLEY.



AAA. Alluvium of river bottom.

BB. Ridges of gravel rising above the alluvium.

CCCCC. Drift gravel.

D. Zion's church on a sand-hill with a core of Waverly rock.

E. Channel of river in gravel.

F. Terrace of ten feet.

G. Terrace of thirty feet, the elevation from G to D being ninety five feet.

Wells drilled for oil on the borders of this stream toward the Coshocton line show that this deposit of coarse gravel extends at least eighty-two feet below the bottom of the valley, and in one instance a log was struck at a depth of one hundred feet. Hence there is here disclosed a broad valley once filled with Drift to the depth of not less than two hundred and seventeen feet, through which a channel has been plowed one hundred and thirty-five feet, in depth, leaving a succession of terraces, the stream now flowing nearly one hundred feet above the bottom of the old gorge. Observations to be noted hereafter indicate even a much greater thickness of this deposit elsewhere.

A section across the stream from Mt. Vernon west, gives a much broader alluvial plain, a similar succession of terraces rising gradually to land covered with unmodified clay Drift, containing striated boulders.

The hills east of Mt. Vernon are generally covered with Drift containing abundant debris of Waverly, and many granitic boulders. Patches of typical clay Drift are most abundant on the slopes near the top of the hills, and in places exposed ten feet thick.

Following the Columbus road westward toward Mt. Liberty, the surface rises very slowly from the river over a bed of fine gravelly and sandy alluvium, filled with small bowlders, many of them of limestone, then striking irregular drift-hills which reach an elevation one hundred and fifty-five feet above the railroad at Mt. Vernon. The material of these hills is coarse, consisting chiefly of gravel and sand, with flat fragments from the Waverly, and a few large granitic bowlders. The surface is irregular and billowy, as if piled up by the action of shore waves when the water stood at this elevation. Thence to Mt. Liberty the surface rises to the height of two hundred and twenty-five feet above the railroad, the wagon road passing over undulating Drift hills, the materials steadily becoming coarser, containing more limestone, and more flat fragments of rock. The underlying strata are entirely covered by this deposit. Wells on the hills at Mt. Liberty show,

		FEET.
1.	Gravel	15
2.	Blue clay	5 to 15

when quicksand, resting upon shelly sandstone, is reached, and affords an abundant supply of water.

West of Mt. Liberty a cut on the railroad at an elevation of two hundred and eighty-five feet above the depot at Mt. Vernon shows that the Drift is wholly unstratified. It contains a large percentage of small limestone bowlders. Many of these are striated, but none of them rolled or water-worn. Finely broken, irregular fragments are abundant, and a moderate quantity of flat and broken pigments of the Waverly are seen. This is typical unmodified glacial Drift, and this deep gorge was filled with it to the height of at least two hundred and eighty-five feet above the present bed of the stream. Similar deposits yet remaining in protected places on the level of the stream show what was the original material which filled the valley.

In Hilliar township the hills are composed of tenacious clay Drift, the wells showing eight to eighteen feet of yellow clay, then blue clay passing into hard-pan on the hills and resting on quicksand in the valleys. On the bottom lands of the stream we find—

		FEET.
1.	Soil, black loam	6 to 10
2.	Blue clay	12 to 14
3.	Quicksand and washed gravel.	

A well at Centerburg passed through—

		FEET.
1.	Yellow clay	12
2.	Blue clay	39

when water was obtained. The material below was not penetrated; no wells here are sunk to the rock.

The timber in this region is beach, maple, oak, white and black ash, and black walnut. Of the latter a very large amount of valuable timber has been cut for shipment east.

The small streams in Hilliar township form the head waters of Licking River. They are bordered with gently rolling hills of modified Drift, containing angular fragments of the Waverly and rounded granitic bowlders, and rising forty feet above the bed of the stream. The soil is a mixture of clay and sand, rich in the debris of the lime rocks.

The wells at Lock, on the south line of Milford, pass through eight to fifteen feet of yellow clay, and fifteen to twenty feet of blue clay, then on the higher lands striking gravel, on the lower, quicksand. The surface is of the same general character through Milford and Miller townships, viz., undulating hills from which the finer material of the Drift has been washed, bordering flood plains through which the small streams flow, generally over beds of water-rolled pebbles, this material resting upon unmodified drift. A section of the bank exposed by a bend in Licking Creek shows this arrangement of the materials:

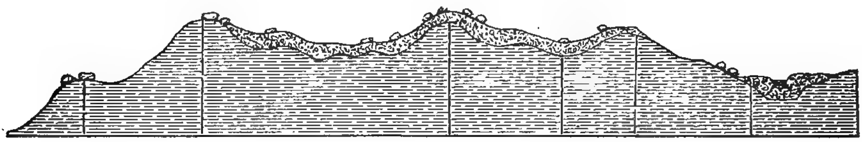
		FEET.
1.	Yellow clay and coarse unstratified gravel	4
2.	Water-washed sand and gravel, rudely stratified	8
3.	Yellow boulder clay	1 to 2
4.	Blue boulder clay to bottom	15

The whole mass is filled with rock debris, that of the two upper members nearly all rounded and water-worn. Granitic and limestone fragments occur in all.

Eastward from Lock, Drift apparently fills the old valley of erosion to the foot of the hills east of the Baltimore and Ohio Railroad. These hills rise somewhat abruptly to the height of three hundred feet above the valley. Their slopes are covered with Drift, so that no rock exposures are found until the descent into the valley of Owl Creek is reached, about one mile from Mt. Vernon. The rock is here broken and crushed as if by lateral thrust. An old water-plain borders the west side of the railroad from Mt. Vernon to the south line of the county, marked by successive terraces, and from one to three miles wide. It is bordered by hills of modified Drift, and forms an extension northward of the valley in which Owl Creek flows, until deflected to the east by Mt. Vernon.

The following profile, reaching from Mt. Vernon to Martinsburg, omitting many of the less important hills and valleys, will show the character of the Drift deposits in this part of the county:

PROFILE SECTION FROM MT. VERNON TO MARTINSBURG.



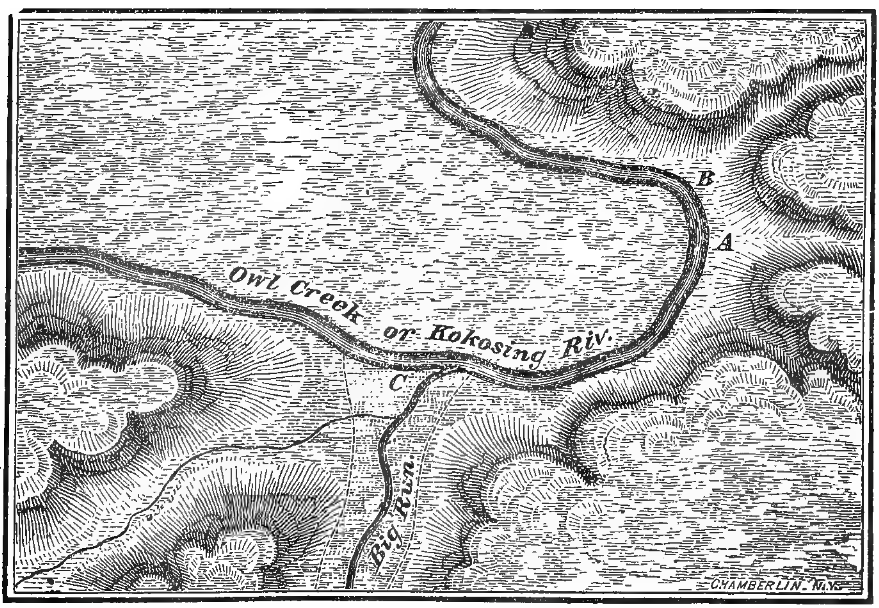
The slope of the first hill, which rises to one hundred and seventy feet above Mt. Vernon, exhibits the olive shales of the Waverly covered by Waverly debris, with no evidences of Drift except occasional granite bowlders. On the top of this hill are found thin bowlder clay and granitic pebbles. Ascending the next slope to the height of three hundred and ten feet, the outcrop and debris of the Waverly continues, with no Drift material until passing about twenty feet downward on the south-east side. There granite bowlders are found, and the slope below is covered with Drift mingled with angular fragments of the local rocks. The Drift continues to the top of the next hill, two hundred and eighty-five feet, but is thin, and the soil is composed mainly of local debris. One mile north of the last are broad expanses of gently undulating sandy fields, exhibiting no evidence of Drift except large scattered bowlders of granite, the soil like the banks of sandy streams. Rising above these sandy billows are irregular ridges of clay composed largely of foreign Drift. At the highest elevation—three hundred and five feet—the hill is capped with a heavy deposit of clay Drift. On the descending slope, at twenty feet from the top, a sandy water-washed surface is reached with granitic boulders scattered over it. Descending toward the eastern valley, the Drift on the slopes is deeper. On the last slope, at an elevation of two hundred and seventy-five feet, the Drift disappears, and the crushed layers of the Waverly are covered only with their own debris. At two hundred and fifteen feet the river Drift of washed sand, gravel, and granitic boulders is reached, which passes into the alluvium of the valley, cut by Big Run at an elevation of one hundred and sixty-five feet above Mt. Vernon. Ascending the divide on the opposite side of the stream, the same series of materials is found in reverse order, viz.:

1. Alluvium of valley, bordered by river Drift.
2. Outcrops of Waverly covered by Waverly debris, and occasional large granite bowlders.
3. Heavy clay Drift.
4. At two hundred and twenty-five feet above Mt. Vernon, outcrop of Waverly without Drift, continuing up a gentle slope to two hundred and sixty feet, where there is a broad undulating plateau of water-washed sandy soil, with occasional Drift boulders.
5. At an elevation of two hundred and seventy-five feet, hills covered with Drift, which extends in the protected depressions to two hundred and thirty-five feet.
6. At three hundred feet, on the last elevation before descending into the valley at Martinsburg, Waverly debris without any appearance of Drift.

In Jackson township the Wahatomaka Creek—which has the sources of most of its tributaries in the recently eroded ravines of the Coal Measure rocks on the east—falls a little north of Bladensburg into the old channel now occupied by Big Run, and is bordered by irregular sandy hills of water-washed material, which are continued northward to the junction of Big Run with Owl Creek.

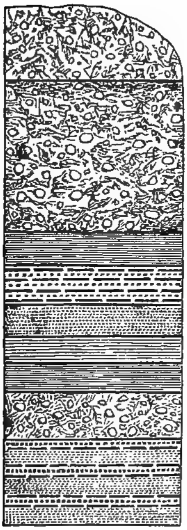
At Gambier the bend in Owl Creek or Kokosing River, called the horse-shoe, gives an interesting exposure of the Drift, and furnishes important facts touching the elevation of the surface deposits and drainage. The following is an outline:

THE HORSE-SHOE.



The river here flows through a broad valley of alluvium, containing pebbles, and resting upon a deep deposit of water-washed gravel. An old deeply excavated channel opens southward at C, the mouth of Big Run, now filled at the surface with sandy material. At A a narrow channel is filled with the original Drift, which has been carried away at the surface by recent erosion, but not down to the present water level. The encroachment of the river at this point exposes a clean section of this original deposit, as given below:

SECTION OF OLD VALLEY DRIFT, BIG RUN.



	FT.
Yellow clay, with Drift bowlders and pebbles, and many flat fragments of local rocks	8
Blue bowlder clay unstratified, with rounded granitic bowlders, gravel, and angular fragments of glacial rocks	20
Laminated blue clay	3
Coarse stratified gravel	4
Coarse stratified sand	2
Yellow laminated clay	2
Blue laminated clay	2
Unstratified bowlder clay	4
Stratified sand and gravel	8

At Mt. Vernon, wells sunk in the alluvium pass only through sand and gravel. Those on the sandy slopes strike—

		FT.
1.	Yellow clay	10 to 15
2.	Blue clay	30 to 40
3.	Gravel, sand, and broken stone to bed rock.	

That part of the county east of the Baltimore and Ohio Railroad and north of the Cleveland, Mt. Vernon and Columbus Railroad, consisted originally of a high undulating table land, covered with glacial Drift. Erosion has intersected it with narrow ravines, and filled it with small streams, leaving a succession of well-rounded hills of very graceful outline, characteristic of the Waverly in this part of the State. This peculiarity is only modified by outcrops of the Waverly Conglomerate. Where this is wanting, or is below the bottoms of the valleys, the hills are entirely without benches; the lines of the landscape are all graceful curves;

the hills susceptible of cultivation to the top, and presenting scenes of quiet beauty rarely excelled. These characteristics change upon approaching the Coal Measure rocks in the south-east and north-east parts of the county.

Standing near the line of division, the observer need make no mistake in regard to the character of any of the hills in sight; those which are symmetrically rounded to the top will be found composed wholly of the Waverly; those of which the summits show benches and irregular lines of contour are capped with the coal rocks. The debris of the olive shales, the upper members of the Waverly, here make a peculiarly elastic and excellent roadway, so that traveling in the night along the margin of the coal field the sound of the carriage wheels will enable one to say when he is passing over a road of this material. These hills at the north retain patches of undisturbed Drift on protected slopes, with scattered erratics, the latter sometimes very abundant on the lower slopes and in the beds of streams, where no other evidences of the Drift are preserved. These hills, when denuded of Drift, have but a slight covering of soil, the shales of the Waverly, finely broken up, coming near to the surface.

West of Ankenytown is a plain about ten miles wide, without rock exposures, but with occasional gravel ridges, the whole composed of river Drift, of sand, gravel and clay on the margin, resting on quicksand and gravel, the whole of unknown depth, filling up the old pre-glacial channel.

The surface deposits render the valley of Owl Creek and the broad plain west of the Baltimore and Ohio Railroad remarkably productive, and the crops rarely or never are injured by drought or rain. The rich alluvium, resting on a deep bed of gravel, through which the stream runs, is most thoroughly underdrained, and the soil can retain an excess of moisture only when the stream overflows its banks. The water also fills this gravel from bluff to bluff to the level of the stream, and the crops can suffer but little from drought, unless so protracted that the stream becomes dry. These surface deposits also afford materials for excellent roads. The drainage in the valleys is perfect, and the heavy beds of gravel which border them are every where available. Upon the hills the decomposed Waverly shales make a road-bed that is well nigh perfect, smooth, elastic, and well drained. Only among the hills, where the clay Drift has been protected and retained, is there a necessity of carrying material for road-making to any distance.

These peculiarities, with the graceful outlines of the hills, their variety and fertility, give great beauty to the county, and where put under thorough cultivation, will make it one of the most delightful spots in the State or country.

TIMBER.

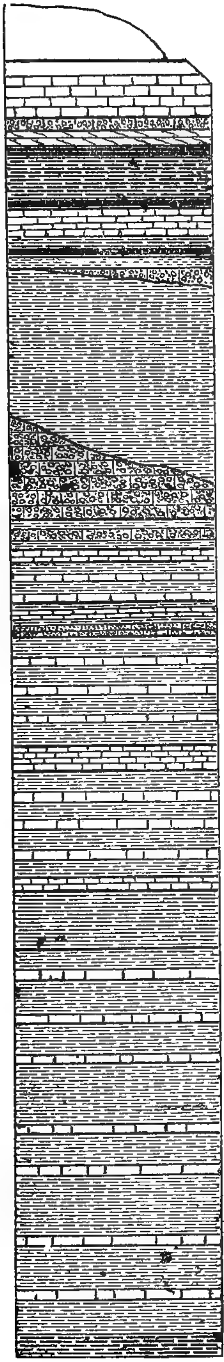
In the broad valleys of the streams the native timber was mainly hard maple and black walnut; of the latter a very large part was destroyed before its value was known, but very much has been cut and shipped to market. The large sugar maples in this district seemed a strange thing, but the thorough drainage afforded by the deep deposit of gravel fully explains their presence. If the alluvium rested upon clay, we should find soft maple, elm, and sycamore growing upon it, but no sugar maple. On the Waverly hills a mixed forest of maple, beech, hickory, oak, and pepperidge; in a few places on the borders of the stream hemlock, and on the ridges where the Waverly Conglomerate comes to the surface, chestnut. On the Coal Measure rocks the predominating timber is oak. On all the hills are scattered trees of whitewood, cucumber, black and white ash, and elm; the latter three being most abundant where the original glacial Drift remains.

GEOLOGICAL STRUCTURE.

The series of rocks exposed in the county comprise about two hundred and seventy-five feet of the Coal Measures, and about three hundred feet of the Upper Waverly, but borings for oil have extended our knowledge of the strata down to the Huron shale, and have afforded important information in regard to the character and thickness of the sub-carboniferous rocks.

The following is a general section of the rocks underlying Knox county, as made known by observations of rock exposures and by the borings for petroleum:

GENERAL SECTION OF THE ROCKS OF KNOX COUNTY.



	Ft.
Covered debris of cherty limestone	115
Bench and springs, coal horizon.	
Sandstone	40
Coarse conglomerate	½ to 1½
Irregularly bedded sandstone	3 to 4
Coal	1½ to 2
Black shale	45
Coal, outcrop, and fire-clay.	
Shaly sandstone	30
Black shale	10
Coal, outcrop, and fire-clay.	
Sandy shale	10
Conglomerate	0 to 15
Coal Measures	255 to 272
Olive shales of Waverly	200 to 250
Waverly Conglomerate	50 to 100
Waverly Conglomerate, with bands of argillaceous shale	30
Fine grained micaceous sandstone	1¾
Argillaceous shales, with silicious bands	41½
Fine bluish sandstone, upper part with bands of shale, lower with quartz pebbles	22
Argillaceous shales, with silicious bands	125
Very fine blue sandstone, with argillaceous bands—local	20
Argillaceous shale. with hard blue silicious bands	115
Fine dark sandstone. lighter at bottom	8½
Red or chocolate shales, with blue argillaceous bands at bottom	62
	726
Blue argillaceous shales. with hard silicious bands—Erie	539
Huron shale.	
Total thickness of rocks exposed or penetrated	1827
Interval between coal-measures and Huron shales	1265

It will be seen from this section that the highest hills rise over two hundred and fifty feet above the Carboniferous Conglomerate. The coal-measure rocks cover the greater part of Jackson and Butler townships, and a small area in the north part of Jefferson. The highest hills in Jackson rise one hundred feet above the upper outcrops of rock and are covered with the bleached and earthy debris of cherty limestone. These limestone hills are exceedingly fertile, and produce excellent crops of corn and other grains. The upper rock exposed is a massive sand rock, probably the equivalent of the Massillon sandstone, and the upper coal bears a strong resemblance to Coal No. 1. Attempts have been made to mine it for local use, and the coal has been exposed of a thickness of from eighteen to twenty-four inches. The material immediately above it indicates the action of eroding agencies immediately after the deposition of the shales covering the coal.

The shale is in patches, sometimes three to four feet thick, in other places wanting; the sandstone there resting upon the coal, and in places cutting it out altogether. This sandstone is irregularly bedded with waved and contorted lines of stratification, and is capped with from sixteen to eighteen inches of coarse pudding stone or breccia, containing also water-worn quartz pebbles. The heavy sandstone above this is compact, massive, and evenly bedded.

The coal is of fair quality, in two benches, in places showing considerable sulphur, and at the outcrops does not exhibit a thickness which would make mining profitable except for local use. The thickness and extent of the coal rocks, and the fact that they include three horizons of coal, would fully justify further exploration. This exploration could be made most easily by drilling from the top of the hills, so that the holes would pierce all the strata, disclosing their character and thickness. The shales below this coal indicate less active disturbances, and whatever was originally deposited on the line of the two lower outcrops probably now remains. A fourth horizon of coal is found above the upper massive sandstone at the bench on the hills, one hundred feet below the highest points, but no outcrop of rocks was observed at this elevation. The cherty debris of the limestone above Coal No. 4 is abundant upon many of the hills, and constitutes flint ridges in the northern part of Butler township. Much less promising territory in other places has been successfully explored, and valuable deposits of coal found. The coal rocks of Butler township extend to within about eight and a half miles of Gambier. At the nearest point is an outcrop of the fire-clay of the lower coal, but the water flowing from it shows much sulphur, an indication of coal of inferior quality.

Patches of the Sub-carboniferous Conglomerate are found in place in most of the deep ravines of Butler and Jackson. The maximum thickness observed was fifteen feet. A small patch of the coal rocks caps some of the highest hills in the north part of Jefferson township, and extends into Ashland county, where coal is found. This coal extends into Knox county, and thin coal seams are found near the tops of the hills. Some of them have been explored and abandoned, as if furnishing no valuable coal. They are probably of no value.

Olive Shales.—The olive shales of the Waverly immediately underlie the Coal Conglomerate, and reach a maximum thickness of two hundred and fifty feet. They are composed of thin, evenly-bedded, silicious rock, of a yellow olive color, the layers occasionally of sufficient thickness to afford a fair building stone. The general homogeneous character of this member of the Waverly series gives a graceful outline to the hills, leaving no benches as the result of irregular erosion of alternations of hard and soft rock strata; the debris, when not covered with Drift, giving a light, porous soil, and, where of sufficient depth, quite productive. The porous nature of the soil and the abundance of small rock fragments in it causes it to absorb the rainfall and prevent the beauty of the slopes from being marred by gullies or irregular erosion. The ordinary shells and fucoids of the Waverly are disclosed here and there in these shales, but nothing of special interest was discovered in the way of fossils.

The Waverly Conglomerate —This is continued from Richland south through the eastern part of Knox county, presenting the best exposure along the banks of Owl Creek near the line between Butler and Union townships. It apparently forms here the crest of an anticlinal, and dips to the east at an angle of about 25°. Further eastward is apparently another anticlinal, the rock dipping in opposite directions. The real character of these disturbances is doubtful. The massive Conglomerate is much broken, and borders the stream of which the old channel is known to be something like one hundred feet below the present bed. It is quite possible that all the displacement is covered by the partial undermining of the Waverly Conglomerate, the ancient cañon cutting below it and eroding the softer shales beneath, so that this heavy sandrock has settled down, and this, instead of an upheaval, has curved the anticlinals. If we knew that this coarse, massive rock extended westward through the county, then we might be certain that the appearance at this point was the result of deep-rooted disturbances, for the general dip of the strata is eastwardly, and the rock so boldly exposed about Millwood does not appear in the western parts of the county, where it ought to rise toward the top of the hills. But here in Richland county this Conglomerate forms a comparatively narrow, tortuous belt, apparently marking an old shore line. The following noted exposures of the Waverly illustrate this fact. Ascending the hills on the road from Mt. Vernon towards Martinsburg, the broken outcrop of the Waverly may be seen on a level with the railroad, and may be found at all elevations on the slopes of the hills to the height of three hundred feet. Throughout this thickness it consists of thin layers constituting the ordinary olive shales. The same thing is seen in ascending the hills between Mt. Vernon and Amity. If the Waverly Conglomerate extends to this part of the county it must dip to the west below the valleys; and in that case the hills would all be capped by the Coal Measure rocks. They are, however, Waverly to the top. From thirty to forty feet of this Conglomerate is exposed in the bluffs of the new channel of Owl Creek, below Millwood, the top being ninety-five feet below Gambier. Three-fourths of a mile south-west of Brownsville the top of the Conglomerate is fifty-five feet above Gambier. It is here full of pebbles, and contains much iron. At Brownsville the Waverly is quarried, and furnishes hard, coarse rock, full of pebbles, but more fissile than the ordinary Conglomerate. The stream west of Brownsville, at an elevation of five feet above Gambier, cuts through the Waverly Conglomerate, which rises to an elevation in the hills not easily determined; the general level of the surface west is two hundred and forty-five feet above this stream. East of North Liberty the top of the highest hills is capped with a coarse, cherty Conglomerate, containing much iron, the base of which is two hundred and forty-five feet above the Waverly Conglomerate, near Brownsville. This is an outlying mass of the true Carboniferous Conglomerate, with the olive shales below it. The descent from the base of this rock to Frederick is two hundred and eighty feet. Here Owl Creek has cut a new channel through a spur of the Waverly, but the Waverly Conglomerate is not exposed, nor is it on the western slope from North Liberty. At A. K. Folb's quarry, in Monroe township, one and a half miles north-east of Gambier, and forty feet below it, the Waverly affords large quantities of good stone, though much stripping is required. Many of the layers are thin and much broken. The heaviest layers are about three feet thick, all fine-grained, most of them yellow, but some blue, with a sharp grit, and resembling the Berea. The ordinary shells and crinoids of the Waverly are here abundant. At Critchfield's quarry, Howard township, about two miles east of Howard station, and fifty feet below, a face of twenty feet of the rock is exposed, much of it in thick layers, coarse, with some pebbles, faintly colored like the Mansfield rock, but generally yellow. This is the horizon of the Waverly Conglomerate, and is by barometer ninety feet below Gambier. Near Brownsville, it is fifty-five feet, and south, at Millwood, ninety-five feet below Gambier. These facts indicate a pretty uniform dip of this rock to the south-east, and that it is a continuation of the coarse body of rock in the east part of Richland county. On the C., Mt. V. & C. Railroad, half a mile east of Howard station, a quarry belonging to Hurd & Israel has been opened, at an elevation fifty feet below Critchfield's, of which the following is a section so far as exposed:

		FEET.
1.	Shaly limestone with layers of argillaceous shale	20
2.	Massive sandstone	6 to 8

The lower stratum is a coarse stone with much iron, containing pockets of soft iron ore, in some places striped like the Mansfield stone, and in others of a deep cherry red; general color yellow; fucoids the only fossils observed.

Indian Field Run, a small stream emptying into Owl Creek from Harrison township, and occupying a rocky valley of recent erosion, gives fine exposures of the Waverly, where many of the layers are from three to four feet thick, but they contain many concretions or pockets of iron ore, and occasionally nodules of iron pyrites. Impressions of fucoids are here abundant. The general color of the rock is yellow. The valley and slopes are filled with the debris of the local rocks, with no indications of Drift except an occasional granitic bowlder. Near the top of the hill on the west, Drift bowlders are more abundant, and heavy masses of Drift cover the western slope descending toward Owl Creek.

From thirty to forty feet of the bottom of the Waverly Conglomerate has argillaceous bands interstratified with the quartz-bearing beds of sandstone. Below this the mass of the material to the chocolate shales is argillaceous, with frequent hard bands of calcareo-silicious rock, and occasionally strata of sandstone. One of the latter, No. 19 of the general section, is twenty-two feet thick, the upper part with argillaceous bands, the lower carrying quartz pebbles; another stratum, No. 21, one hundred and twenty-five feet below the last, is a very fine blue compact sandstone, bearing some resemblance to the finer grades of the Berea. It is not persistent, and in most of the hills its horizon is occupied by argillaceous shales. Indeed, all these thin beds of sandstone seem to disappear eastward, the whole interval between the Waverly Conglomerate and the chocolate shale being filled with argillaceous shale.

One hundred and fifteen feet below the hard blue sandstone mentioned above, a similar rock occurs eight and a half feet thick, the upper part dark colored. This is about on the horizon of the Berea grit, and it is evident that the latter, which is a conspicuous and well marked deposit in all the northeastern counties of the State, thins out in this direction, and like the Carboniferous Conglomerate, it was a shore deposit, the coarse materials being carried no great distance into the deep waters which then lay to the south. At the depth of about six hundred and seventy feet below the Sub-carboniferous conglomerate is the red or chocolate shale, the lowest member of the Waverly, and the first in this county which can be identified fully with any of the subdivisions that are so clearly defined in the valley of the Cuyahoga. This is apparently the equivalent of the Bedford shale, which in many places at the north is all or in part red shale. In Erie county this red shale reaches a thickness of some forty feet. The well-borings here show that it is very homogeneous in structure, except that near the bottom there are interstratified bands of argillaceous shale.

Below this chocolate shale are the Erie shales, which so far as their character can be determined by an inspection of the borings, present precisely the same characteristics as in the northwestern counties, where they are fully exposed. They consist of a mass of soft, blue argillaceous shale, with hard calcareo-silicious bands.

Below this Erie lies the Huron or "Black shale," the thickness of which cannot be determined. It seems evident that along the western margin of the Sub-carboniferous rocks the lower members of this series and the upper member of the Devonian are thinning out, and that their advance further west is not altogether the result of erosion, but that their extent in that direction was limited by the presence of dry land at the time of their deposit.

Petroleum and Gas.—The report upon this county would be incomplete without an acknowledgment of the very important aid derived from the borings for oil on Owl Creek, and a brief account of this interesting work. Some ten years ago the attention of enterprising parties was called to the "oil signs" of the eastern part of Knox county. On the western margin of the coal field were indications of dislocation in the rock strata; gas springs were abundant, and from several places it is reported that oil in small quantities was obtained. A company was organized, territory leased, and since that time something like $85,000 has been expended in explorations, mainly under the superintendence of Peter Neff, Esq., of Gambier. The registers of the wells, which have been kept with commendable care by Mr. Neff, show that there is a marked disturbance in the strata extending to the lower rocks reached, its apparent extent, however, being exaggerated by the causes mentioned on a preceding page.

The red or chocolate shales, the lower member of the Sub-carboniferous, constitute a well marked horizon, and enable us to determine the relative position of the different strata in the wells which reach this material.

The location of eight wells is indicated on the accompanying map of the territory around the junction of the Kokosing and Mohican rivers, and the following table gives the depth below the surface of the top of the red shale:

	Ft.
Well No. 1	615
" 2	615
" 3	591
" 4	562 (?)
" 5	705
" 6	575
" 7	607
" 8	627

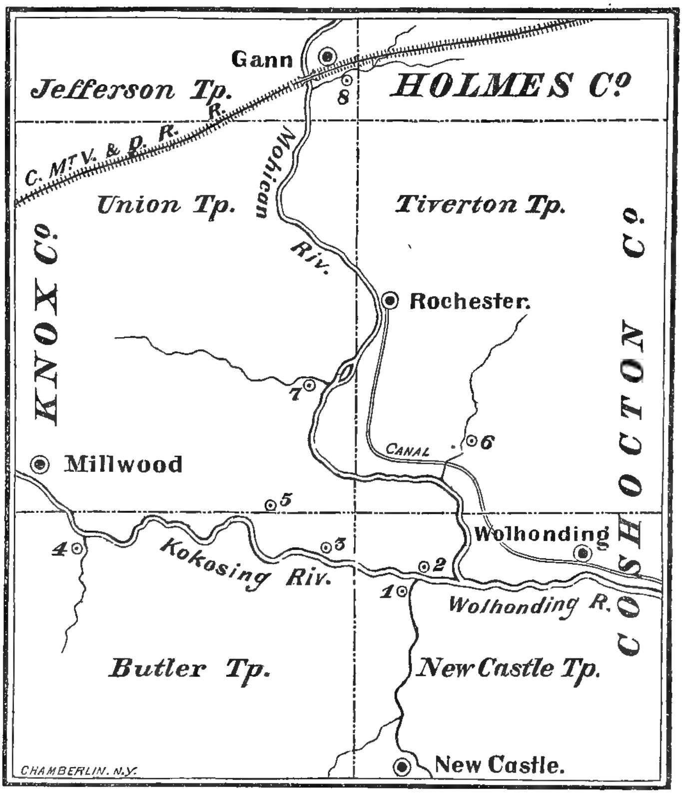
By barometrical observations taken as rapidly as practicable, and on a clear day, the elevation of the surface at each of the wells above that of Nos. 1 and 2, is as follows:

	Ft.
No. 3	50
" 4	125
" 5	95
" 6	75
" 7	25
" 8	30

From these data, the dip of the upper surface of the red shale between the different wells, is as follows:

	Ft.
From No. 8 to Nos. 1 and 2	18
" No. 8 to No. 6	33
" No. 4 to Nos. 1 and 2	128 (?)
" No. 5 to Nos. 1 and 2	135
" No. 5 to No. 6	150
" No. 3 to Nos. 1 and 2	74
" No. 7 to No. 6	48
" Nos. 1 and 2 to No. 6	15
" No. 4 to No. 8	160 (?)
" No. 7 to No. 2	33
" No. 7 to No. 8	15
" No. 3 to No. 8	56
" No. 3 to No. 7	41
" No. 3 to No. 6	189

MAP OF KOKOSING OIL DISTRICT.



The record of No. 4 is not entirely reliable, and some uncertainty exists as to the depth at which the red shale was then struck, but all the other borings indicate a dip to the north-east, and that the line joining No. 8 and No. 2 is nearly on the line of the strike.

The following is a copy of the register of No. 1, on the south side of the Kokosing, three hundred feet west of its junction with the Mohican, supplemented at the bottom by the register of No. 2, five hundred feet north of it, and on the opposite side of the stream.

Specimens of the borings bearing the number on the right-hand column are deposited in the State Cabinet, at Columbus:

No. of Strata.	Material.	Thickness.	Depth.	No. of Sample.
1.	Earth	10	..	..
2.	Coarse yellow sand-rock	7	17	1
3.	Fine sand-rock	2	19	2
4.	Drab "	3	22	3
5.	Coarse "	1	23	[illegible]

No. of Strata.	Material.	Thickness.	Depth.	No of Sample.
6.	Coarse sand-rock	10	33	6 to 13
7.	" "	3	36	13
8.	Drab "	6	42	14 to 17
9.	" " fine	2	44	18
10.	Lighter "	1	45	19
11.	Coarse "	2	47	20
12.	" "	2	49	21
13.	" "	2	51	22
14.	" "	2	53	23
15.	" "	2	55	24
16.	Fine, hard, blue sandstone	9	64	25
17.	" " lighter sandstone	2	66	26
18.	" " sandstone, with pyrites	2	68	26½
19.	Coarse blue sandstone	8	76	27
20.	Fine blue sandstone, with shale partings	14	90	28
21.	" " " "	8	98	29
22.	Bluish gray shale	20	118	30
23.	Silicious blue shale	4	122	31
24.	Blue shale	8	130	32
25.	Hard, fine sandstone	12	142	33
26.	Blue argillaceous shale	10	152	34
27.	" " lighter	12	164	35
28.	Fine, hard sandstone, with pyrites	4	168	36
29.	Fine, blue sandstone	8	176	37
30.	" " with shale bands	10	186	38
31.	Fine-grained micaceous sandstone	16	202	39
32.	Blue argillaceous shale, with sandy bands	12	214	40
33.	" " " "	18	232	4.
34.	" " " "	18	250	42
35.	Argillaceous shale	8	258	43
36.	Blue grit sandstone	6	264	44
37.	" " shale bands	12	276	45
38.	Dark, bluish shale	4	280	46
39.	" " with thin silicious bands	20	300	47 and 48
40.	" " " "	10	310	49
41.	" " " "	18	328	50
42.	" " " "	34	362	51
43.	" " " "	2	364	52
44.	Dark, bluish shale, with red ferruginous and silicious bands	36	400	53
45.	Red sandstone and blue shale in bands	64	464	54
46.	" more silicious	36	500	55
47.	Blue argillaceous shale	20	520	56
48.	" " with dark sandstone bands	24	544	57
49.	Dark shale	24	568	58
50.	" lighter	14	582	59
51.	"	16	598	60

No. of Strata.	Material.	Thickness.	Depth.	No. of Sample.
52.	Sand-rock	..	...	61
53.	"	15	613	2-62
54.	Red shale	12	625	2-63
	Total depth	625		

In all the wells bored, a similar succession of strata has been pierced. The chocolate, the Erie, and the Huron shales were struck in all wells carried deep enough. The rocks included between these and the Coal Measures present alternations of sand-rock, argillaceous and sandy shales, which, after passing the olive shales that cap the Waverly, present a great variety in the different wells, and forbid all minute systematic subdivision. The most marked and most general alternations are exhib-in the general section of the rocks of the county.

In nearly all the wells bored, gas, oil, and brine have been found in greater or less quantities, and from two of them a remarkably strong flow of gas has issued, which, properly utilized, can be made of great value.

The employment of natural gas elsewhere in the manufacture of iron would indicate the proper use to be made of it were it not that the wells are situated several miles from any railroad or other adequate means of transportation.

The Neff Petroleum Company, which, under the management of Peter Neff, of Gambier, made the explorations for oil, has been recently reorganized under the name of "The Kokosing Oil Company," and has attempted to utilize the gas in a novel manner, which gives promise of complete success. It has expended about $25,000 in erecting buildings and appliances for the manufacture of carbon-black, and is now obtaining a product not excelled in quality by any thing in the market, except bone or ivory-black, and has demonstrated that the well has a capacity of producing about five hundred pounds per day of No. 1 black, which is said to command, at wholesale, eighty cents per pound. This company has also devised a mode of utilizing the acid-waste of oil refineries, as it makes a very excellent carbon-black from that of ordinary quality, by using with the acid-waste a small amount of the natural gas. With eighteen hundred burners, for the consumption of the natural gas, it produces from forty to fifty pounds of the "Diamond," or No. 1 black, per day, and with twenty-eight burners, for the consumption of the acid-waste, one hundred to one hundred and fifty pounds per day of the "Pearl," or No. 2 black. The fact that the gas has flowed from the well without diminution for ten years gives good promise of its permanency; and the indications now are that by this use of the gas a good return will be secured to the stockholders for all the money so perseveringly expended in sinking the well.

Well No. 2 also yields a steady flow of gas, and from well No. 1 over three thousand barrels of water escape per day.

These wells afford an opportunity of obtaining exact measurements of the thickness of the Waverly rocks on the margin of the Coal Measures, and aid in determining the character of the successive strata.

Well No. 8, near Genoa Station, in Jefferson township, shows that the Waverly above the red shale is eight hundred and seventy-two feet in thickness, and, including the red shale, is nine hundred and thirty four feet, the Waverly being here capped with sixty feet of coarse sand-rock, either the Carboniferous Conglomerate or the Massillon sandstone. If this is regarded as the Conglomerate, sixty feet should be added to both the above numbers. Above the sand-rock is sixty feet of shaly sandstone, capped with the cherty limestone, underlain by fire-clay, and a faint outcrop of coal. I am inclined to regard this, as well as the massive sandstone over the lower coal at Newcastle, as the Massillon sandstone, Coals Nos. 1 and No. 2 having disappeared in this direction. The Massillon sandstone rests upon the Waverly, on the hills above Genoa Station, and directly on Coal No. 1, at Newcastle. At wells Nos. 1 and 2 the Waverly is eight hundred and seventy-seven feet thick, the olive shales rising to the coal, under the same rock, at Newcastle. Westward from that point this sandstone rests directly upon the Waverly shales.

At well No. 6, the interval between the lowest known coal, which is certainly near the base of the Coal Measures, and the top of the red shale, is eight hundred and fifty feet. This well commenced in the Waverly at one hundred and fifty-five feet below the lowest coal, passed through Waverly shales to the depth of two hundred and forty feet, then argillaceous shales, with not more than six thin silicious bands, four hundred and fifty-eight feet. At six hundred and ninety-eight feet a hard, fine-grained sand-rock, with oil, was met with, but it was without crevices, and no water flowed from it. The entire absence of the Waverly Conglomerate, and of the second sand-rock, and the predominance of argillaceous shale is quite significant. Westward, the materials in all the wells gradually become coarser; the Waverly Conglomerate, and the other sand-rocks were found in normal position, and the supply of oil in the wells was more abundant. All the indications point to an old shore line, a little to the west during the deposit of the Waverly rocks, along which the coarse sandstones accumulated as shore deposits, while the finer argillaceous shales were deposited in deep water at the east.

In well No. 3 the second sand-rock was struck at two hundred and eighty-five feet, and was six feet deep; the third sand-rock at five hundred and eighty-five feet, and was nine feet thick. The red shale was reached at five hundred and ninety-five feet. This well still flows oil, gas and brine; the latter yielding two pounds and ten ounces of salt from eleven quarts of water.

Well No. 4, the "Buckingham Well," yields heavy green oil from the thin sand-rock, which was struck at about five hundred and sixty feet, and is eighty-eight feet thick. The record of this well was imperfectly kept, and the red shale was not certainly located. Mr. Neff, in a supplemental report, puts it at six hundred and twenty-eight feet. If this is correct, there is a reverse dip here to the south-west from well No. 5 to well No. 4, of twenty-eight feet.

In well No. 5, the "Hard Well," the third sand-rock was struck at five hundred and seventy-five feet, and was ten feet thick, yielding gas, oil, and water, which still flow from the top of the tube, about eight gallons of oil per day. The red shale was reached at five hundred and eighty feet. If the record of the well is correct, the interval between the top of the red shale and the top of the Huron is sixty-two feet less than at well No. 8 or No. 6.

These borings develop the following interesting facts:

The surface disturbance is much in excess of that of the deeply buried strata, is therefore in part superficial, and covered by the undermining of the surface, as suggested above.

There is a deep seated disturbance involving all the rocks down to and including the Huron shale, which is the great oil-producing rock, so that the dip of the strata is substantially northeast. Eastward the silicious rocks gradually give place to argillaceous shales, the coarse sandstones becoming thin or disappearing altogether. In the opposite direction, or westward, the materials are coarser, and the sand-rocks thicker.

On the eastern margin of the territory explored by boring, gas predominates, and at well No. 2 has flowed for ten years with a continuous pressure of about one hundred and eighty pounds to the inch. Westward, petroleum is more abundant. The oil is thus far nearly all found in the sand-rock directly above the red shales.

The water obtained *above* the second sand-rock and that below the red shale is fresh; that between the second sand-rock and the red shale is salt, and affords a suggestion as to the probable source of the coloring material in the red shale—iron deposited by the salt water.

The results obtained suggest further explorations in the south-eastern part of the district for gas, and in the western part for oil. With the new uses developed for natural gas, it is difficult to decide which would be the more valuable.

Recent borings for salt north of Shawnee, in Perry county, reach the red shale at a depth of eight hundred and thirty feet, commencing on the horizon of the blue limestone, which is here one hundred and thirty-five feet below Coal No. 6, or the Great Vein of Perry county. The red shale is reported as from thirty to forty feet thick, and is here also at the base of the salt-bearing strata.

Analysis of Gas from Wells.

An analysis made by Prof. Edw. W. Morley, of the gas emitted by one of Mr. Neff's gas wells, and such as is used by him for the manufacture of lampblack, gave the following formula for its composition:

Specific gravity		0.65
Oxygen		0.8
Carbonic acid		0.3
" oxide		0.5
Carbon and hydrogen, equivalent to	Marsh gas	81.4
	Ethyl hydride	12.2
Nitrogen		4.8
		100.0

CHAPTER LXVIII.

REPORT ON THE GEOLOGY OF LICKING COUNTY.

BY M. C. READ.

TOPOGRAPHY.

The same influences which shaped the topography of Knox and Richland counties have left their impress upon that of Licking, have determined the direction of the water-courses, and have divided the county into several well-marked topographical areas. A deep pre-glacial channel from the north enters the county a little west of the Sandusky branch of the Baltimore and Ohio Railroad, extending southward to Newark, and is now occupied by the northern branch of Licking River. At Newark it divides; one branch turning directly to the east, in the valley of Licking River, and one branch extending north-westerly, through what was evidently at one period a broad lake, and in which now the south branch of the Licking flows with a reversed current to join the main stream at Newark. A smaller channel, coming from near Martinsburg, Knox county, passes through Eden township and the valley occupied by the Rocky Fork of the Licking, to its junction with the main stream. This channel is marked by debris of the adjacent bluffs, and has had less influence upon the topography of the county than the others named. The larger channels are now filled with water-washed pebbles, resting ordinarily upon the old rocky bed, but in places upon the remains of the original Drift clay, covered with alluvium, and sandy ridges marked by a succession of terraces and corresponding water-plains. South and south-west of Newark these water-plains expand, covering a large area. Borings for wells indicate that the rock has been here excavated to a depth corresponding with that of the old channels, and that in the latter part of the glacial epoch a lake of considerable size covered the surface. These old flood-plains, from the same causes indicated in the report on Knox county, are exceedingly fertile, and all that is said of them there would be substantially true of them here. The surface above these plains is divided into four topographical areas. In the district north of the Licking, and east of Rocky Fork, including the townships of Perry and Fallsburgh, are a succession of hills rising to the rocks above the third coal seam. These are separated by the deep and narrow valleys of the modern streams, which generally have a rock bottom and bluff banks. The slopes of the hills are usually covered with the debris of the local rocks. North of the Licking, and between the North Fork and Rocky Fork, are similar hills in Mary Ann township, rising to a height sufficient to catch the lower coal, and in Newton township to the horizon of the Carboniferous Conglomerate, which is here mainly represented by a stratum of silicious iron ore.

In the south-eastern part of the county are hills of like character which reach above the horizon of Coal No. 6, the surface diversified in a similar manner by a net-work of deep ravines, the channels of the recent streams.

In the north-eastern part of the county is a high, undulating table-land, the rocks all Waverly, and in the northern and central part deeply covered with unmodified Drift clay. The undisturbed, billowy surface of the original deposit still remains, except upon the borders of the streams and upon the southern slope where the clay of the Drift has all been carried away, and the evidences of its presence remain only in the pebbles of the streams and occasional erratics on the slopes of the hills.

In the south-western part of the county an irregular series of low hills project into the old water-plains of the valleys, in part covered with Drift, the latter in places extending below the beds of the present streams.

SURFACE DEPOSITS.

Along the valley of the old channel that enters the county from the north, and a little west of the Baltimore and Ohio Railroad, the surface is in many places composed of the original, undisturbed bowlder clay, marked by frequent swamps and marshes. In places, deposits of sand and gravel designate the line where excavations were carried to a lower level. Farther south the channel of excavation was wider and beds of gravel and sand are more abundant. Three-fourths of a mile south of Utica an isolated hill rises to the height of one hundred and fifty feet, composed of Waverly rock which resisted the denuding agencies that excavated the valley. Calvin Miller's quarry, opened near the top of the hill, illustrates the crushing force of these agencies. The rock is broken and displaced as if by a lateral thrust exerted upon both sides of the hill with a force sufficient to break up the rock to its center, but not sufficient to carry it away. Between Utica and Homer are Drift clay hills, with granitic bowlders, rising to the height of seventy-five feet above the valley.

The north-western part of the county is a succession of undulating hills, rising to a height of 495 feet above the railroad at Newark, deeply covered with typical clay Drift, with few rock exposures, these all Waverly. The timber is largely beech and maple, with a mixture of oak, ash, and elm. The roads often lead over clay ridges rising from forty-five to seventy-five feet above the intervening hollows, the only rocks exposed being erratics of the Drift. Approaching these undulating Drift hills from the south and southeast, the observer would note the outcrop of the Waverly rocks, covered with their own debris, and no evidences of the Drift except occasional erratics. Passing southward, the high hills about Granville are covered wholly with the debris of the local rocks, but in the valleys there are yet remaining heavy deposits of bowlder clay, extending to an unknown depth below the present surface of the streams. At a cut in the Atlantic and Lake Erie Railroad, south-east of Granville, the blue bowlder clay, with occasional striated pebbles, is exposed, of the thickness of fifty feet, and in places is known to underlie the gravel beds of the streams. This clay is sometimes wholly unstratified, containing a profusion of metamorphic and granitic pebbles, some of them well rounded, others angular, oblong, and striated, and mingled with the debris of the limestones and the local rocks.

In the south-eastern part of the county the hills are covered only with the debris of the local rocks, conspicuous among which is the flint of "Flint Ridge," the evidences of the Drift being found only here and there in the valleys, and mainly in the form of pebbles in the gravel banks and beds of the streams.

The following is a section of the materials disclosed by a small stream a little west of Linville:

1. Stratified gravel, rising to the top of the hills adjoining the stream.
2. Finely laminated, compact blue clay, similar to that found upon the north side of the divide which separates the waters of the Lake from those of the Ohio, and in the deep valleys penetrating the divide from the north.

Among the hills the ravines are the result of recent erosion. This erosion is largely determined by the location of subterranean water-courses, supplemented by the geological structure. The fire-clays of the Coal Measures, and the argillaceous shales alternating with the harder rocks exposed in the deeper ravines under the influence of surface erosion, only form terrace-like slopes, each bench in the hill marking the outcrop of the softer and more easily disintegrated material. Wherever a spring flows out over these argillaceous strata, under the combined influence of the water and the frost, the harder beds above are undermined, are finally broken, and fall by their own weight. This process being continually repeated, the gorge gradually eats its way into the hills, following the sinuous course of the subterranean streams, and resulting in valleys many times greater than could be caused by surface water alone. After the torrents which accompanied the retreat of the ice sheet to the north had expended their force here and further north, removing nearly all the typical glacier Drift deposits, leaving only stratified beds of sand and water-worn pebbles, and exposing in many places the sharp outcrops of the rocks, the subsequent excavating agencies were mainly these springs. The small streams pouring into the valleys over precipices formed by the springs, aid in the work, but are only a supplemental agency. All these causes, together with surface disintegration and erosion, combine to produce the conditions described by Prof. Andrews in the south-eastern part of the State. No glacial striæ or ice-polished surfaces are seen, nor are there any crushed outcrops of the rocks, or typical glacial clays, water-washed and stratified material being the only Drift deposits. In Licking county as in Knox, patches of bowlder clay on the tops of some of the highest hills, and in places below the beds of the lowest streams, still remaining, bear witness to the action of the Drift agencies, the results of which are so conspicuous in the northern counties. Farther south, where these phenomena are wanting, and the present surface has been wholly modified by post-glacial agencies, it may be difficult, perhaps impossible, to determine whether glacial deposits once covered the surface and have since been removed, or whether we have passed southward beyond the original area of the Drift.

In places in this county unstratified bowlder clay rests upon deposits of stratified sand and gravel. Near the eastern line of Union township an excavation gives the following section:

1. Unstratified bowlder clay .... 8 feet.
2. Stratified sand and gravel to bottom of exposure.

The rock fragments in this bowlder clay are not striated, but are irregular and angular in shape; many of limestone and other local rocks; a small percentage granitic.

On the banks of the Licking north of Newark old water-plains can be traced at different elevations, leaving in places four well-marked terraces respectively (commencing at bottom) of eight, twelve, and eighteen feet in height.

A section across Wilkins Run, in Mary Ann township, shows water-washed sand hills rising in places to the height of one hundred feet above the bottom of the stream. The wide valley and these elevated water-washed and assorted sand hills indicate the influence of water in quantity vastly in excess of any that could be derived from the local precipitation. They are the result of the torrents which followed the melting and retreat of the glaciers which brought down the Drift from the north.

The following sections of the material beneath the flood-plains and terraces near Newark, furnished me by W. M. Cunningham, Esq., confirms the above conclusions in regard to the extent of the erosion of the valleys and the foundation of a temporary lake basin at that point.

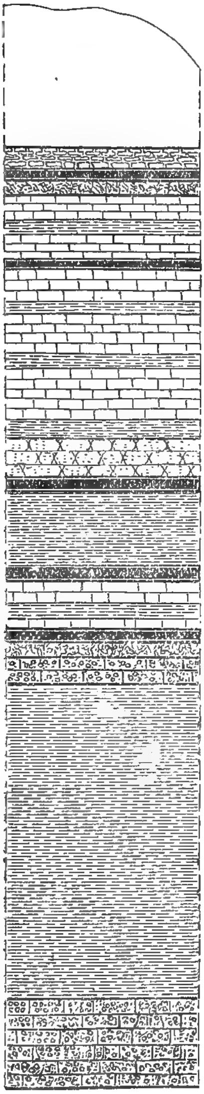
		FEET.
1.	Soil, alluvium	1 to 2
2.	Yellow clay, with coarse gravel	1 to 6
3.	Ordinary sand and gravel, sometimes with quicksand.	
4.	Blue clay, sometimes in pockets of 20 to 30 feet	2 to 10
5.	Coarse sand and gravel	2 to 4
6.	Blue clay.	

In sinking a well six miles west of Newark a piece of coniferous (?) wood was obtained at a depth of forty feet.

GEOLOGICAL STRUCTURE.

The geology of Licking county is largely a repetition of that of the counties lying immediately north of it, and the space given to the description of the geological structure of those counties renders it unnecessary to enter here into details which would be mere repetition of what has gone before.

The following is a general section of the rocks exposed in the county:



	FEET.
Fire-clay ten feet below top of hill	70
Chert, with quartz-crystals, "Flint Ridge"	2 to 8
Coal thin, often wanting.	
Fire-clay	2 to 4
Sandstone and sandy shale	20 to 25
Coal thin, often wanting.	
Sandstone and shale	75
Limestone	4 to 14
Coal, cannel or bituminous	3 to 5
Ferruginous sandy shale	25 to 35
Coal, outcrop.	
Sandstone and shale	20
Coal thin, in places	2 to 3
Fire-clay and shale	2 to 5
Conglomerate	15
Fine grained olive shales of Waverly	150 to 190
Waverly Conglomerate	40 to 60

The number of this series found on the summit of most of the hills in the south-east part of the county is the flint, which is ordinarily regarded as on the horizon of Coal No. 6, the Great Vein of Perry and Hocking counties, this coal being represented by the thin and worthless seam underlying the flint. I am disposed, however, to regard the flint as the equivalent of the "Black Marble," so-called, of Coshocton county—which has beneath it a thin seam of coal, and is found in places only ten or twelve feet below Coal No. 6—and the representative of the drab limestone of Columbiana county, often found directly beneath No. 6. In Coshocton county this "Black Marble" often passes into a chert, as do all the limestones of that county, but none of them form so extensive and continuous deposits as the flint of Flint Ridge. Any one traversing this ridge for the first time would be surprised to find such a deposit on such a geological horizon. It simulates very accurately the broken-up debris of a vertical dike, the fragments often covered with perfect crystals of quartz, the rock itself being highly crystalline and often translucent. It is something of a puzzle to understand how such a deposit is found in a series of undisturbed and unmodified sedimentary rocks. The adjacent surfaces of two blocks of the chert are often found covered with quartz crystals of considerable size, as thoroughly interlocking with each other as if one were a cast, and the other the matrix. I can not imagine conditions which would spread such a deposit over the floor of a sea or any other body of water. A substitution of silicious matter deposited from solution, in the place of a soluble limestone previously deposited, is the only plausible explanation. This substitution has taken place over large areas in this part of the State, and has left these silicious deposits only upon the horizons of the different limestones.*

The coal immediately below the flint is indicated by outcrops in various places, but wherever observed is thin, and apparently of no value. Below is a bed of fire-clay two to four feet in thickness, which appears to be of good quality.

A few hills rise to the height of eighty feet, by the barometer, above the flint, showing debris of chert and sand-rocks. At an elevation of seventy feet above the flint in one place, a heavy outcrop of fire-clay was

* The question of the origin of the silica, which so often replaces the carbonate of lime in the Coal Measure limestones, is discussed at some length in Vol. II. of this report, and it is there attributed to *Diatoms*. These microscopic plants, as is well known, bear silicious frustules, which accumulate at the bottom of some lakes and ponds till they form beds many miles in extent and several feet in thickness. They probably inhabited portions of the shallow land-locked basins where the limestones were formed in such numbers as to supply silica for concretions or cherty layers, and sometimes to replace the calcareous bed entirely, just as we find the diatomaceous earths locally replacing shell-marl in the bottoms of our lakes and marshes. The silica which forms the frustules of the diatoms has been proved by experiment to be unusually soluble, and in the flint beds, the individual forms have doubtless been either so completely dissolved or so enveloped in soluble silica as to be lost. The quartz crystals referred to by Mr. Read as coating the blocks and filling the crevices and cavities of the flint, are evidently of modern origin, and have been formed by a deposit of silica, from solution, in whatever receptacles were open to it. (See Vol. II., Part I., page 142.)

observed, probably the horizon of Coal No. 7. If so, we have all of the lower Coal Measure rocks represented in this county, but with a comparatively small amount of workable coal.

Directly below the fire-clay of the flint is a bed of sandstone and sandy shales—the sandstone in places massive—but I noticed no places where it was quarried for use. Its thickness to the occasional faint outcrop of coal observed below it, ranges from twenty to twenty-five feet. There was nothing observed to indicate any valuable coal at the base of this sandstone.

Below, for a distance of about seventy-five feet, the surfaces of the hills indicate substantially homogeneous material, and the outcrops observed were sandstone and sandy shales. Considerable iron ore was seen in the shales, but no places were found where explorations had been made to determine its quality. Much of the sandstone is evidently well fitted for building stone.

Directly below this is a heavy bed of limestone reaching in places a thickness of fourteen feet, the upper part apparently suitable for water-lime, and the lower for quick-lime; but it is by no means persistent in this horizon. In places a black, calcareous shale takes its place, and in others shale, with little, if any, calcareous matter. This limestone contains an abundance of the ordinary limestone fossils of the Coal Measures. An outcrop on the top of a hill above Dr. Wilson's old opening, in Madison township, shows a great profusion of that very pretty shell, *Chonetes mesoloba.*

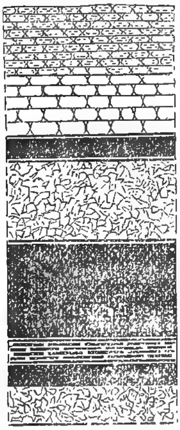
The coal below this limestone is the most valuable mineral deposit in the county.

On Wm. M. Beals's land, lot No. 1, Military section, Hopewell township, this coal seam has the following structure:

		FEET.
1.	Coal	1
2.	Shale	½ to 1
3.	Coal	4½

The coal is here all bituminous, and, apparently, of fair quality. The owner regards this coal as above the cannel, and believes that the latter would be found on his land at a lower level; but the interval between this coal and the chert or Flint Ridge, leaves no question as to its identity. As, in other counties so here, the cannel coal is not continuous, and probably marks the deeper water in the old coal marsh, gradually silted up with the finely comminuted carbonaceous matter from the vegetation f the higher parts of the swamp, where ordinary bituminous coal was formed, one variety shading off into or replacing the other.

The most important opening in this coal in the county is that of the Licking Cannel Coal Company, in the western part of Hopewell township. The coal, by my barometer, is one hundred feet, and by report of railroad engineers, one hundred and four feet below Flint Ridge. It is capped by a thick bed of limestone, presenting with the coals, shales, and fire-clays, the following section:



Earthy limestone	2½ feet.
Pure limestone	2½ "
Cannel coal	1 "
Fire-clay	3 "
Cannel coal	4 "
Black shale	9 inches.
Cannel coal	10 "
Fire-clay.	

The limestone is highly fossiliferous, the lower part burning into a good quick-lime. The lower part of the fire-clay above the main body of the coal passes into an indurated fire-clay shale, which, in most places, makes a strong roof. The coal is of excellent quality, bright, compact, containing a moderate quantity of sulphur, and makes an excellent grate fuel and a superior gas coal. For a time it was extensively used for the production of coal oil, the following average yield being obtained from the distillation of one ton of coal:

Crude oil	40 galls.
Refined oil	17½ "
Lubricating oil	7½ "
Parafine	3¾ to 5 lbs.

When crude petroleum fell to two cents per gallon in 1861–2, the work was suspended, and, I believe has not since been resumed; the cost of the crude oil obained by distillation being about six cents per gallon. It is evident that our cannel coals and bituminous shales are capable of producing an abundant supply of cheap illuminating oils if that from petroleum should fail.

Nearly one-half the surface of Hopewell township is high enough to contain this coal, but it is not persistent over all this area, and where present, it will probably not be always found thick enough to be profitably mined.

In Fallsburgh township are several outcrops of the limestone which caps this coal, and it is there ninety feet above the lower coal, but there is no indication of any workable coal beneath it.

The coal marked in the general section as from twenty-five to thirty-five feet below the cannel, shows faint outcrops in many places in Hopewell township. Many of the hills in Franklin and Fallsburgh are high enough to reach it, but there is no probability of its furnishing here any valuable coal.

Coal No. 1 is, in several localities in the county, of sufficient thickness to be mined for local consumption. In some places it rest upon a thin bed of the Carboniferous Conglomerate, in others upon the olive shales of the Waverly; a bed of fire-clay and a thin stratum of shale being sometimes interposed between it and these rocks. In Madison township, about two miles south-east of Newark, about two hundred tons of this coal have been taken from Dr. Wilson's mine. The coal, as far as worked, was of fair quality, and reached a thickness of thirty inches. Near this point, a shaft sunk through the coal disclosed the including strata as follows:

		FEET.
1.	Shale	4
2.	Coal	2
3.	Conglomerate.	

On this hill the limestone of the cannel coal is, by barometer, one hundred feet above Coal No. 1.

On the south-east quarter of section 1, Hopewell township, entries have been carried into this coal where it is reported to be from eighteen to twenty inches thick.

On Lewis Baker's land, Mary Ann township, it is found near the top of the hill, and where opened, ranges in thickness from one and a half to two feet. The Conglomerate here appears in bed a few feet below it.

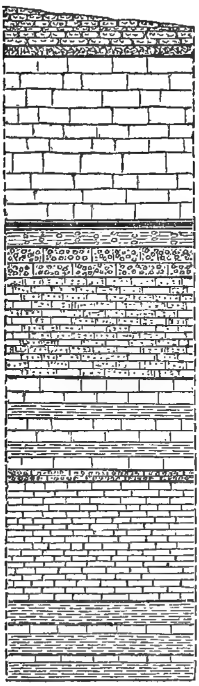
On Wesley Painter's land, in the west part of Fallsburgh township, Coal No. 1 has about the same thickness, and the including strata are as follows:

		FEET.
1.	Gray shale, thickness undetermined.	
2.	Coal	$1\frac{1}{2}$ to 2
3.	Fire-clay	1
4.	Hard, white sand-rock, with *Stigmaria*.	

At an opening on Jacob Priest's land, in Fallsburgh township, this coal is from two and a half to three feet thick, in two benches; is bright and hard; a very good coal; but containing a rather large percentage of sulphur. On the whole, this is the best exposure of Coal No. 1 observed in the county, but as the roof is sandstone, it is more liable to be reduced in thickness as the entry is carried farther into the hill.

It will be apparent that the coal of the county is quite limited in quantity, and that, aside from the cannel, none of it is of first quality. Further explorations may disclose openings where it is thicker, and a considerable amount may be mined for local consumption.

Carboniferous Conglomerate.—The following section, prepared by Mr. Hertzer from the fossiliferous limestone at the top of the hill above Dr. Wilson's old coal entry to the bed of Licking River, and which I have modified slightly as the result of subsequent observations, exhibits the relations of the Conglomerate to the other rocks where it reaches the maximum thickness observed in the county:



	FT.	IN.
Limestone, very fossiliferous	6	
Fire-clay	1 to 2	
Coarse sandstone	100	
Coal seam		2 to 3
Shales, with iron ore	10	
Coal-measure Conglomerate	15	
Thin sandstone flags, with small *Producta and Orthis Michelini*	65	
Coarse-grained sandstone Arenaceous shales Thick, yellow sandstone layer Argillo-arenaceous shales, with *Sanguinolites* Thick, yellow sandstone layer, with *Aviculopecten, Platyceras, Phillipsia*, etc	60	
Dense conglomerate, with *Spirifera*, etc	2 to 3	
Yellow sandstone, with *Nucula, Goniatites, Platyceras*, etc	75	
Blue arenaceous shales, with bands of sandstone, containing *Nucula, Pterinea, Cypricardia*, (?) and Sanguinolites	50	

The iron ore, which here overlies the Conglomerate, is of special interest, as in many places in the county this alone, resting directly on the Waverly, marks the horizon of the Conglomerate. As a silicious iron ore, some of it is of great excellence. It caps some of the hills in Newton and Mary Ann townships, and, judging from the debris around the old charcoal furnace, in the latter township, was the source of supply of the ores there used.

In the hills, on the south side of the Licking, east of Newark, the Conglomerate is occasionally found in place, and fragments of it are frequently observed in the slopes below its horizon. Along the Rocky Fork large blocks of it are strewn over the surface, containing angular fragments of fossiliferous chert, showing that the agencies which deposited the conglomerate broke up a cherty limestone, and re deposited its debris near the place of its original deposition.

The thin bed of very hard, white sand-rock, full of *stigmaria*, which is is seen in places below the lower coal in Fallsburgh, and which seems to take the place of the Conglomerate, belongs above it, and is an evidence of the prevalence of similar conditions over large areas at the time of its deposition. It is found beneath Coal No. 1, in Summit county, where the Conglomerate below is one hundred feet thick; in Holmes county, in places just above the Conglomerate, and in others, where this rock is wanting, resting directly upon the olive shales of the Waverly. It is the normal bottom deposit in the old swamps of Coal No. 1.

Olive Shales of the Waverly.—In the general section of the county, the interval of one hundred and fifty to one hundred and ninety feet below the Carboniferous Conglomerate is designated as "The Olive Shales." This name properly describes the general character of these rocks, but at various elevations there are, in places, strata of massive sandstone, and in others, thin beds of argillaceous shales. These occur oftener than in Knox county, and therefore the Waverly hills are less symmetrically rounded, and have less graceful outlines. The section on page 358 illustrates these changes in the character of the Upper Waverly. The succession of strata there indicated is by no means persistent through the county, but on all horizons the sandy shales are occasionally cemented in thick, massive layers, and thin beds of argillaceous shale occur at all levels.

These upper Waverly rocks are in this county quite rich in fossils. Near their junction with the Conglomerate, and in the Conglomerate, beautifully preserved *Trigonocarpa*, and other fruits of the Coal-measure plants are abundant, and on lower levels species of *Orthis*, *Productus*, *Spirifer*, *Goniatites*, *Nucula*, etc., are to be found.

On the top of the hills, at Granville, the Waverly is quarried, and, as far as exposed, shows the following section:

		FEET.
1.	Earth	4
2.	Crushed and broken rock	2
3.	Shaly sandstone, in thin, evenly-bedded layers	8
4.	Sandstone, filled with *Cauda-galli*	4
5.	Sand-rock, good building stone	14

The layer of sand-rock containing *Cauda-galli*, is of the same character, and apparently on the same horizon as that found in Ruggles township, Ashland county. At Granville, this deposit is, by barometer, 214 feet above Newark, or 460 feet above Lake Erie. The corresponding deposit in Ruggles township, on the North line of Ashland county, is forty feet below New London, or 381 feet above Lake Erie, so that if these are parts of the same deposit, the excess of elevation of that at Granville over that at Ruggles is seventy-nine feet.

Citizens of the county report that coal has been found on this elevation in Alligator Hill, a little east of Granville. Several excavations have been made into the hill, and one near the top. All expose shaly sandstone, which can clearly be identified as Waverly, and the debris of the Waverly is strewn over the surface of the highest part. I think no coal can be found in the hills, or in this part of the county. It is true that in several places on the western margin of our coal fields coal is found, in one sense, below the Upper Waverly. It is found, topographically, below it, not geologically, in the valleys, and on the slopes of the Waverly hills, which, in this neighborhood, rose above the old coal-marshes, and marked the original western limit of the coal-fields. My observations in this county, and northward, along the margin of the coal-field, render it very certain that the supposition sometimes made, that the Ohio coals were once continued westward over the Devonian and Silurian rocks to the Indiana and Illinois field, and that they have since been carried away by erosion, is untenable.

Along this margin of the coal field the strata tend to thin out to a feather edge. In places the third or fourth coal seam is sometimes the lowest one present, and is found just above the Waverly. In one place a continuous ridge contains at one end six coal seams, all in their proper position and substantially horizontal, while at the opposite end of the ridge the Waverly, capped with the Conglomerate, rises to the height of the upper coal.

Waverly Conglomerate.—This rock is conspicuously exposed along the south bank of the Licking in Madison and Hanover townships, presenting abrupt, precipitous bluffs twenty to forty feet high, with vertical fissures like those in the Carboniferous Conglomerate. It contains fewer pebbles than in Knox and Richland counties, being more assimilated to the Logan sandstone. On Rock Run, north of the old furnace in Mary Ann township, where one hundred feet of the Waverly is exposed, the Waverly Conglomerate is seen in well-defined, even layers of six to ten feet each. It is here a fine-grained, easily quarried, yellow sandrock, with very few pebbles, and containing occasionally characteristic Waverly fossils. Here unlimited quantities of very good building stone could be obtained, and the same may be said of nearly all of the outcrops of this rock.

ARCHÆOLOGY.

A proper description of the archæological remains found in this county would require the work of an entire summer devoted to their study. In Fallsburgh, Hopewell, Madison, Newark, Granville, and Jersey townships, and perhaps in others, are remains of the earth-works, and other structures of the ancient races, most of them referable to the times of the "Mound Builders," all of which deserve a more careful and systematic study than they have yet received. Fortunately, the most important of these monuments were carefully surveyed and platted by Col. Charles Whittlesey, at the close of the first Geological Survey of the State, and thus the form and locations have been recorded of many earth-works, which have since been obliterated by the plow, but further exploration with the spade is needed to gather all the available facts tending to explain their character and uses. The excavations made in mining the chert of Flint Ridge cover large areas, and the exploration of these would doubtless give much information as to the character of the implements used, and the mode of mining practiced by these early races. It is to be hoped that, if no other provision is made for it, the citizens of the county will organize a local society for the purpose of thoroughly exploring, mapping, and preserving these interesting remains.

CHAPTER LXIX.

REPORT ON THE GEOLOGY OF MEDINA COUNTY.

BY ALFRED W. WHEAT.

Medina county is bounded on the north by Lorain and Cuyahoga, on the south by Wayne, on the east by Summit, on the west by Lorain and Ashland counties.

There are seventeen townships in the county, containing collectively four hundred and fifteen square miles. Like most of the "Western Reserve," this county is largely given up to the dairy interest—the manufacture of cheese.

The total number of farms in Medina county, as given in the census report for the year 1870, is 2,722, over 2 000 of the number being of less than one hundred acres each, and of the latter number a few more than half are farms of less than fifty acres each.

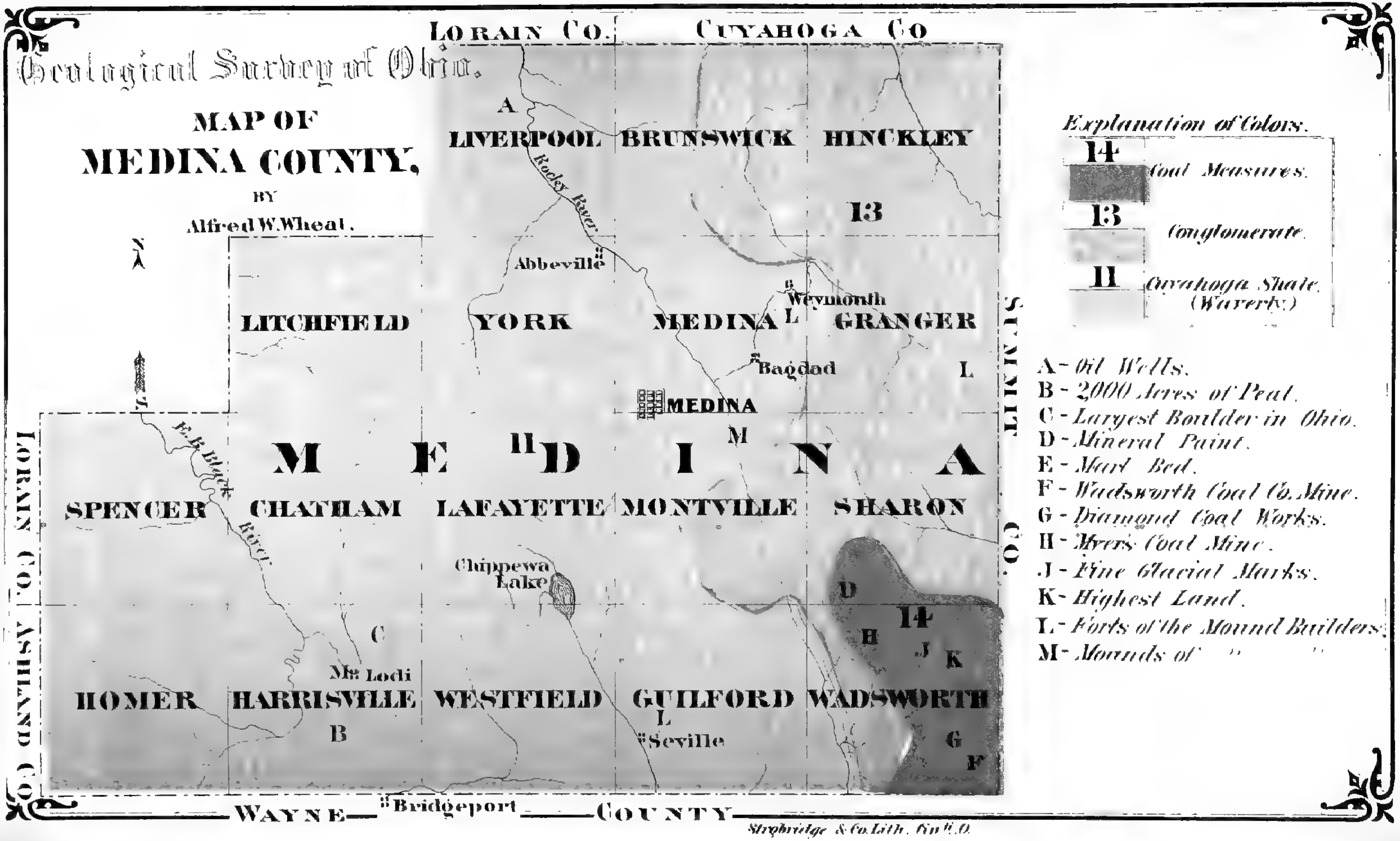
The highest land in the county is in Wadsworth, one mile north-east of the village; and it is over seven hundred feet above Lake Erie. Some portions in the north-western part of the county have an altitude of from two hundred and fifty to three hundred feet only above Lake Erie. The eastern half of the county is quite rolling, the western much more nearly level.

The accompanying map shows the principal channels of drainage; the streams flow both to the north and the south, eventually finding the St. Lawrence and Mississippi Rivers. There is but one lake in this county, Chippewa Lake, the extreme length of which is one mile and a half.

The soil in the western portion of the county is mostly clay. In Harrisville township two thousand acres are covered with peat.

The indigenous forest trees upon the clay lands are elm, beech, maple, oak, hickory, linden, black walnut, butternut, and, in the river bottoms, sycamore. Chestnut trees are prevalent along the ledges and sandy tracts in the eastern part of the county.

Glacial markings are shown wherever the rock is exposed and is of such a nature as to retain them. The general trend of the striæ is



Geological Survey of Ohio.
MAP OF
MEDINA COUNTY,
BY
Alfred W. Wheat.
LORAIN CO.
CUYAHOGA CO
SUMMIT CO.
WAYNE COUNTY
LORAIN CO.
ASHLAND CO.
MEDINA
LIVERPOOL
BRUNSWICK
HINCKLEY
LITCHFIELD
YORK
MEDINA
GRANGER
SPENCER
CHATHAM
LAFAYETTE
MONTVILLE
SHARON
HOMER
HARRISVILLE
WESTFIELD
GUILFORD
WADSWORTH
Rocky River
E. B. Black River
Abbeville
Weymouth
Bagdad
Chippewa Lake
Lodi
Seville
Bridgeport
Explanation of Colors.
14 Coal Measures.
13 Conglomerate.
11 Cuyahoga Shale. (Waverly.)
A - Oil Wells.
B - 2000 Acres of Peat.
C - Largest Boulder in Ohio.
D - Mineral Paint.
E - Marl Bed.
F - Wadsworth Coal Co. Mine.
G - Diamond Coal Works.
H - Myers Coal Mine.
J - Fine Glacial Marks.
K - Highest Land.
L - Forts of the Mound Builders.
M - Mounds of " "
Strobridge & Co. Lith. Cin. O.

south-east. The glaciated surface is generally covered with a bowlder clay containing many pebbles of crystalline rock, granite, quartz, etc., brought from the far north, and more and larger stones derived from some neighboring region or locality.

GEOLOGICAL STRUCTURE.

A detailed account of the geological structure of the county will follow this introduction, the exposures of rock in each township being described separately. A brief summary only will be given at this point. The general section of the rocks exposed in the county is as follows:

		FEET.
1.	Coal Measures	100
2.	Conglomerate	135
3.	Cuyahoga shale (Waverly group)	250

The *Coal Measures* reach into the south-eastern corner of the county, and Coal No. 1 is worked with profit in three mines, all in Wadsworth township. This bed of coal also underlies a portion of the south part of Sharon township, these two townships being the only ones in the county which contain coal. Where mined, the coal reaches a maximum thickness of nearly five feet, is of superior quality, containing but little sulphur. The production of the two principal mines during 1871 was over fifty thousand tons.

The *Carboniferous Conglomerate* is exposed in seven townships, all in the two eastern tiers excepting Guilford. But most of this conglomerate region shows the Cuyahoga shale of the Waverly group in the deeper ravines; in fact, the prevailing rock in Medina county is of this older division. Some fair building stone is quarried from the Conglomerate, but a great portion of this rock is unfit for building purposes. The character of the Conglomerate varies materially in the several places where exposed. In general the pebbles contained in it are quite small, and compose no considerable part of the formation, sand constituting the bulk of the material. The estimated thickness of the Conglomerate in Medina county is one hundred and thirty feet.

The *Waverly series*, or the upper division of it, now named Cuyahoga shale, is the third and oldest group of rocks found in Medina county, the greater portion of the Drift being immediately underlain by the Cuyahoga shale, which is exposed in a majority of the townships. Roughly estimated, the Cuyahoga shale in Medina county may be said to have a thickness of two hundred and fifty to three hundred feet.

This formation is exceedingly rich in fossils, some of the characteristic species being *Hemipronites crenistria*, *Productella Newberryi*, *Sanguinolites* *æolus, Pleurotomaria textiligera, Grammysia Hannibalensis, Dictyophyton Redfieldi, Gyracanthus Alleni,* etc.; *Platyceras coniforme, P. Lodiense, Fenestella multiporata, Lingula melie, Discina Newberryi, Athyris lamellosa, Spirifer biplicatus, Schizodus Medinaensis, Promacrus Andrewsi, Conularia micronema, C. Newberryi, Phillipsia Lodensis,* etc.

The lithological character of the Cuyahoga shale is quite variable, ranging from a very soft shale to a hard argillaceous sandstone. Some of it, by exposure to weather, separates into thin, tough sheets, but the greater part crumbles down into clay. A few beds contain lenticular concretions of lime and iron. The rock is usually gray in color. The shade, composition, and hardness differ very greatly in successive layers.

The *Economic Geology* of Medina county makes no great show. The mineral wealth of the county lies chiefly in coal. Of iron stone there is but little, and that contains only a small per cent. of iron; and of lime there is a notable lack. Gas springs are known in nearly every township which is immediately underlain by the Cuyahoga shale, but in no case has this gas been utilized.

While traveling about the county I not infrequently had persons whisper in my ear, with great caution, the word "lead;" and I found several tracts of land under lease to parties who were confident that they should develop large deposits of galena. My own work with hammer and chisel in a secluded ravine or by the roadside would at times call from a passer by this question: "Stranger, are you prospecting for lead?" All parties were assured that such a search would be quite profitless. Small quantities of galena are found among the fossils of the Cuyahoga shale at Lodi and Weymouth, but *only* small quantities.

For particulars concerning the quarrying of building stone, and the manufacture of mineral paint, reference may be had to the following notes on the several townships:

BRUNSWICK TOWNSHIP.

The soil of Brunswick is largely clay. Wells dug near the Center do not pass through the gravel Drift. James Woodward makes this statement about a well which he dug fifty rods north of the Center: Below the alluvium there were twelve feet of yellow clay, and below the yellow clay the well was dug forty-two feet into blue clay, which contained a little gravel throughout. This may be called a sample of all the wells dug near the Center.

The Conglomerate appears further west in Brunswick than in any other township. The extreme western limit is perhaps one hundred rods west of the north and south center road, in the upper part of the township.

It is here nearly a pure sandstone, the quartz pebbles being comparatively rare. The product of the quarries in the rocky ravine two miles north of the Center is variable, some of the stone being a fine white grit, while much of it is badly stained with large dark patches.

CHATHAM TOWNSHIP.

The general level of this township is much below that of the three which lie east of it. There is a rapid fall from the center road to the west amounting to nearly two hundred feet in the three miles to the east branch of Black River.

The Cuyahoga shale is exposed on Gray's Creek, which flows along the western border of the township, and empties into Black River near the east and west center road in Spencer. The upper strata are of very hard shaly sandstone, quarried for foundations. The gray soft shale below is much like that on Rocky River below Abbeville, and contains similar lenticular concretions of iron, but the limestone concretions are here very few. The fossils are not well enough preserved in this shale to be of value as cabinet specimens. The under surfaces of the thin layers of shaly sandstone, which occur every few inches in these beds, show abundant tracings of fossil forms, but none of them are distinctly marked. A bowlder, estimated to weigh eleven or twelve tons, can be seen in the bed of Gray's Creek.

GRANGER TOWNSHIP.

The Conglomerate underlies all of Granger, as it is one of the townships in the most easterly range of the county. There are abrupt ledges on lots 39, 41, 42, and 98. Quarries have been opened on lots 42 and 78, and also on lot 38. Along the west line of the township there is a sandrock which comes near the surface, and may be seen on lot 50, and is doubtless referable to the upper layers of the Cuyahoga shale.

An ancient fort stood on land a half mile east of Grangersburg; it is now but an indistinct remnant of the original fortification. It once consisted of a circular trench with embankment, and was, perhaps, ten rods across, the northern extremity being now cut off by the public road. A perpetual spring fed a small stream which flowed along the base of the wall.

GUILFORD TOWNSHIP.

The Coal question is one of special interest in Guilford township, which is the first one west of Wadsworth, where are three coal mines in full operation. The River Styx Valley lies between the townships. The altitude of Guilford is less than that of Wadsworth, being at Seville Station, on the Tuscarawas Valley Railroad, four hundred and ten feet above Lake Erie. Borings to discover coal have been made at several places in Guilford, but all without success up to the time of the Geological Survey, when it was understood that the railroad company was furnishing money for further tests by boring.

No true conglomerate rock was seen in the township, nor were any fossils to be found in the sandstone and shale. So far as can be made out, the upper rock is a fair grit, the top layers being shelly or broken. First below this sandstone is a soft shale, which in turn is succeeded by a hard but brittle shale that has considerable grit in it, as can be seen at the Fall Creek exposures, where the color is light gray.

Some years preceding the Survey drilling was done on Mr. Jacob Smith's land, in the bed of Fall Creek, a half mile west of the north and south center road. The bluff above, where the drill was put down, shows the succession of the rock about thirty feet. It is a hard, brittle shale, of a light dove color, with an occasional layer a few inches thick, of a bluish shade, without grit. There is rarely a hard concretionary manifestation, and occasionally kidney ore. Below this bank the drill was put down forty-five feet, through rock quite like that in the bank above.

The sandstone is quarried in the ravine of Fall Creek, one and a half miles east of Seville; it is also quarried at a place just over the county line in Wayne. Whetstones and grindstones have been somewhat extensively worked out of the rock in the north-east corner of the township by David Wilson, Esq. The grit is coarser but not so sharp as that worked on Webster Hard's land, in Wadsworth. All the rock seen in the township is below the coal, and apparently belongs to the Waverly group.

An ancient fort, now quite obliterated, once stood on land one mile north of Seville, and one-half mile east.

HINCKLEY TOWNSHIP.

Hinckley township is in the north-east corner of the county. The soil is loamy, for the most part, affording a growth of chestnut, walnut, hickory, and oak timber.

The Carboniferous Conglomerate is exposed more abundantly in Hinckley township than in any other in Medina county. Immense perpendicular ledges, having very curiously worn sides and caves, from which issue fine springs of never-failing water, are characteristic of this township. The stroller over these extended rocky ledges sees many astonishing passages in the rock made by the falling away of large masses consequent upon the undermining of the softer rock below. The small river running northwardly through the township was once a powerful wearing torrent that filled the valley, in the bottom of which it now so quietly flows. The passage of glaciers also helped to break up the rock and wear away the softer, looser portions, leaving additional evidences in the groovings of the surface.

HOMER TOWNSHIP.

The south-western township in Medina county is named Homer. The rolling surface is cut through the whole length of the township by one of the fountain streams of Black River, affording some fine exposures of *Cuyahoga shale.* The bluffs are thirty feet high in some places, and the opportunity of tracing out the succession of the layers is very good. The rock is a soft gray shale with interspersed layers of hard sandy shale, of a lighter color. The latter is occasionally worked out of the river bed and used for foundation stone for bridges, etc.; but it is too hard to be cut well, and long weathering will cause it to disintegrate or split into thin slabs. Concretions of iron are found in the shale of this township as in others, but the lime concretions are infrequent. No good fossil specimens were obtained here, the shale being too soft to hold the forms.

Galena has been found in Homer, and a few parties, more sanguine than wise, have taken leases of land for lead-mining purposes.

HARRISVILLE TOWNSHIP.

The land of Harrisville township is somewhat rolling, and affords a variety of soils. In some parts the land is clayey, and in others slightly sandy.

Peat covers over two thousand acres in this township. One-half of this territory has the deposit not over eighteen inches deep, the underlying clay being heavy, yet light colored. The average depth of the peat on one thousand acres is about five feet. Most of the western and southern parts of this Harrisville marsh have been plowed. The bed rock is twelve to eighteen feet below the surface of the marsh. The land can be shaken by jumping upon it, although cattle go all over it. The digging of ditches has revealed quantities of shells, but no large fossils, so far as could be learned.

Railroad levels were run in 1853, between Wooster and Grafton, by Mr. W. E. Ferguson, Engineer. The extreme elevation of the road, as it was surveyed through the marsh, was three hundred and forty and three-tenths feet above Lake Erie. The road was to have run west of the village of Lodi, and the elevation there was three hundred and thirty-six feet above Lake Erie. This would give the surface at the town-pump an altitude of about three hundred and fifty feet.

Harrisville is one of the townships in which the water "divides" to the Ohio River and Lake Erie. The great marsh is drained in both directions, and is much lower than most of the land along the "divide."

The Cuyahoga shale is very finely exposed north of the village of Lodi, many rods of abrupt river-bluff offering superior sections of this formation. Lime is quite rare in the rock here, and iron concretions are not as abundant as in some of the exposures of this shale in Medina. Fossils in the soft shale are numerous, though difficult to preserve. Brachiopods and bryozoan corals abound, and occasionally a crinoid or a trilobite may be found.

Quarrying has been carried on since 1840 in numerous places along Whetstone Creek, a mile south-east of Lodi. The rock is chiefly an argillaceous sandstone, most of the beds being only a few inches thick, and the thickest not twenty inches. The exposures here are twenty-five to thirty feet high Large crevices run through all the rock, which is badly broken up. Many layers show something of a micaceous nature, and one of an inch in thickness splits into thinly-laminated sheets of large size.

Above the shale is a deposit of Drift-conglomerate but slightly cemented together. This bed is four to five feet thick, and when cut into, usually stands up against the weather, though in places it falls away very quickly. Large masses may be found in the ravine where they have stood years of washing, and yet seem very compact and hard to break up. This deposit of Conglomerate is largely made up of stones of the size of eggs, and some are even large enough to weigh two pounds.

One mile west of Bridgeport, the town just across the county line in Wayne, there is a large quarry on the south side of the Killbuck River. At this exposure the rock lies in thicker beds than it does along the Whetstone Creek. I found in this quarry a large fish spine (*Gyracanthus compressus*), also an abundance of fossil shells (*Productus*).

Travertine is being deposited in a lot owned by Col. Robert English. It is a mile from Lodi by the north-east road. Some of the masses are large, and they are quite numerous about the spring which issues from a hill-side.

The *largest bowlder* in Ohio, with possibly one or two exceptions, may be seen in a field at the cross-roads, one mile and a half north of Lodi, and a little east. This mass of erratic rock is that variety of granite called syenite. The feldspar in this is dark flesh colored. These masses are of metamorphic rock, unknown in Ohio except as bowlders. Like all such granitic bowlders, these are fragments of Canadian rocks which were broken from the hills and ledges where they belonged, and brought to the south either by the great glaciers which once ground down the whole northern country, or were dropped where they now lie by the icebergs which broke from the glaciers, and floated southward over the great body of water which then filled the lake basin, scattering their burden of rocks and gravel upon the bottom. This large mass of syenite shows two perpendicular sides; the highest of which measures twelve feet above the sod. One of these sides measures fifteen feet across the face, and the other is ten and a half feet across. The sloping side rests against a grassy bank, and gives access to the top of the mass. The depth of the bowlder below the soil can not be stated; apparently it is considerable, and perhaps the larger part of it is out of sight. If half of the mass is below ground, as can be fairly inferred, then the weight of the block can be stated at about one hundred and sixty-five tons.

Two rods distant from this block is another mass of the same kind of rock, which evidently was once broken from it, probably from the side which now shows the bold front of fifteen feet in breadth. This second block is mostly under ground, the exposure being simply one corner and three triangular surfaces. It projects about seven feet above the sod. The three faces exposed measure respectively twelve, fifteen, and twelve feet at the base.

There is yet another large mass of the same rock lying near the two already described, and the three, it would seem, were once one single gigantic block. The size of the third mass can not be estimated, as it lies almost wholly below ground. It can be struck with an iron probe some distance away from the exposure, which measures three by six feet across. These specimens are of especial interest to those who understand what were the transporting forces which brought these masses so far from their original beds.

Gas springs and deer licks are known in Harrisville township.

The first house built in Medina county was a log house, erected in the year 1810, within what is now the village of Lodi. It was built by Judge Joseph Harris.

An ancient mound of much interest can be seen in the center of Lodi village. Upon this mound Judge Harris, the first settler of the county, built a house in about the year 1830. This house still stands. The mound is just south of the public green of Lodi. The elevation of the mound above the general level of the land upon which it stands is twelve feet. The outlines are yet quite distinct, though the grading of the yard has somewhat changed the original appearance. When the town was first settled, the mound was covered with large trees, among them several black walnuts which were over two feet in diameter. The decayed stump of one is yet to be seen. The longest measurement of the mound is one hundred and sixty feet—this is from north to south. The east and west measurement is one hundred and thirty-five feet.

Upon this large mound were formerly two knolls forty feet apart. Each was about two feet high, and ten across, with a distinct ditch around it. One knoll was upon the east side, the other on the west, the house now standing on the edges of both knolls. When the trees were cut away, it was noticed that large sugar maples had grown upon both.

In digging the cellar of the house, nine human skeletons were found; and, like such specimens from other ancient mounds of the country, they showed that the mound-builders were men of large stature. The skeletons were not found lying in such a manner as would indicate any arrangement of the bodies on the part of the entombers. As our informant, Albert Harris, Esq., said, "It looked as if the bodies had been dumped into a ditch." Some of them were buried deeper than others, the lower ones being about seven feet below the surface. When the skeletons were found, Mr. Albert Harris was twenty years of age, yet he states that he could put one of the skulls over his head, and let it rest upon his shoulders, while at the same time he was wearing a fur cap. The large size of all the bones was remarked, and the teeth were described as "double all the way around." They were kept for a time, and then again buried by Judge Harris. At the center of the mound, and some nine feet below the surface, was found a small monument of cobble stones. The stones, or bowlders, composing this were regularly arranged in round layers, the monument being topped off with a single stone. There were about two bushels in measure of these small bowlders, and mixed with them was a quantity of charcoal. The cobblestones, charcoal, and skeletons, were the only things noticed at the time of digging the cellar, which was in 1830. Many years later, in 1869, as digging was being done to lay stone steps at the front of the house (the north side), two other and smaller skeletons were found only three feet below the surface. They lay with their heads to the north. The interment of these two bodies was probably much more recent than that of those found deeper down, and a different race of men may have put them there. Doubtless there are other skeletons in the mound at present, as the digging referred to was done solely for the purposes mentioned, and not for the sake of learning anything concerning these relics, so no care was taken to fully investigate this very interesting matter. Mr. Harris thinks that the ground in front of the house, if dug over, would afford many valuable relics. This mound may possibly go back in history to the time when the Harrisville swamp was a lake, and the region about good hunting territory. Chippewa lake is but six miles distant. Great quantities of flint arrow-heads and stone axes have been found about the marshes.

LITCHFIELD TOWNSHIP.

The soil of this township is a tough clay, much like that of Lorain county, which lies immediately west. The surface is level, but a slight ridge runs north-east and south-west, crossing the center road two miles east of the village of Litchfield. On this ridge are flowing wells which afford large supplies of water throughout the year. There is a thickness of eight feet of clay above the Cuyahoga shale at the "Center."

A gas well of some note is situated one mile and a half north and one mile west of the Center. Mr. J. V. Straight—who, with Mr. E. Rice, bored the well in 1860—makes this statement concerning the boring

"We passed through the following strata:

		FT.	IN.
1.	Clay	15	..
2.	Shale	160	..
3.	Hard slate	2	..
4.	White flint	2	..
5.	Coal	..	2
6.	Shale	1	..
7.	Sandstone	25	..

"Of the above series, No. 1 is Drift clay; Nos. 2 to 6, Cuyahoga shale; No. 7, Berea Grit. No. 5, "Coal," is not true coal, but either a layer of carbonaceous shale, or a local accumululation of vegetable matter, such as is sometimes met with in the Waverly rocks.

"Oil was brought up by pumping, but not in any great amount. During the drilling, gas escaped with a clear, whistling sound, and when set on fire it blazed up from twenty to thirty feet, the outlet being eight inches square."

Three other gas springs are known in the township.

LIVERPOOL TOWNSHIP.

Liverpool is the most westerly of the northern tier of townships. Rocky River flows through the Center from the south to the north, making an occasional exposure of the Cuyahoga shale. For most of the distance the river flows so far from the old bluffs that not being subject to its wearing action, they have become gentle slopes, and so have a dense covering of vegetation. The old bluffs are, in several places, full a half a mile apart, while the river channel is not over fifty feet wide. There is but slight exposure of the rock in the northern part of the township. At the Center a succession of some thirty feet of strata can be seen. The lowest bed is rather hard; with this exception, and that of a layer eight inches thick of fine-grained shaly sandstone, some fifteen feet above the river bed, the rock is of a uniform dark grey color, and quite soft. *Fucoids* in great abundance cover the under surface of the layer of sandstone. *Spirophyton* is abundant in a shaly sandstone which is exposed in the river bed at a place one mile south of the Center. Fossils in great variety—crinoids, bryozoans, brachiopods, orthoceratites, and trilobites—are to be found in a water-washed bluff, where the bridge crosses the river one mile below Abbeville. About one hundred and fifty species were obtained here. Most of them were found in the lenticular concretions of lime and iron; those in the soft shale were all unfit for preservation. Scarcely one per cent. of the concretions are fossiliferous, but those which are so are very rich in well-marked forms. This bluff is on the east side of the river, and extends as an abrupt wall for some eighty rods, the height being generally thirty feet. Thin continuous layers of sandy shale can be traced along the cliff. Concretions are very abundant from the base of the exposure to the summit, and are, as is usual, arranged in continuous layers; the average thickness ot the concretions is one inch, and the maximum thickness four inches. These concretionary beds can be seen in their connection with those above them, in York township, a quarter of a mile north of the Abbeville bridge.

Nine wells, which were bored for *petroleum* in Liverpool, yielded a small amount of oil; two others failed to afford any. Some wells which were sunk only one hundred feet "struck oil." Mr. John Jordan put one well down fourteen hundred and fifty feet. The location of this well is over half a mile north of the Center. No satisfactory section of this and other wells can be obtained, but only general statements, which are too indefinite to be of real value. Five wells were put down over five hundred feet. The Gardner well was nearly one hundred and fifty feet to the sand-rock. The well at the grist mill was put down to the sand-rock, one hundred and forty-five feet. The deepest well, Mr. Jordan's, was put through the sandstone (Berea Grit), the red and black shale (Bedford, Cleveland, Erie, and Huron shales), some flinty layers (Hamilton), and then five hundred feet into limestone (Corniferous, Water-lime, and Niagara). One hundred and fifty barrels of oil were taken from one well; others yielded from thirty to forty barrels each. None of these can be profitably worked for their oil at present prices. *Gas* comes continually from several of these wells.

LAFAYETTE TOWNSHIP.

The most central township in the county is Lafayette. The altitude is not nearly as great as that of Montville, the next township on the east. There are no exposures of rock of especial note, and the streams are small. There is also a noticeable absence or scarcity of bowlders.

Chippewa Lake is in this township. It is the only lake worthy of note in the county. Its extreme length is a mile and a half, the breadth being about half the length.

MEDINA TOWNSHIP.

Conglomerate may be seen in one locality in this township. It is in the extreme northern part, just south of the diagonal road between Weymouth and Brunswick. There is a fine glaciated surface on the rock at that exposure.

Cuyahoga shale is the rock which predominates in this township, being exposed in numerous places. At Weymouth it is for the most part a gray sandy shale, with some softer beds. The lime and iron concretions are here quite infrequent. Only the upper part of the formation is seen in the township. This is highly fossiliferous in several localities, especially at Weymouth, Bagdad, and Medina. The most abundant species are *Hemipronites crenistria, Productella Newberryi, Grammysia Hannibalensis, Pleurotomaria textiligera, Sanguinolites aeolus, Edmondia tapesiformis, Spirifer biplicatus, Schizodus Medinaensis*, etc.

A *sandstone quarry* at Weymouth affords a fine-grained, drab-colored stone, valuable for monuments. A slab of this stone in the cemetery at Hinckley has stood weathering over thirty years, and now looks in a better condition than a majority of the marble slabs in the same cemetery. This bed of stone is nearly two feet thick, but to be worked out a large amount of superimposed soft shale has to be removed.

The *altitude* of Medina village is about the same as that of the highest land crossed by the Tuscarawas Railroad, the summit, according to the old survey of the road, being nearly two miles south of Medina village, in Lafayette. The altitude there is five hundred and seventy feet above Lake Erie; at Medina Station it is five hundred and seventeen feet; at Grafton Station (Lorain county), it is two hundred and thirty-seven feet; at the Atlantic and Great Western Railroad crossing, south of Medina county, it is three hundred and ninety-three and six-tenths feet.

Passing north along the western border of Medina township we descend upon successive flats quite regularly disposed. The off-look from some of the elevations is picturesque in the extreme, though not from any bold, rocky exposure in the landscape, for vegetation covers every thing.

Gas springs are known in this township; the one on Mr. Z. White's land, one-third of a mile north-west of Weymouth, being the most easterly observed in the county. The gas comes from a spring of water which has never been known to freeze over. Another gas spring is in the bed of the west branch of Rocky River, three miles north of Medina village and west of the turnpike bridge.

An *ancient fort*, just south of the business houses of Weymouth, is one of the best preserved and most interesting of its kind which can be seen in this region. Like other such evidences of the old power and importance of the race of men known as the mound-builders, this fortification is called an Indian fort, though the Indians which the early settlers ot the country found, knew nothing of these ancient works of defense. How could they when the maple trees growing on the embankment gave evidence of being over seven hundred years old? The fort is an intrenched projection of land, which has abrupt, bluff outlines, excepting at its rear connection with the main land. The river having made an abrupt turn, back upon itself, there was formed a peninsula-like projection of land having shale bluffs over fifty feet high. The defense of this point was easy after trenches had been cut across the neck. Three such trenches are now plainly discernible, and they bear on the surface evidence of the former greatness of the work. The trenches are two hundred and ten feet long (width of the point of land); the inner trench is three hundred and sixty feet back from the end of the point; the middle trench is forty-one feet from the inner one.; and the outer trench is forty-nine feet from the middle one, or four hundred and fifty feet from the end of the point. The trenches run east and west, the point of land being a southward projection. Even now, after these many centuries of change, the average depth of the trenches is three feet, while in some places it is five to six feet, the embankment projecting above the general level of the land about two feet, making the bottoms of the trenches below the tops of the embankments five feet, and in places seven feet. Early settlers of the township thought this high point of land, this old fortification, a superior place for a burying ground, and it was used for this purpose for some years; a few of the brown stone slabs still stand as reminders of the pioneer whites who dispossessed the red man of this territory, which had once supported the the semi-civilized mound-builders. To get at the cemetery a road was cut through the center of the three embankments. The Clinton Line Railroad (never built) was to have passed just in the rear of the other trench, and some excavation was done toward cutting a roadway across the point. Fortunately that work was not carried far before it was abandoned, leaving this old relic of a departed race but little defaced.

MONTVILLE TOWNSHIP.

Montville township, as its name implies, is high land. The Tuscarawa Valley Railroad was diverted to the west out of the township and out of the direct route, because of the difficulty of grading over the high land of Montville.

The billowy character of the surface in some places was another obstacle.

The *water divide* in this township is a matter worthy of mention. Much of the water falling upon the southern part of the township runs southward to the Ohio River; but all that falls in the northern part finds its way eventually into the St. Lawrence. Harrisville and other townships are thus drained, both to the river and the lake.

Conglomerate is the upper rock in the eastern part of the township of Montville. It has been quarried to some extent on land owned by Oliver Ingham and William Waters, half a mile west of the Sharon line, and one mile south of the Medina line. The grains of the rock are about the size of bird-shot, with quartz pebbles as large as blue birds' eggs scattered sparingly through the mass. Quarrying is also done in a ravine one mile south of the Center school-house.

Cuyahoga shale shows itself in the north-western part of the township. Its sandstone layers are quarried at a place some forty rods south of the Medina line, and east from the west line of Montville about one mile. Mr. Samuel Bowman owns the quarry. The stone is unreliable in quality, as it often splits into thin sheets after continued weathering. Judge Castle put this stone into foundation walls of business blocks in Medina, and in the course of twenty years it had disintegrated so much that he was obliged to have it replaced with new stone.

In the south-east corner of the township, two miles and a half from the Myers coal-bank in Wadsworth, is a ravine which gives a section of perhaps one hundred feet. At the top is a very tough shale of a gray color. The underlying sandstone is of varying fineness.

A fine *Conglomerate* bed, ten inches thick, is seen about twelve feet below the upper stratum of tough shale, with beds of sandstone above and below. This bed of Conglomerate is made up almost wholly of pebbles, there being in it only sand enough to fill in the interstices between the pebbles, which are generally as small as or smaller than hazelnuts.

An *ancient mound* may be seen on Mr. John Archer's land, known as the Philip King farm, two miles south-east of Medina village. It is nearly midway between Rocky River and Champion Brook, and perhaps fifty rods above their junction. The mound is now ten feet high, and some seventy feet in diameter, though centuries of washing and several years of plowing have extended its borders and rounded its outlines. The soil of the mound is different from that of the "bottom land" on which it is built. The nearest ridge or bank is about thirty rods distant. Flint arrow-heads abound on the surface about the mound.

SHARON TOWNSHIP.

The Coal Measures extend into Sharon township from Wadsworth, which lies immediately on the south. Borings have shown the presence of coal in the south-east and south-west corners of the township.

The *Conglomerate* shows extensively in ledges which are crossed by the north and south State and Center roads, two miles north of the south line. There are perpendicular bluffs of Conglomerate along Spruce Run, and it is shown to some extent in lot nine at the north of the township. George W. Crane, Esq., owns a quarry of the rock situated a little north-east of the Center. There are no large pebbles in the stone, and only a few very small ones. Mr. Glenn Freeman's south lot line on the Center road is on the highest land in the township—over one hundred and fifty feet above the village. The west part of the township has much heavy clay; the eastern part is loamy.

The Mineral Paint made from the shale in the south-western part of the township is a valuable commercial article.

SPENCER TOWNSHIP.

Lying as it does at the extreme western border of the county, Spencer township differs much from the territory in the eastern portion where the surface is so much broken up. Clay soil and level surface, such as characterize southern Lorain, are the predominant features in Spencer. It also forms the lowest portion of the county. Between the soil and the Drift clay is a variable layer of sandy loam. The north-eastern quarter of the township affords a few exposures of *Cuyahoga shale* in the banks of the East Branch of Black River.

Gas springs have been observed in the river.

Salt is indicated in the wells and springs which are found on a narrow belt of land running westwardly, and about eighty rods north of the Center road. The percentage of salt in the water is small, yet it was enough to interfere with the working of a steam-boiler, producing saline incrustations upon it. Salt licks are known in the township along this belt of salt territory.

WESTFIELD TOWNSHIP.

Westfield is the middle township in the southern tier. The northern part is clayey, but the southern part is sandy. Over three hundred acres are covered with peat. There is a *marl* marsh of twenty acres, situated a mile and a half south of Leroy post-office. The marl is like a whitish clay with minute shells, and when burnt, the lime produced is a shade between the white and gray lime in the markets, but the strength is not nearly equal to that of ordinary lime. The houses of the town were formerly plastered with this marl lime.

A mastodon or elephant skeleton was found in this township in the year 1832. Most of the bones were taken to Wooster at the time of their discovery.

WADSWORTH TOWNSHIP.

The *Coal Measures* cover three-fourths of Wadsworth township, which is the extreme south-easterly one in Medina county. By careful estimate it is thought that four hundred and fifty acres of workable coal exist in this township. Drilling has been done very generally over the coal territory, and basins of excellent coal found and mapped, but insufficient railroad facilities delay the general development of it. Three mines are now in full operation, the coal mined being of good quality, such as sells in Cleveland on an equality with the Willow Bank coal.

The Wadsworth Coal Company began shipping coal in December, 1869. At the time of my visit (September, 1871) the daily production of this mine was one hundred and fifty tons, the estimated product for the year being fully forty thousand tons. Eighty miners are employed. The mine is in the south-east corner of the county. The coal is shipped by the Silver Creek Branch of the Atlantic and Great Western Railroad.

The Diamond Coal Works of Humphrey, Coleman & Co. are situated two miles south-east of the village of Wadsworth, the railroad running close to the mine, which was first opened in December, 1869. At the time of my survey daily shipments of seventy-five tons were being made. The yield of this mine in 1871 was stated to be thirteen thousand tons. Thirty miners were employed by this company.

The *Myers Coal Bank* is in the north-western part of the township, three miles from the other mines. It has some peculiar features, but at the time of my visit it was filled with water, which the engines made slow progress in removing. A conglomerate of mixed pebbles, etc., immediately overlies the coal in this bank, but is somewhat broken and tilted up, showing great crevices. The coal also is broken up and shows many mud cracks; but is of good quality. It does not fall to dust by weathering, or run together when burning in a grate. The market for this coal is a local one; the towns to the north and west generally send their wagons to this bank for their coal supply. Unfortunately, there is a large fissure in the floor of the mine through which comes a flow of water, necessitating constant pumping.

The succession of rocks in this region of the Coal-Measures, according to Mr. Julian Humphrey, is as follows, and as he is senior partner of the Diamond Coal Company, and a man who has had thirty years' experience in drilling for coal, his statements are deserving of credit:

		FT.	IN.
1.	Drift	20	....
2.	Coarse sandstone	40	....
3.	Dark soft shale	....	6
4.	White clay	....	4 to 6
5.	Gray shale	16	....
6.	Chocolate shale	16	....
7.	Dark shale	16	....
8.	Coal	3 to 5	....
9.	Fire-clay	....	1 to 6
10.	Fire-stone, "Bottom rock."		

The last stratum, a quartzose sandstone, was not drilled through, as it is extremely "hard." The Conglomerate is supposed to be below the firestone. Mr. Coleman has put down perhaps seventy-five drill-holes in this section of the State, and says that this, his ideal section, is always essentially encountered where coal is found..

The roof shales of the Wadsworth coal mines are generally mazes of fossil coal plants, all pressed into thin sheets, and printed upon the shale as distinctly as if photographed. The thickness of the coal is, in some cases, over five feet, but it is generally thinner, the larger portion of the township affording only thin coal. This coal lies in "pockets" (local basins), and as it is the lowest in the coal series of Ohio, and forms the margin of the great coal basin, it is more irregular than the seams of coal which were deposited subsequently.

The *Conglomerate* is seen one and three-fourths miles south of the center, by three-fourths of a mile west. A coarse-grained sandstone, locally a conglomerate, is quarried somewhat extensively at a place one mile north of the center of the village, on land owned by Henry A. Mills. The dip at the quarry, as made out at the most north-westerly outcropping of the ledge, is toward the north-west, and would seem to be a local exception to the general dip. This is explicable on the supposition that here was the limit of this deposit, and the slope was naturally to the shore, the dip being in the opposite direction or south-east.

The Conglomerate overlying the coal would appear to be the result of the washing in of the pebbles derived from the true and older Conglomerate.

A well marked *glaciated* surface is shown at the Mills' quarry. The striæ run south-east and north-west, the general dip of the glaciated surface being nearly ten degrees to the north-west. There is quite an extent of rock exposed along the road, affording an unusually good opportunity to see a continuous, well-marked glacier-planed surface. There are a few short, single striæ which strike fifteen degrees more easterly, and were perhaps made by icebergs succeeding the glaciers which made the greater portion of the linings. The last-mentioned set are generally far apart, and usually but three to four feet long, while the glacial markings proper are continuous throughout the exposure, and are as true as "chalk lines."

Picturesque scenery characterizes this township, though several others vie with it in this respect. The western part of the township falls away into a well-marked valley—that of the River Styx—which is in all probability the western limit of the coal fields. Some of the highest land in the State is in this township. A Locke's level used on the range, east of the center, at a high point, one mile north-east of the town, showed no land along the horizon as high, though the ranges of Wayne and Summit counties were in sight. Basing my estimate on railroad levels in the township, we put this elevation at eight hundred feet above Lake Erie. Mr. Sargent made a survey, for the Lake Shore and Tuscarawas Valley Railroad, through Wadsworth, and if the road had been built on his line, the summit level would have been one mile south-east of Wadsworth village, and five hundred and eighty-five feet above Lake Erie. The south part of Wadsworth village is seventy-five feet higher than Medina Square.

Whetstones have been manufactured quite extensively from rock taken from the bed of Mineral Run, on land owned by Mr. D. W. Hard, located on the north border of the township, and one hundred and sixty rods east of Guilford line. Two hundred and twenty-five thousand pounds of whetstones have been manufactured by Messrs. Reynolds, Sisler & Co., of Manchester, Summit county. This stone is called an "oil and water stone." It was worked into all shapes required by the market, some of it meeting the demands of surgeons and dentists. The three layers of stone found at the locality vary in fineness and softness, the lower ones being coarser and harder than the upper one, which was mostly worked up into hones, etc. The average thickness of the three layers is four inches. *Spirophyton Caudagalli*, fucoids, and *Producti* were seen in this quarry.

The geological section in the ravine cut by Mineral Run is approximately as follows: Below the soil are, first, a buff-colored shale, some twenty-five feet in thickness; below this a darker shale, ten feet thick—both these shales are valuable for pigment; below these shales a layer of iron-stone, one foot thick; then follow alternate layers of soft shale and the whetstone rock, thickness not easily determined. Passing down the ravine a few rods, a shaly sandstone is exposed, which gradually runs into a coarse-grained rock, containing very small pebbles. This ravine gives a section of eighty or ninety feet.

An analysis of the iron-stone found in Mineral Run was made by the State Chemist, Professor Wormley, at the request of Col. A. Munson, member of the Legislature from Medina county. It had been supposed to be quite rich in iron, but the analysis showed that it contained only two and one-half per cent. of metallic iron.

The *Eureka Paint Mills* make two tons of paint per day. The principal materials used are the shale from Mineral Run, Lake Superior iron ore, and a mineral from Brandon, Vermont.

YORK TOWNSHIP.

The soil of this township is for the most part clay, the surface of the land being level. There is an exposure of shaly sandstone in the extreme north-east corner of the township. Beds of this, ten feet thick, show for quite a distance along Rocky River, but at exposures lower down the stream, in Liverpool township, it is seen to run into a mixture of sandstone and shale, the latter differing noticeably from the beds still lower in the series, because of the absence or scarcity of concretions—weathered specimens of the sandstone split into thin sheets. The concretionary beds are seen in the bluffs a quarter of a mile north of the Abbeville bridge, and the shale is there harder than further down the river, where fossils were found in abundance The upper layers of these concretionary beds are dark gray, and they are pressed in upon themselves, many layers showing the shale broken into small pieces and massed on edge. The concretions are out of their usual horizontal positions Some layers, ten inches thick, disappear altogether in a distance of less than six feet.

CHAPTER LXX.

REPORT ON THE GEOLOGY OF WARREN COUNTY.

BY EDWARD ORTON, ASSISTANT GEOLOGIST.

Warren county is bounded on the north by Montgomery and Greene, on the east by Clermont, on the south by Clermont and Hamilton, and on the west by Butler. The Little Miami River, which crosses it diagonally in a south-westerly direction, divides it into two nearly equal divisions. Its western side slopes towards the valley of the Great Miami, and reaches this valley in its north-western corner.

From these statements, it can be readily understood that the surface of the county consists of two main divisions of the table-land that constitutes south-western Ohio—one of them lying between the two rivers, and forming a water-shed—the other making the beginning of the flat-lying tract that stretches away to the east and south, which has been noticed in previous reports.

The northern range of townships is traversed by the deep and comparatively narrow gorge of Clear Creek, the east and west direction of which is unusual in the tributaries of the Miami.

Turtle Creek and Union townships furnish striking examples of the waste that the country has suffered from erosion of an earlier day. A broad channel, at present occupied by Muddy Creek and Dick's Creek, connects the valleys of the two Miamis through this district. The old branch of the Miami Valley Canal, from Lebanon to Middletown, followed this ancient channel, connecting the two points named above, without intermediate lockage. It is certain that by means of this channel the two rivers were formerly united, at least there are no rocky barriers to divide them, either the Little Miami holding the westerly direction, which it now has, from Morrow to Deerfield, or, as is more probable, the valley of the Great Miami being opened out by glacial erosion to the south-east, the direction, indeed, in which glacial action has been most conspicuously exerted in south-western Ohio.

The main valley of Turtle Creek furnishes another example of erosion which the present conditions do not fully account for. The stream no where runs upon a rocky bed, and to the north-eastward it furnishes an almost, if not quite, uninterrupted channel from the valley of the Little

Miami, at Cæsar's Creek, to the same valley, north of Deerfield, shortening the distance between these two points by more than eight miles. This is one of the lines by which Lebanon has sought railroad connections.

On the east side of the Little Miami, the valleys of Cæsar's Creek and Todd's Fork are the only ones of considerable importance. Both streams take their rise in the flat track of Greene and Clinton counties, from which they descend to the Miami in a south-westerly course.

The dividing ridge between the two Miamis, already referred to, holds the highest land of the county, the altitude increasing towards the northern boundary, where it reaches its maximum of about 625 feet above low-water, at Cincinnati. The highest land *measured* in the county is the summit of William Morris's hill, on the boundary-line between Wayne and Clear Creek townships, one mile east of Utica. This has an elevation above low-water at Cincinnati of 595 feet. The ridge in these same townships, occupied by the Harlan, Tibbals, Stokes, and other farms, has, certainly, somewhat greater elevation.

The lowest point of the county is found at its southern boundary, on the Little Miami River. The railroad track, at this point, has an elevation of only 150 feet above low-water at Cincinnati. The bed of the stream at the point named is not more than 125 feet above the same base. The vertical section of the county, then, embraces 500 feet.

Geological Scale.—The geological scale of the county is identical in its elements with that of Montgomery county, described in the first report of the Survey, and with that of Clarke county, figured in the previous volume. The 500 feet already given as making the vertical scale of the county, are divided among the three formations there named in the following order, viz:

	FEET.
Niagara limestone	50
Clinton limestone	16
Cincinnati group	434

Each of these formations will be characterized as it is exhibited in the county.

1. *The Cincinnati Group.*—The main divisions, previously established in this group, will need to be recalled. This system of rocks, which has an aggregate thickness of nearly eight hundred feet, is divided into three divisions, viz:

	FEET.
The Lebanon beds	263
The Cincinnati beds, proper	450
The Pt. Pleasant beds	50

Warren county shows better than any other county in Ohio the upper-

Geological Survey of Ohio.

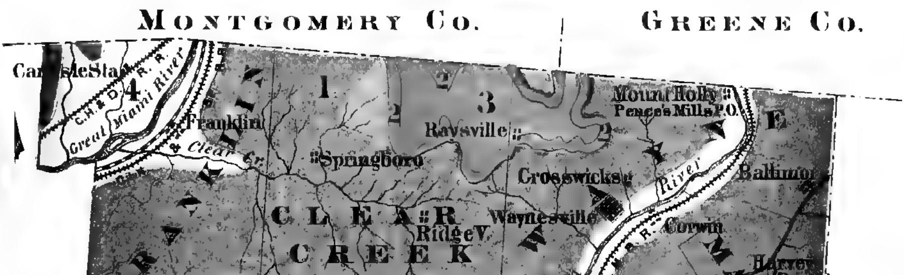
MAP OF
WARREN COUNTY,

BY

Edward Orton.

Explanation of Colors.

4	*Alluvial Lands*	2	*Clinton Group*
3	*Niagara Group*	1	*Cincinnati Group*



most division, viz., the Lebanon beds. Besides this, it contains from 125 to 150 feet of the upper beds of the middle division, or the Cincinnati beds, proper. These strata have dipped from a height of 450 feet at Cincinnati, to that of 275 feet at Lebanon, an average fall of about six feet to the mile to the northward, a result which is, in the main, harmonious with the general facts already established in regard to the dip of the Blue Limestone beds.

The Cincinnati rocks furnish the floor of Warren county, as of Southern Ohio generally. Indeed, they constitute almost the entire surface of the county, the Cliff Limestone not occupying more than ten square miles of its area. The accompanying map indicates the outliers of the Cliff Limestone and also the boundaries of the main valleys of the county.

No detailed description of the strata of the Blue Limestone of Warren county is necessary. All the typical peculiarities of this division of rocks are shown here. As a consequence, the county is abundantly supplied with an excellent quality of building-stone, which can also be burned into lime fit for coarse work and for agricultural purposes. Unexampled displays of the strata, especially of the upper division, are furnished by the many tributaries of the Little Miami, so that every foot of the vertical ascent can be studied in hundreds of exposures. As a consequence, the fossils of the system are here displayed in their greatest perfection. They occur in such numbers and in such striking and well-preserved forms, that they can not fail to attract the notice of even careless observers. It is hardly necessary to name particular localities in this connection, when every branch, if followed back from the river to its sources, reveals these beautiful forms in wonderful profusion. A section exposed on the old Lebanon and Wilmington road, just after it crosses the Little Miami River, in passing eastward, deserves mention, however, because of its unusual extent. It shows in a very steep ascent, about two hundred feet, mainly of the Lebanon beds, beginning with that stratum of *Orthis biforata*, which is taken as the summit of the Cincinnati section proper. This locality is one of the best known for the occurrence of the interesting form *Orthis retrorsa*, Salter, which comes in at forty to fifty feet above the *Orthis biforata* bed. It has no monopoly of this fossil, however, as the shell occurs in every section between Morrow and Cæsar's Creek that exposes its particular stratum. This locality is of special interest, also, because it yielded the typical specimen of a new crinoid—the *Heterocrinus juvenis* of Hall.

A very interesting section is furnished by Longstreth's Branch, opposite Freeport, which deserves special notice, also, on account of having given several new fossils to science, among them two crinoids—*Glypto-*

crinus O. Nealli, Hall, and *Poteriocrinus caducius*, Hall, both of which, as well as the form named above, were discovered J. Kelly O'Neall, Esq., of Lebanon.

The most valuable single section, however, remains to be named in a branch that comes directly down from Morris's Hill, and which enters he Little Miami opposite the mouth of Cæsar's Creek. Its value lies in he fact that, starting at the river from the summit of the Cincinnati section, it completes the series to the Clinton Limestone (Upper Silurian) in a short course, almost every foot of which is laid open for examination. Attention has been already called to this section in the general discussion of the Cincinnati Group, and use has been made of it in determining the thickness of the Blue Limestone series.

The vicinity of Waynesville, though giving a less extended section, has been found wonderfully prolific in fossils. The smaller trilobite, especially, *Calymene senaria*, has been found here in greater numbers than anywhere else. The collection of Israel Harris, Esq., of Waynesville, is, doubtless, the finest ever made in this country in this particular fossil. It includes not less than one thousand specimens. In this neighborhood, also, the rare fossil *Trochoceras? Baeri*, Meek, has been found. A single specimen was obtained from a piece of flagging that had long been laid in one of the sidewalks of the main street of the village. The only other points in the State where it is now known to occur are Camden, Preble county, and Clarksville, Clinton county. The specimen upon which the species was established came from Richmond, Ind.

On the western side of the county some of the tributaries of Clear Creek furnish fine ground for gathering fossils, exposing the same portion of the series already referred to.

Morris's Hill, already named as the highest elevation measured within the county limits, contains a finer show of two corals that mark the junction of the Lower and Upper Silurian than is elsewhere found. These corals are a species of *Tetradium* (*T. fibratum?* Safford) and a *Stromatopora*. Both occur in massive forms and in great abundance.

CLINTON LIMESTONE.

The Clinton Limestone, the next formation in ascending order, occurs in all of the outliers of the Cliff Limestone that are found in the county, and to which attention has already been called. All of the characteristic peculiarities of this formation are here shown with great distinctness. Its lower beds are of a sandy texture, and give to it the local name of *sandstone*. It will, however, be borne in mind that no silica, or, at least, no notable portion of silica, enters into its composition. It is a lime sand. The courses overlying these beds are enabled by their chemical composition, as it appears, to resist the action of fire to a good degree, and are accordingly known as *fire stone.* The general composition of the group can be seen from the appended analysis:

Carbonate of lime	85.21
Carbonate of magnesia	13.56
Alumina and sesquioxide of iron	0.80
Silicious matter	0.35
	99.92

This portion of the series serves a very useful purpose in this respect. Chimney jambs manufactured from it have been kept in constant use for fifty years without being defaced.

The fossils of this series are also very interesting. Mention will here be made of only one—a unique specimen obtained from the Burnett farm, near Waynesville, and now in possession of Israel Harris, Esq., of this place. The fossil is probably a fucoid or sea-weed, but it simulates in its mode of growth, especially in its branches, land-plants, none of which have yet been found as low in the rocks. It has been described in the transactions of the Lyceum of Natural History of New York by Dr. Newberry as *Fucoides Harrisi.*

The thickness of the Clinton limestone in the county does not exceed twenty feet, and falls below this in an included section measured on the farm of Dr. William Stokes.

All of the characteristics of the line of junction of Lower and Upper Silurian, described in the report on Montgomery county, are to be observed in the exposures of this line in Warren county. A small outlier of Clinton limestone that occurs on the east side of the Miami, near Freeport, deserves mention in this report, though place could, perhaps, more appropriately be found for it under the head of the glacial agencies shown in the county. The outlier has been known from early days in the neighborhood as the *Betty Heidy* quarry. It embraces about three-fourths of an acre, and is about sixteen feet in thickness. The peculiarity of its history is that it has been transported to its present position bodily from some adjacent locality. It is marked upon the map as outlier *C.* It overlies drift materials, such as glacial clays and gravel, and is one hundred and twenty-five feet below the elevation required for the formation at this point. There is no evidence whatever of any dislocation of the strata generally at this point, and we are compelled to regard it as a gigantic bowlder, transported from the opposite side of the river by the great glacier which occupied Southern Ohio in the earlier stages of the Drift period. According to the direction shown generally by the glacial striæ in this district, the nearest point from which it could have been derived is the high ground between Morris's Hill and Genn Town.

Spring Hill, or Wilkerson's Hill—the outlier marked *D* on the map—lying upon the eastern line of the county, is worthy of mention as the most southerly of the Clinton limestone outliers in south-western Ohio. It is traversed by the Lebanon and Wilmington road, and may be recommended as giving the clearest and most interesting exhibition of the line of junction of Lower and Upper Silurian formations shown in the county, and indeed in this respect it is not surpassed in the State. The Clinton beds here yield in their outcrops very beautiful fossils, especially of the corals that belong to them.

THE NIAGARA LIMESTONE.

The main outlier, marked *A* upon the map, adds to the scale of the county the Niagara formation. This great division, it will be remembered, generally begins with beds of shale, but in south-western Ohio a local exception is often marked in the occurrence at this point of a very heavy and even-bedded limestone, of great value for building stone, known quite extensively as *Dayton stone.*

This variety of the lower beds of the Niagara occurs in Warren county. It is shown most clearly in its connections on the land of Stephen Burnett, three miles north of Waynesville. In a valley near Mr. Burnett's house, the uppermost beds of the Cincinnati group are exposed, and the Clinton limestone overlying them, while in the fields a few rods beyond a valuable ledge of glacial planed Dayton stone is found. It has been quite extensively quarried here. There are several other quarries of the same stone in this outlier, the most valuable of which are located along its southern extension. The heaviest section measured is found on the farm of Dr. William Stokes. The Niagara shales here overlie the Clinton limestone, and the higher courses, or the Springfield beds, furnish excellent quarry stone. This section has a thickness of at least fifty feet, a fact which agrees with one already stated, viz., that the highest land of Warren county is to be looked for in this very locality.

These three formations—the Cincinnati group, the Clinton and Niagara formations—complete the geological scale of the county, so far as its bedded rocks are concerned.

DRIFT.

The drift beds of the county have no feature to distinguish them in any way from those of the adjacent counties already discribed. The whole surface is overlain with deposits of this period. The south-eastern townships are covered with the white clays that have been described in previous reports. These deposits have an average thickness of ten to fifteen feet, and cover at a depth of six to eight feet the ochreous deposits of these flat tracts. Below the ochre the blue glacial clays, commonly known as hard-pan, are found. The more particular report on the corresponding region of Clermont county will answer, without change, for this district.

In the remaining uplands of the county the Drift deposits are divided into the three general divisions:

1. Blue, glacial clays, holding scratched pebbles, and weathering into gray clays.

2. Yellow clays, passing into white and black clay, according to location.

3. Sand and clean, water-worn gravel, generally interstratified with the yellow clays.

The first division appears only in the beds of the smaller streams, and on the breaks of the hills. It is very generally the water-bearer of the regions that contain it, a supply being found either on its surface or at some sand-seam, but a little way below the surface. There seems no reason to doubt that it is the product of the melting glacial sheet, all of its characteristics being easily explicable on this hypothesis.

The second division, or the yellow clays, consist of materials that were arranged and deposited in water. The elements composing these, as well as the sand and gravel, are doubtless the weathered glacial clays, a submergence of the continent being required to account for their existence in all the areas which they occupy.

The *forest soil* holds its regular place in Warren county, the ochre-bed already referred to being one of its equivalents. On the north and west sides of the Miami, especially, buried wood is of very common occurrence. Some of this wood is no doubt pre-glacial in its growth, it being a part of the vegetation that covered the land before it was occupied by the great ice-sheet. This portion is found imbeded in the blue clays. A large part, however, lies upon the surface of the blue clays, and certainly grew where it now occurs.

Sand and gravel are as likely to be met with on the high lands of the county as elsewhere. In the northern townships, especially, bank-gravel is very abundant and of excellent quality. It is far more serviceable for road-making than creek-gravel, on account of the greater readiness with which it can be hardened or cemented into a road-bed.

The drift deposits on the northern sides of valleys and slopes have long been known to be more productive than those on southern slopes. The greater fertility of northern slopes is not confined to the drift-deposits of Warren county, but is shown equally well in distant sections of the State. The hills of sandstone and shale that border the Scioto valley, for instance, have very different forest-growths on their opposite slopes, that of the northern aspect being by far the most valuable. The wear and waste of slopes that face the sun is certainly much greater than northern slopes would experience, and the supply of moisture is much more rapidly withdrawn by evaporation.

In speaking of the upland drift-beds of Warren county, mention can appropriately be made of the wonderful strength and fertility of the soil along the ridge between the rivers. The belt of country traversed by the Dayton and Lebanon pike can scarcely be surpassed in general advantages by any part of Ohio. Much of it equals in productiveness the best bottom lands, and certainly excels them in durability, while in water-supply, in beauty of scenery, and in healthful conditions generally, it has a decided advantage. The appreciation of these excellencies can be seen in the fact that well improved farms in this region never change hands at less than one hundred dollars per acre, while, in some instances, the price runs up to double this amount. Comparatively few of the farming lands of the State yield clear profit to the owner when all needful elements are taken into the account, such as interest on the value of the land, taxes, and the expenses of producing the crop, but among these tracts will certainly be found the uplands of Warren county. They are being depleted in value, however, as rapidly as possible, under the prevailing system of agriculture. The raising of tobacco is coming extensively into favor, and no crop makes a more fatal drain upon the soil, as all intelligent agriculturists are aware.

Reference has already been made to the water-supply of some districts of the county. It may be said, in general terms, that the water supply is derived from the drift. The outliers of cliff-limestone furnish along their outcrops a fine series of springs, as they always must, from the collocation of their geological elements. Some districts, scattered here and there through the county, are obliged to depend upon the Blue Limestone, the yellow clays overlying, at little depth, the rocky strata. Such a supply is always poor, alike defective in quantity and objectionable in quality. Rain water, properly secured in cisterns, is the only adequate and profitable supply in all these districts. The sooner this mode of supply is brought into requisition, the better for man and beast. In the region of the heavier drift-beds, however, a generous supply of water is accessible in wells and springs. The wells, in but few instances, are carried to inconvenient depths, fifteen to twenty-five feet being the general depth of the water-sheet.

The distribution of the water is, very often at least, if not generally, in horizontal sheets, which fact helps. perhaps, to account for the frequent success of "water-witches" in finding, by their arts, the "veins" of water. There are, without doubt, underground channels, by which the water moves in its established circuits, but it would seem that if they could be found it would be better to avoid them, and make our appeal to the reservoir instead for our supply.

Among the springs of the county, perhaps the strongest and most serviceable is one that rises in the land of Edward Heston, near Springboro, and which is turned to account in running the machinery of a flouring mill and woolen factory. Its origin is in heavy deposits of Drift.

Bowlders, of northern origin, are everywhere distributed through the county. There are several of unusual size, and one of them deserves especial notice. It is found three miles to the south-east of Lebanon, near the residence of John Stephenson, and gives a name to the school-house located near, which is known through the township as the "Rock School-house." The bowlder is composed of gneiss—in which rose-colored felspar is a large element—a composition shared by most of the largest erratics of the region. It weathers very rapidly, and must have had considerably greater dimensions at an earlier day. It now measures above ground seventeen feet in length, thirteen feet in breadth, and eight feet in height. Examination shows it to be sloping outwards under ground in all directions. It is fair to conclude that at least one-half of it lies buried. Its weight above ground will not fall below one hundred and forty tons.

Mention has already been made of the enormous block of Cliff Limestone found near Freeport, and which deserves to be counted among the bowlders of the county.

The eroded river valleys of the county constitute a district by themselves—whether occupied by rivers to-day. as in the case of the two Miami valleys, or whether marking the presence of greater streams in the earlier chapters of the history of the country. To this latter division belongs the broad tract stretching from Lebanon, westward, to the Great Miami. These lowlands of the county constitute agricultural tracts of very great value. An excellent example of them in their best estate, is to be seen in the Shaker farms around Union Village.

These lowlands are to be divided into at least two well-marked divisions—*the bottom lands proper*, and *the gravel terraces.*

The "first bottoms," or *bottom lands proper*, consist of the flood plains of the present rivers. They are composed of gravel—coarse below, large slabs of blue limestones being sometimes laid against one another, in almost regular courses, and finer materials upward, the surface consisting of clays, loams, or, very frequently, of a loess-like deposit, of which land and fresh-water shells make a notable element.

The following shells are among those that are found here, all of them inhabiting the valley to-day, though in very different proportions from those that are shown in these deposits:

Helix elevata, Say.	Helix solitaria.
" concava, Say.	" tridentata.
" alternata, Say.	Goniobasis depygis
" hirsuta, Say.	Planorbis trivolvis.
" monodon, Rackett.	Amnicola lapidaria, Say.
" thyroideus.	Succinea. sp. ?
" profunda, Say.	

The conditions under which these shells were accumulated were probably not very different from those that now prevail. The bottom lands of previous years were their places of growth and habitation. The occasional floods that cover these lands, buried under sandy sediments the thickly strewn shells. In some instances, not less than six feet of the higher deposits are largely composed of these shells. Since the clearing and occupation of the river valleys, these shells are far less numerous than before, and, consequently, the sediments of the later overflows are not mingled with shells, but are blackened by organic growths. The whole composes a soil of unusual fertility. At some points in the valleys, as at Middletown, the whole of the upper series of deposits is burned into a cream-colored brick, which, when subjected to a high degree of heat, makes a pavement as enduring as limestone.

The *gravel terraces* differ from the above-named deposits, in this important particular: their form and structure are not to be explained by the conditions that now prevail in the valleys. The materials that compose them were associated and deposited in water, but they are situated from twenty-five to fifty feet above the highest overflows of the present. They point unmistakably to the period of submergence that closed the Glacial Period of later geological history. As has been already stated, the more detailed description of these beds will be reserved until the geology of Butler county—the last of these four blue limestone counties—is treated.

It is well known that very interesting archæological remains abound in Southern Ohio. The extensive and elaborate earthworks of the

Scioto and Miami valleys are referred for their origin to a people whom, in default of positive knowledge, we call the mound-builders. Archæology, in some of its subdivisions, is loosely connected with geology, and an account of these remarkable memorials of an extinct race might properly enough find place in a geological report of the territory within which these monuments occur. They are so numerous and interesting in this region, however, as to deserve an amply illustrated volume rather than the passing notice which is all that could be here given to them. In the reports already published on the counties of the Third Geological District, a bare reference has been made to the more interesting and conspicuous of these works found within their respective areas. To this list must now be added Fort Ancient. The remarkable earthworks known by this name, are perhaps better known than any others in Southern Ohio. They are located in a populous district, they are easily accessible, being within a stone's throw of the station on the Little Miami Railroad, known by the same name, and they have been less obscured by cultivation and occupancy than most works of this class.

Prof. John Locke published, more than thirty years ago, a survey plat of the entire works, accompanied with a brief description, and since that time, many accounts have been given to the public in archæological works, in scientific journals, and in newspapers. A thorough and systematic exploration is, however, still a desideratum. Recent examinations go to show that such explorations would be rewarded by discoveries, which would give to theories of origin and use a much better foundation than they have hitherto had.

CHAPTER LXXI.

REPORT ON THE GEOLOGY OF BUTLER COUNTY.

BY EDWARD ORTON.

BOUNDARIES AND TOPOGRAPHY.

Butler county is bounded on the north by Preble and Montgomery counties, on the east by Warren, and on the south by Hamilton county. It extends to the Indiana line upon the west.

It is divided into two unequal divisions by the Great Miami River, the division lying west of the river being about twice as large as that on the eastern side. The river now pursues a general south-westerly direction through the county, but an earlier-formed channel diverges from the present valley opposite Hamilton and bears to the south-east. Within the limits of Hamilton county this older channel is known as Mill Creek valley, which divides at Cumminsville into two branches, one of which enters the Ohio on the western boundary of Cincinnati, and the other enters the little Miami valley at Red Bank station, on the Little Miami Railroad.

Part of another old channel is also found in the north-eastern corner of the county, adjacent to Middletown, which is connected with the Little Miami valley by way of Lebanon. Both of these ancient valleys have been turned to account within the last forty years for canal beds, the Miami Valley Canal from Cincinnati to Hamilton occupying the first named channel, the second furnishing the route for the unsuccessful branch from Lebanon to Middletown. Very little lockage was found necessary in either.

The drainage of the eastern division of the county is mostly effected by streams of inconsiderable size. The tributaries of the Miami that enter upon the western side deliver the surface water of more than seven hundred square miles of territory. These streams have a remarkable agreement in direction, all of them flowing to the south-east. It is altogether probable that their channels owe much to glacial erosion, as this same south-easterly direction has been shown to be that in which the glaciers advanced in this portion of the State.

Some of these streams, as, for example, Seven Mile Creek and its tributaries, run largely on rocky beds, and thus show themselves to be of comparatively recent date. Others again, as Twin Creek and Indian Creek, agree with the deeper valleys of the county in having the rock altogether concealed by heavy alluvial deposits, and thus lay claim to a longer history.

The highest land of the county is not more than 650 feet above the Ohio River at Cincinnati. The highest land *measured* is two miles west of Jacksonburgh, Wayne township, on the farm of Col. Phares. Its elevation by barometer is 642 feet above the base above named. Locke gives the elevation of a point of Cliff Limestone that barely enters the county on the north line of Milford township as 601 feet. Two miles due west of Oxford, on the Fairfield turnpike, an elevation, determined by the level, occurs of 610 feet above the Ohio River at Cincinnati. The elevations of a few of the prominent points in the county are appended, as obtained from canal and railroad and turnpike surveys. For several of the elevations here recorded, I am under obligations to Prof. R. W. McFarland, of the Ohio Agricultural and Mechanical College:

	FEET.
Hamilton Canal basin above low-water at Cincinnati	169
Low-water of the Miami at Hamilton	131
Middletown, canal level	211
Oxford, grade of railroad at depot	480
Oxford, highest ground within corporation	532
Somerville	334
Jacksonburgh	543
Phares's farm, two miles west of Jacksonburgh	642
Snively's Hill, one mile south of Jacksonburgh	563
Turnpike, two miles west of Oxford	610
North-east corner of Oxford township, on Darrtown pike (formerly Riley's tavern) by Locke	601

The lowest ground in the county is to be found on its southern boundary, in the Miami valley. Its approximate elevation above the base already named is fifty feet.

The principal areas of the alluvial lands and uplands of the county, as they are distinguished from each other, are represented in the accompanying map. The former division embraces the valleys both ancient and modern—the eroded regions from which the rocks have been carried away to a depth at least below existing drainage courses. These areas could be approximately described as the portions of the county that have an elevation of not more than 250 feet above the Ohio River.

On the other hand, the uplands embrace the lands above this level. A large proportion of them, however, lie at an elevation between 400 and 600 feet above the Ohio. This division of the surface of the county is much less definite on the east side of the river than it is on the west, for the reason that the Drift deposits are heavier in the first named district. In other words, the lines of the valleys are here harder to be traced. There are areas of unmistakable uplands, but they are connected with the valleys by slopes of considerable extent, which completely obscure the true outlines of the rocky floor.

The uplands proper are remnants of the Blue Limestone plateau that once occupied all of south-western Ohio, but so much of which has already been removed by aqueous and glacial denudation. They are almost universally covered with shallow deposits of drift, but over very large areas the character of the underlying rock shows through, giving its peculiar features to the topography, to the agricultural capacity, and to the water-supply of the districts occupied. These upland drift deposits are in considerable part derived from the waste of blue limestone land to the northward, so that a closer bond of connection exists between the soil and the underlying rock than is usually found in drift-covered regions. A more detailed description of the drift deposits of the county can appropriately find place here.

DRIFT BEDS.

The divisions of the drift that have been recognized in those portions of the Third Geological District already reported upon, are found here also. The lowest of these deposits, or that which rests directly upon the bedded rocks, is the *bowlder clay.*

1. This formation is shown with great distinctness and in very numerous exposures in Butler county. Almost every stream in some portion of its course discloses it. Its general composition has been fully enough described in previous reports. A particular feature of the bowlder clay in Butler county is that of ancient vegetable growths, branches, trunks and roots of trees in large quantities. Examples can be seen in following almost any stream to its source, but one or two points may be named which are specially noteworthy in this respect. Collins' Run, near Oxford, a small tributary of Four Mile Creek, shows in its banks very numerous exposures of these pre-glacial and inter-glacial forest growths.

The vegetation is imbedded in the clay very often, and part of it shows that it has been subjected to rough, mechanical agencies. The frequent presence of leaves and roots in or upon the deposit serves to show, however, that the source of the vegetation was not very far removed. The north bank of Elk Creek, opposite the mill at Miltonville, also gives a fine exposure of the clay. At this point a peculiar modification of the bowlder clay is found that deserves particular mention. It is a clay distinctly green in color, and, as shown by a single analysis of a specimen obtained at this point, is very rich in potash and soda. The analysis made by Prof. Wormley is here subjoined:

Water combined	4.50
Silicic acid	55.10
Iron sesquioxide	6.79
Alumina	19.41
Carbonate of lime	4.55
Silicate of lime	3.55
Magnesia	0.82
Potash and soda	4.95
	99.67

It will be seen that the elements above named, viz., potash and soda, are abundant enough here to make the clay a fertilizer of considerable value. Vivianite, or phosphate of iron, is of frequent, perhaps constant, occurrence in it. Vegetable matter is also always present. This green clay has been more frequently met with in Warren and Butler counties than elsewhere.

The vegetable matter that is intermingled with the bowlder clay is to be distinguished from that which is borne upon its surface. The presence of a buried soil of inter-glacial age has been repeatedly mentioned in the reports on this Geological District. Examples of this ancient soil are not wanting in Butler county. An interesting case of this sort is recorded by David Christy, Fsq., in his Letters on Geology, published in 1848. In the last letter of the series, page 5, he says:

"Beneath our *Diluvium* are occasional beds of 'hard-pan or very tough blue clay, with imbedded pebbles.' I had my attention directed to this new and interesting feature of our Geology last summer by Robert Beckett, Esq., eight miles east of Oxford. He called upon me to examine the stump of a tree standing erect in this deposit at a point where a small stream is encroaching upon a bluff. The roots penetrated the *hard-pan* in all directions. Twenty feet of *Diluvium* overlies it. We dug out the stump and a part of the roots. Some years since, Mr. B., in digging a well twenty or thirty rods distant from this point, at a depth of ten feet in the *Diluvium*, struck upon another small tree, standing erect, with the trunk and some of the branches almost entire. This tree continued down to a depth of thirty feet, where he found its roots, in the natural position of growth, penetrating the hard-pan."

The remarkable example noted in the second edition of the Report of the Ohio Geological Survey for 1869, in the chapter on Montgomery county, will be recalled. (See also Silliman's Journal for July, 1870.) A peat bed, fourteen feet in thickness, was found buried under one hundred feet of drift deposits, itself overlying gravel and clay.

2. The yellow, gravelly clay that makes the main element of the Drift in all of this region is also very abundant in Butler county. It is not formed from the weathering of the upper portions of the bowlder clay *in situ*. The action of the atmosphere upon an exposed bed of blue clay changes its color and also its texture, it is true, but much more than this is required to account for the surface clays of Southern Ohio. They have been worn away from their old places of deposit by water, and have been re-deposited. The bowlder clay is always unstratified; the yellow clays are generally distinctly stratified. The uplands of the county, especially of its northern and central portions, are almost universally covered with deposits of this kind. There are no elevations in the county that escape the deposits of the modified drift.

The sand and gravel that make a third element in the Drift of this region do not deserve a place by themselves. They form a phase only of the second order of deposits, and must be referred not only to the same general line of agencies, but also approximately to the same time. As has just been stated, the highest elevations in the county give clear proof of having been involved in the submergence, by which alone these facts can be explained. Bowlders are found at all altitudes, and some of the largest size are found at the greatest elevation. One lying on the highest land of the west side of Ross township measured one hundred and thirty cubic feet above ground.

In concluding this description of the Drift formations of the county, the opportunity may be taken to say that the history involved is a long and complicated one. There can be no doubt that the general order of events has been correctly determined in the best statements that have thus far been made in regard to North American Drift; but the details of the history are yet to be worked out. Oscillations of temperature and level will doubtless be found to have taken part in the history, and the time occupied in these changes will stretch into long cycles.

In a description of the Drift of the county, the deposits of the Great Miami valley require a place by themselves. The map accompanying this report shows two groups of areas in the county, as has been already stated, viz., the *uplands* and the *alluvial lands*. This latter division demands a brief description at this point. The valley in which the Great Miami now flows, and the two south-eastern branches of this valley that were occupied by the river in some earlier period of its history, together contain not less than seventy-five square miles. This area constitutes one of the finest agricultural districts in the State. Land embracing a greater number of advantages, in fact, is scarcely to be found anywhere. The following points are to be observed:

1 The bedded rock has been cut out to a greater depth than existing agencies can account for throughout most of this area. The rocky floor is very seldom laid bare by the river, and it is as seldom struck in any excavations or borings that are made in the valley.

2. The valley is filled with immense accumulations of gravel and bowlders. These gravel-beds undoubtedly overlie deposits of bowlder clay in many parts of the valley. Indeed these deposits are occasionally, though rarely, struck in wells and similar excavations; and sometimes they even approach very near the surface. The gravel is of various sorts and sizes, and indicates various degrees of strength in the currents that have transported it. Large quantities of sand are distributed through it. In composition, it is principally limestone, thus agreeing with the pebbles and bowlders that fill the Drift clays of the country, but, unlike the true Drift pebbles, it has lost the marks of the previous stage in its history, viz., the shaping which it received under the glacial sheet. Its pebbles no longer show the polish and striation due to this stage, but, on the other hand, bear unmistakable marks of having been fashioned in running water.

3. The gravel beds are in all cases covered with considerable deposits of loam and sand, which form the present surfaces of the valley. These deposits are arranged in three natural and well marked divisions, viz., the *first bottoms*, the *second bottoms*, and the *gravel terraces*, sometimes called the *third bottoms*. Of this series, contrary to the general order in geology, the lowest member, viz., the first bottoms, is the newest, and the highest member viz., the gravel terraces, is the oldest. In other words, the first and second bottoms do not extend beneath the gravel terraces, and consequently do not result from the denudation of portions of the valley. The gravel terraces are at least one hundred feet above low water of the river now. They are generally left in small and isolated fragments on the margins of the valley, but sometimes they are found to hold considerable areas. In the vicinity of the village of Trenton they can be seen

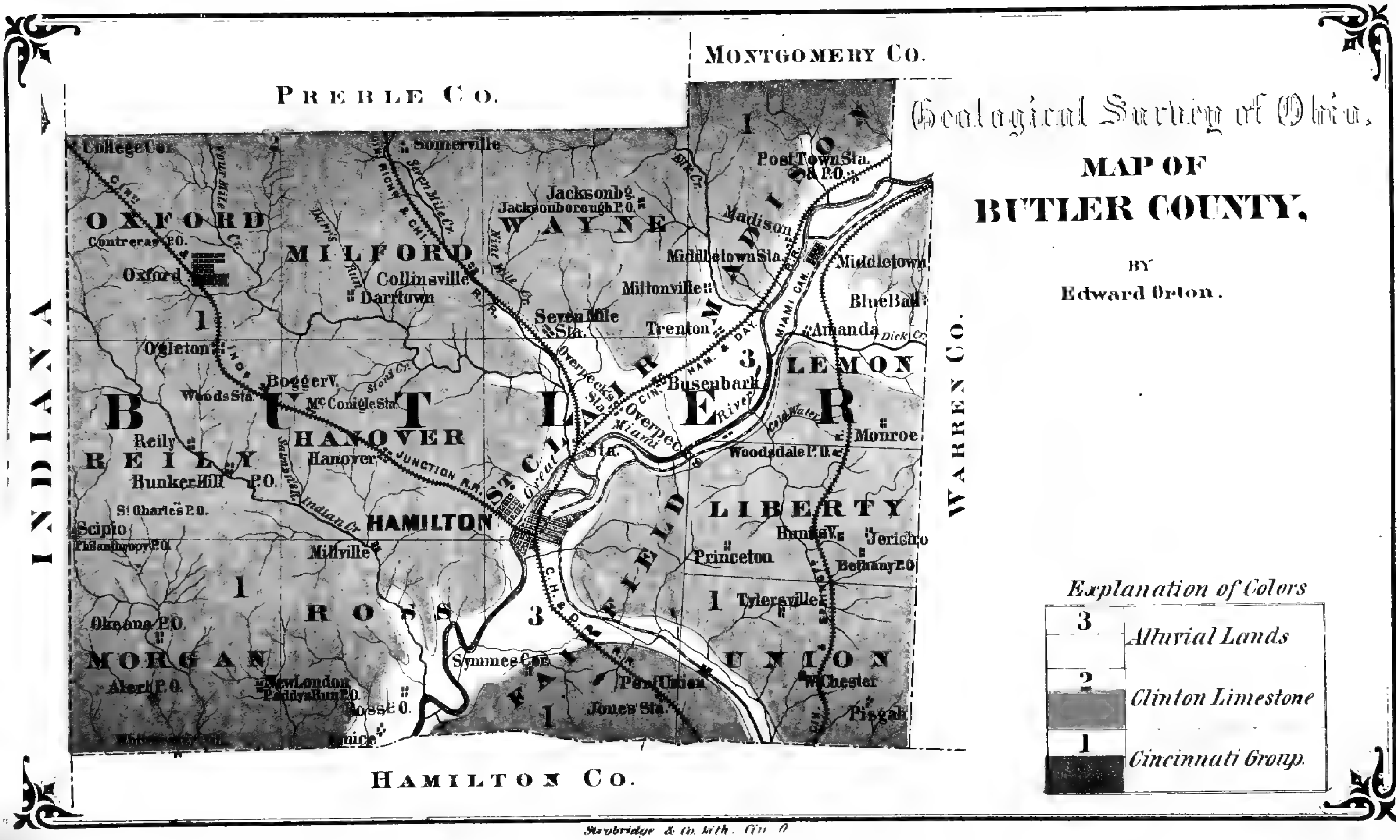
and studied to the best advantage, as also in the vicinity of Post Town, on the Banker and Lucas farms.

To follow their history we must go back to the "Champlain Epoch" of geology—to the period of submergence that followed the glacial epoch. The level of this portion of the country was at that time four hundred feet lower than at present. Stratified deposits, on a large scale, of sand, gravel, and clay are found four hundred feet above the present drainage of the country. At the period of greatest submergence there could have been little or no current through the valley, but during the slow-advancing movement of depression the valley was filled with immense accumulations of re-arranged Drift. We may suppose, then, that the gravel terraces are a part of the old floor of the valley, and that they once extended with a degree of uniformity throughout the wide basins in which we find the remnants of them to-day. As the continent emerged once more and slowly regained its present elevation, the river channels would be cut deeper and deeper into these deposits, the former surfaces of which were left one hundred feet or more above the present river beds.

Little needs to be said in regard to their composition, as the name by which these deposits are known, viz., *the gravel terraces*, indicates the main element in their making up. Gravel, sand, and loam, variously intermingled, constitute the whole series. The sorting and arranging of materials could only have been accomplished in long-extended periods of time. There are no indications of tumultuous deposition in any portion of the series. The soils formed from the weathering and decomposition of the surfaces of these beds are kind and productive.

(*b*.) The second bottoms, like the terraces, must be referred to causes and conditions not now existing in the valley. They lie above the reach of the highest floods, being thirty feet or more above low-water in the main valley. They occupy broad areas, and constitute, by way of excellence, the farming lands of the valley. They consist of loams from two to six feet in thickness, overlying gravel which perhaps belongs to section *a*. They seem to owe their origin to an arrest of the upward movement of the continent, which continued for a considerable period.

(*c*.) The first bottoms are the most recent of the series. They are, indeed, very closely connected with the present state of things. They occupy the deeper parts of the valley, and are covered by all of the higher floods. To these floods they owe their origin in part, being made up of the sediments deposited from high water. An arenaceous deposit filled with land-shells is a common and characteristic member of this formation. The shells must have mainly grown upon the regions where we now find them, and were buried by the deposits of annual floods.


Geological Survey of Ohio.
MAP OF
BUTLER COUNTY.
BY
Edward Orton.
Explanation of Colors
3 Alluvial Lands
2 Clinton Limestone
1 Cincinnati Group.
PREBLE CO.
MONTGOMERY CO.
WARREN CO.
HAMILTON CO.
INDIANA
BUTLER
OXFORD
MILFORD
WAYNE
MADISON
LEMON
LIBERTY
UNION
FAIRFIELD
ST. CLAIR
HANOVER
REILY
ROSS
MORGAN
HAMILTON
Oxford
Middletown
Trenton
Monroe
Princeton
Collinsville
Darrtown
Somerville
Seven Mile Sta.
Millville
Symmes Cor.
Jones Sta.
Pisgah
W. Chester
Jericho
Bethany P.O.
Tylersville
Busenbark
Amanda
Blue Ball
Madison
Post Town Sta. & P.O.
Milltonville
Middletown Sta.
Jacksonbg.
Jacksonborough P.O.
Ogleton
Woods Sta.
Boggery
Mc Conigle Sta.
Reily
Bunker Hill P.O.
St Charles P.O.
Scipio
Okeana P.O.
Aker P.O.
New London
Paddys Run P.O.
Woodsdale P.O.
Contreras P.O.
College Cor.
Hanover
Miami River
MIAMI CAN.
JUNCTION R.R.
C.H. & D.
Stowbridge & Co. lith. Cin. O.

The clearing of the valleys and their drainage basins has introduced many elements of change, and the formation of these bottom lands may almost be said to have been interrupted. This sandy bed, to which reference has been made, is akin in composition and character to the *löess* of European geologists. An excellent example of the formation may be seen in the river banks within the limits of the village of Middletown. It is burned here into a cream-colored brick that answers well for a paving brick, and which is quite extensively used for this service.

Its composition is shown in the following analysis of a specimen taken at the point above named. (Prof. Wormley.)

Water combined	5.20
Silicic acid	42.30
Sesquioxide of iron	3.48
Alumina	7.52
Carbonate of lime	23.21
Silicate of lime	5.09
Carbonate of magnesia	13.09
	99.89

As can readily be judged from such a composition, soils of great fertility are not formed from this deposit, but there can be no doubt that it would serve an excellent purpose as a top-dressing for uplands. It is, in reality, a shell marl, and would reward intelligent use very liberally. The thickness of this bed has not been found to exceed four feet in any exposures noted.

There is often associated with the above-named formation a sort of clay from two to four feet in thickness that agrees in physical characters very closely with the "joint clay" of the western valleys. Its composition is shown in the appended analysis. (Prof. Wormley.)

Water combined	4.20
Silicic acid	70.10
Sesquioxide of iron	5.30
Alumina	13.90
Silicate of lime	2.10
Magnesia, carbonate	1.44
Potash and soda	3.20
	100.24

This deposit can be also seen at the point named under the last head. It is, however, less widely distributed through the valley.

GEOLOGICAL SCALE, ETC.

The bedded rocks of Butler county belong, with the exception of the very limited area of one or two square miles, to the Lower Silurian, or Cincinnati Group of Ohio. The exception named above is found in the north-eastern corner of Oxford township, where a spur of the Cliff Limestone crosses the county line, and covers a section or two of the county. Dr. Locke called attention to this spur in the report of the former State Survey. Both the Clinton and Niagara formations are shown here, but the area is so small, and is known to so few residents of the county, comparatively, that it will be dismissed from further consideration at this time.

The general geology of the Cincinnati Group has been treated at length in Chapter XIII. of Vol. I. of the Final Report of the Ohio Geological Survey. This chapter may be taken as a part of the report on the geology of Butler county. To it the reader is referred for the general considerations upon the origin and history of this most interesting formation. The series, which has in the State an aggregate thickness of about eight hundred feet, is there divided into three divisions, which are named, respectively—

The Lebanon beds	300 ft. thick.
The Cincinnati division proper	425 "
The Point Pleasant beds	50 "

The Butler county scale begins at about two hundred feet above the base of the system, and extends to the summit of the series. It thus contains about six hundred feet of bedded rocks—or, in other words, comprises somewhat more than one-half of the Cincinnati division proper, and the whole of the Lebanon division.

There are few peculiarities of stratification or fossil-contents in the county that deserve special mention here; and, on the other hand, there are few points of interest in the formation at large that are not shown in Butler county. It is emphatically a Blue Limestone county, its bedded rocks belonging almost entirely to this series, and its drift being also largely referrible to it, while its topography, its soils, and its water-supply are all controlled in considerable part by this formation.

One of the best sections in the county can be found at and near Hamilton. In the quarries just west of the river, the section can be begun at a horizon about two hundred and seventy-five feet above low-water at Cincinnati, and it can be followed in frequent outcrops to the summit of Heitsmann's Hill, on the Millville pike, where many of the characteristic fossils of the Lebanon division are found.

The streams in the vicinity of Oxford, Seven Mile, and its tributaries, furnish very prolific although not very extended exposures. The horizon is quite definitely fixed by the presence of *Orthis retrorsa*, Salter—*Orthis Carleyi*, Hall. This shell is found on the banks of Seven Mile very near to the water's edge, directly east of the village of Oxford. As was shown in the chapter already quoted, the vertical range of this fossil is very limited while its horizontal range is wide, so that it serves an excellent purpose as a landmark in the system. Its altitude is a horizon about four hundred and seventy-five feet above low-water at Cincinnati.*

The Oxford sections are of interest from the fact that they yielded thirty years ago, many of the type fossils of the formation. The early geological work of David Christy, Esq., was done in this field, and through him collections of the fossils found here were distributed among eastern and foreign geologists. The name of Oxford is, accordingly, very widely known as one of the typical localities of the Blue Limestone or Cincinnati Group of Southern Ohio. The original cabinet of Mr. Christy is now in possession of Miami University, at Oxford. It contains a number of interesting fossils.

Wayne and Madison townships, and especially the latter, furnish unsurpassed exposures of the Lebanon Beds in the banks of the smaller streams that drain their highlands. Kemp's Run, near Middletown Station, furnishes excellent ground for the collector, as do also several branches that flow from Loy's Hill to Twin Creek, on the north line of the county.

SOILS AND WATER SUPPLY.

The agricultural capabilities of some portions of the county have already been touched upon incidentally. A few additional statements upon the general subjects of soil and water supply will be, however, appropriate here.

Butler county stands scarcely second in productive power to any equal area in the State. No qualification certainly would be required if the valley of the Great Miami and that portion of the county lying east of the river were alone to be taken into account. This region might put in an unquestioned claim to be styled the garden of Ohio. It is made up

* Note.—Mr. U. P. James reports that he has found this shell during the present summer, 1874, in Clermont county, associated with *Strophomena planumbona*, and other characteristic fossils of the Lebanon beds. This gives it a higher position, by at least one hundred, feet than it has been known to occupy before, and would seem at first sight to destroy the value of the fossil as a measure of elevation, but it does not necessarily bring about this result, for the first named fact remains as stated heretofore, viz., that at a horizon four hundred and seventy-five feet above low-water at Cincinnati, there is a widespread distribution of this fossil with the narrowest vertical range. When the fossil is met with, it can easily be determined by an examination of the nearer beds, whether it belongs to the universal sheet or whether it belongs to a sporadic bed like that noted by Mr. James.

of the broad and fertile intervales of the streams that now traverse the valleys or of the still more desirable areas that were the valleys of an earlier epoch, but which are now deserted by streams, and which are evenly filled with the beds of the later drift, together with uplands rising by gentle slopes to an altitude of four to five hundred feet above the river, and whose surfaces are scarcely less productive than the areas first named.

The soil of all this district consists, in great measure, of decomposed limestone-gravel, and exhibits every excellence of limestone land. A single area may be noted here as furnishing a unique line of facts in the native vegetation of the county. A chestnut grove is to be found in the south east corner of Union township, near Pisgah Church. It is well known that the chestnut confines itself generally to the slate and sandstone soils of the county. Indeed, the boundary between the slates and the limestones in south-western Ohio could be defined with satisfactory precision by noting the line where the chestnuts begin as one passes eastward. Isolated trees are known in the gravels and sands of limestone districts, it is true, but they are very rare. Dr. John A. Warder has called attention to one growing near Milford, in the Little Miami Valley, and another is known in Greene county, but in the area to which attention is now invited, a forest growth in which the chestnut is a large element, is found. The trees have attained a diameter of four feet in some instances and in others stumps, long dead, are seen with large trees growing from them. The tree fruits well here and reproduces itself abundantly. Chestnuts (the fruit) were sold to the amount of forty dollars from a single farm three years ago.

The soil does not betray any peculiarities upon a superficial view, but the wells in the vicinity all show a great deposit of yellow sand beneath the surface here. Many fruitless attempts to secure wells in this neighborhood are on record, the sand proving to be a quicksand, and caving in so rapidly as to frustrate the sinking of the shaft to water. It has been thought that the sand would prove to be a moulding sand, but no trials of it have been made. The bed of sand is anomalous, and it is interesting to note that the native forest growth which covers it is also exceptional. There are no peculiarities in the remaining drift soils of the county that deserve special mention.

The poorest of them, as those covering the uplands of the northern and and western townships, if handled with skill and subjected to a rational system of agriculture, would take high rank when compared with even the strongest lands of the Atlantic border. Measured against the fruitful valleys and slopes just mentioned, and tilled under a system which even these noble tracts can not much longer endure, they seem somewhat stubborn and sterile.

There are no native soils on the uplands of the county, but the beds of drift grow thinner as we pass to the southward, and occasionally they disappear for limited areas from the slopes of the hills. The soil that is there formed from the waste of the shales and limestones of the Cincinnati series is of unusual excellence. The famous blue-grass land of Kentucky, it will be remembered, is derived from this same system.

The fact that the boundary of the drift is being rapidly neared as we approach the southern line of the county explains certain points in the topography of the four south-western townships. They are much rougher and more broken than the remaining areas. This arises from the failure of the drift to cover the irregularities here as it has elsewhere done. There is certainly no reason to suppose that the contour of the rocky floor is more irregular in one district than in another. What Butler county owes to the drift can be well seen by comparing Liberty and Union townships of the south-eastern corner with Reilly and Morgan townships of the south-west.

The views furnished by the uplands, especially as we approach the Great Miami Valley from either side, are, many of them, very wide and attractive. Several can be named that are not to be surpassed in quiet, pastoral beauty by any thing within the limits of the State.

From Snively's Hill, near Jacksonburgh, a wide and beautiful expanse of country is shown, of the main valley on the east and south, and of the valley of Seven Mile Creek on the west.

A still more commanding outlook is furnished on the farm of Randolph Meeker, Esq., near Pisgah. It comprises nearly one-fourth part, and that the richest corner, of Butler county.

Such elements as these are not to be omitted in making out the catalogue of attractions that a country possesses for human occupation.

The water supply of Butler county can not be said to be good. The geological formation from which the county is built is universally and necessarily poor in this respect. The rain-fall can not penetrate the fine-grained clays of the Cincinnati series, and is consequently turned outwards in surface drainage. Wherever the rock is heavily covered with drift beds the supply is improved, both in quality and quantity; but in the thinly covered uplands reliance can not be safely placed on wells. There is no excuse, however, for a defective supply for either man or beast in a district which has so generous a rain-fall as Southern Ohio enjoys. It is only necessary to save the roof-water in properly-constructed and properly-guarded cisterns.

CHAPTER LXXII.

REPORT OF THE GEOLOGY OF PREBLE COUNTY.

BY EDWARD ORTON, ASSISTANT GEOLOGIST.

Preble county is bounded on the north by Darke, on the east by Montgomery, and on the south by Butler county. Its western boundary is the Indiana line.

The altitudes of a few points in the county are given. The first five are taken from Dr. Locke's report of the former Geological Survey of Ohio, and were furnished to him by Col. J. W. Erwin, of Hamilton. For the remainder, the survey is indebted to Phineas Pomeroy, Esq., of Winchester, Indiana. They were obtained by him in making a survey for a proposed railroad line along the valley of Twin Creek. All are counted above low-water of the Ohio at Cincinnati, and to be changed into altitudes above the sea, must be increased by four hundred and thirty-two feet. The elevations furnished by Mr. Pomeroy assume Greenville, Darke county, to be (railroad grade at depot) five hundred and seventy-six feet above low-water at Cincinnati. Different railroad surveys, however, give different figures for this elevation, the variation between them amounting to seventeen feet. This element of uncertainty can not be eliminated here:

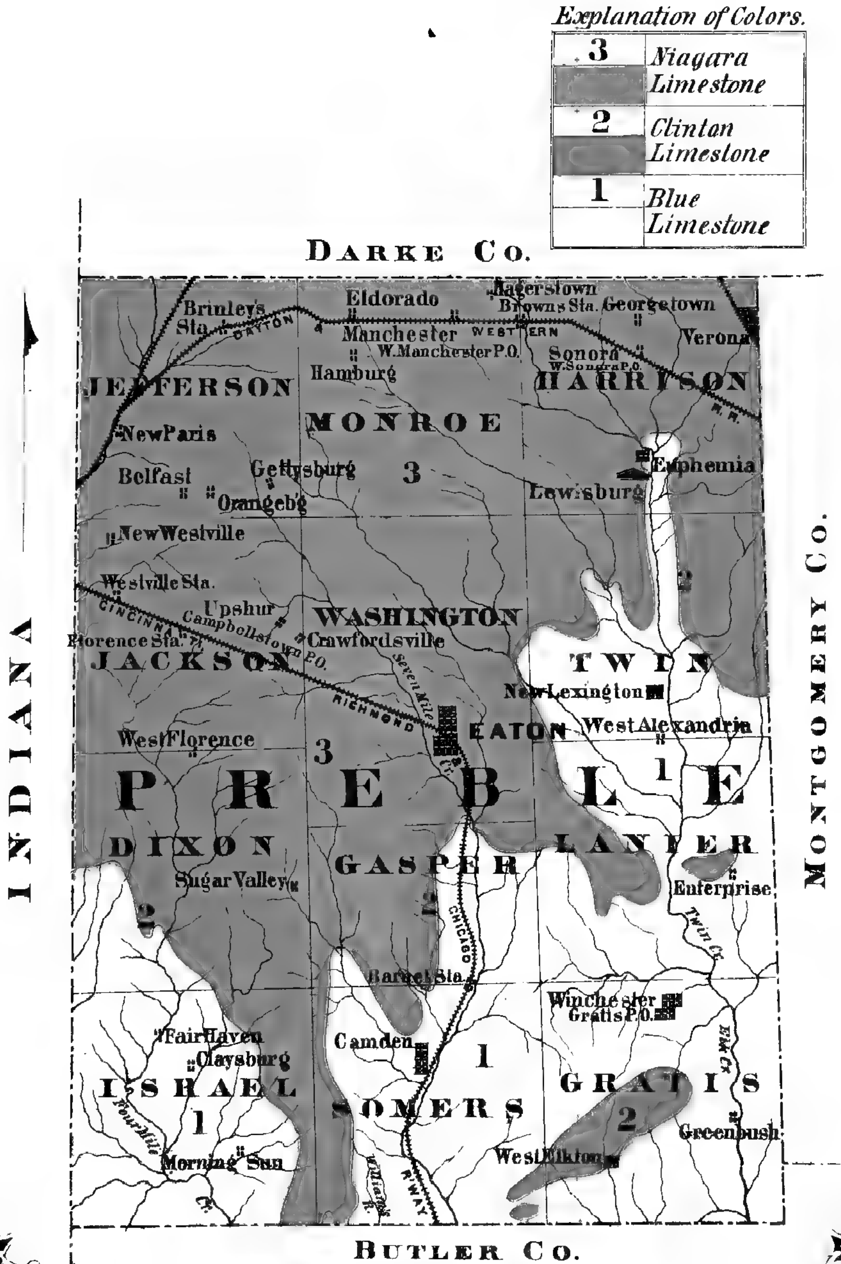
		FEET.
1.	Eaton (sill of court-house)	612
2.	Camden (general level of town)	407
3.	County line in Section 32, Sonora township	601
4.	North-west corner, Israel township	656
5.	Summit of Blue Limestone, Halderman's mill	515
6.	South line of county in Section 33, Gratis township	586
7.	Winchester	425
8.	West Alexandria (valley of Twin Creek)	427
9.	Lewisburg " "	495
10.	Sonora (railroad grade)	544
	Extreme south-east corner, Lanier township, valley of Twin, say	350
	Valley of Seven Mile, on county line, say	325
	Ridge passing through Monroe, Jackson, etc., say	675

The vertical range, then, of the county is about three hundred and fifty feet. The geological range, as far as the bedded rocks are concerned, is somewhat less.

Geological Survey of Ohio.

MAP OF

PREBLE COUNTY.



Strobridge & Co. Lith. Cin. O.

Strobridge & Co. Lith. Cin. O.

An examination of these altitudes, in connection with the appended map of the county, will serve to show that, in a general way, they connect themselves directly with the geological formations. In other words, a geological and a topographical map of Preble county will have many points in common. The Cliff Limestone may be said to have an altitude of more than five hundred feet above low-water at Cincinnati, and the Blue Limestone an altitude of less than five hundred feet. Elevations No. 4 and No. 6, above given, show exceptional altitudes for the Blue Limestone, and are to be explained, at least in No. 4, by the presence of heavy beds of drift.

The drainage of the county is principally effected by four streams, named in the order of their importance, Twin Creek, Seven Mile Creek, Four Mile Creek, and Elk Creek. All of these deliver water to the Great Miami. On the extreme western boundary, small areas are found, the drainage of which is directed to White River. The highest land of the county is found on the dividing ridge between these drainage basins, the water-shed passing through Israel, Dixon, Jackson, Jefferson, and Monroe townships.

Parts of Washington and Jackson townships lie quite flat; but there are no swamps in the county, and no considerable areas from which the water runs even sluggishly. The Blue Limestone corner of the county, comprising Twin, Lanier, Gratis, Somers, and Gasper townships, is beautifully diversified in surface, and constitutes a very attractive as well as a very rich agricultural district.

GEOLOGICAL SERIES.

The geology of the county agrees very closely, as far as its bedded rocks are concerned, with that of Montgomery county and Clarke county already reported upon. It will not, therefore, need extended treatment here. The series comprises three main elements, one of which belongs to Lower Silurian time, while the other two are of Upper Silurian age. The series can be shown in diagram thus:

Upper Silurian	Niagara Group	Guelph. Springfield stone. Niagara shales. Dayton stone.
	Clinton Limestone	
Lower Silurian	Cincinnati Group, Lebanon division.	

The approximate thickness of the divisions can be given as follows:

	FEET.
Niagara Group	75
Clinton Limestone	15
Cincinnati Group	225

The areas occupied by each division are indicated on the accompanying map. The formations will be briefly treated in ascending order.

1. The Blue Limestone or Cincinnati Group is principally shown in the valleys of the county. Of these the valley of Twin Creek is the widest and deepest, but it is so much obscured with drift, that it does not furnish as satisfactory exposures of the rocky floor, as many of the shallower valleys do. Seven Mile Creek gives, on the whole, the best exhibition of this series. From Camden to Halderman's mill, the stream runs much of the way upon the rock, and excellent opportunities are furnished for studying the structure and collecting the fossils of this interesting formation. The Blue Limestone is so homogeneous that a full description of its beds at one point will cover almost every exposure of the system. No general statements, therefore, will be added to those that have already found place in previous reports. At Barnett's mills, several specimens of a fossil, elsewhere quite rare, have been found, viz., *Trochoceras? Baeri, M. and W.*, an early representative of a still existing family of chambered shells. *Rhynconella dentata* is also found in the same locality.

The Blue Limestone yields a large quantity of building stone of fair quality for local use. It was formerly the main dependence of that part of the county in which it occurs as a source of lime, but the numerous advantages of the Cliff Limestone for this purpose have brought it into universal use as a substitute.

2. The Clinton Limestone comes next in order. The line of junction between the Lower and Upper Silurian is very distinct in Preble county. The same line of facts observed in Montgomery county is met with here. A series of springs and a very productive belt of country mark this geological boundary. The explanation of each fact is obvious when the nature of the formations that are in contact is taken into consideration. The shales with which the Blue Limestone series is terminated are impervious; the Clinton Limestone that covers them is porous and is also traversed with lines of fracture. Springs must, therefore, necessarily appear along the outcrop of the two formations. Springs flowing over the margin of shales will do something toward imparting fertility to them, and this particular series of shales possesses the elements of fertility in large measure in their natural constitution.

Many of the finest farms of the county belong to this particular horizon. All of the facts here noted can be very clearly seen in the Morningstar neighborhood in Lanier township.

The Clinton Limestone exhibits, in the county, all the usual characters of the formation as it is found in Southern Ohio.

(*a.*) It is everywhere uneven in its bedding. The contrast between it and the overlying Dayton Stone, or the even courses of the Cincinnati Group beneath, is very striking. A layer of the Clinton Limestone can rarely be followed for a rod. The stone itself, in many instances, seems solid, but it lies in very flat lenticular pieces rather than in a regular wall. It is on this account but little valued for building purposes where either of the other formations above named is accessible.

(*b.*) Parts of it are sandy in texture, and render the local name of sandstone that is applied to it appropriate. The sand, it must be understood, however, is lime sand.

(*c.*) Throughout the exposures of this series in Preble and several adjacent counties, beds are everywhere found that acquire the name of *firestone.* They are sought for chimney backs and for all similar uses to which ordinary limestones can not be applied. The chemical composition of the stone does not explain this peculiarity. The firestones do not differ from many of the other limestones of the State. They consist of 84 per cent. of carbonate of lime and about 12 per cent. of carbonate of magnesia. They can, in fact, be burned into a very fair article of lime, and have been so used in many localities, but they endure without crumbling all ordinary exposures to heat.

Stone from the quarries of J. Halderman, Esq., are largely in demand for these uses, finding market through all the country around Eaton for many miles.

(*d.*) The Clinton Limestone is, in all of its outcrops throughout the county, rich in its characteristic fossils. Favosite corals, chain corals, cyathophylloid or bull's horn corals, and many forms of bryozoans are very abundant and very beautifully preserved. Some of these, the chain corals especially, can be well shown in polished sections of the rock. The stems and plates of crinoids or stone-lilies, however, outrank all other groups of fossils in the abundance in which they occur. The substance of the rock is often composed of these fragments. But few perfect bodies are to be found, but the plates most commonly met with have been identified as belonging to the genus, *Cyathocrinus.*

(*e.*) In close connection with this last-named fact, viz., that the formation is made up of organic remains, it is to be added that *petroleum* abounds through many of the exposures in the county. Geologists are generally agreed that petroleum, when occurring in a limestone rock, is derived from the animal remains of the rock, but no explanation can be given of the fact that the product occurs at one point, and is wanting at another. Its occurrence in the Clinton limestone of the county was noted by Dr. Locke in the previous Geological Survey of the State.

When the excitement caused by the discoveries on Oil Creek was at its height, the show of oil along the outcrops of this formation did not fail to attract attention, and rights to explore and develop the territory were bought up through several counties of Ohio and Indiana. Companies were formed and wells were sank at several points in south-western Ohio. The deepest of these wells was at Eaton, where the boring was carried 1,170 feet below the surface. There was, however, no geological promise in these undertakings. The Clinton limestone, it is true, is rich in petroleum in many localities, but its thickness does not exceed a dozen feet, and there have been no disturbances in its stratification by means of which reservoirs for the oil have been prepared. When the Clinton limestone was passed in the boring, the long series of the Cincinnati shales and limestones was met with, and the 1,170 feet above named were not enough to exhaust the limestone series of the State. A considerable fragment of rock was brought up from a depth of 1,130 feet, which proves to be a silicious limestone, quite after the pattern of the older limestones of the continent in their more northern outcrops. The samples of rock saved from different depths in boring were turned over to the Geological Survey by the persons who had them in charge, together with the records of the company. These latter show alternations of hope and disappointment, dependent partly on the geological series traversed. The boring was begun in the Niagara, and when the Clinton was reached the show of petroleum was sufficient to kindle a blaze of excitement. The telegraph was used to announce to distant stockholders the success of the enterprise, and the work of boring was temporarily arrested until a tank could be provided, so that there might not be "a sinful waste of the oil."

There are several points in the county which still yield a fine show of petroleum, the springs that issue from the base of the Clinton limestone being often thickly coated with it.

As will be seen from an examination of the map, there are numerous outliers of the Clinton limestone in the county. The work of denudation has been carried so far in all of these instances as to entirely remove the Niagara beds that originally covered them.

The great series of the county remains to be mentioned, viz., the Niagara Group. Its vertical extent seems less than in Clarke and Greene counties. There are, at least, no sections furnished like those at Springfield and Yellow Springs, in which all the members can be seen in one continuous exposure. The most considerable section is shown in the bed and banks of Seven Mile Creek, at Eaton. There are nearly fifty feet exposed within a mile or two of the village. It is probable that all of the members found and reported in the counties to the eastward occur here also, but, for the reason given above, they are not as easily marked. The order of occurrence, it will be remembered, is the following:

5. Cedarville or Guelph limestone.
4. Springfield limestone.
3. West Union limestone.
2. Niagara shale.
1. Dayton limestone.

The three lowermost are somewhat obscure, and the third has not been positively identified. The Eaton building-stone is not, as Dr. Locke suggested, the equivalent of the Dayton stone, but belongs in No. 4 of the above series, representing the building-stone of Springfield and Yellow Springs. It constitutes the main resource of the northern portions of the county. The same courses, together with the overlying Cedarville or Guelph beds are also struck at New Paris. The upper beds are here burned extensively into lime of the same approved quality which this horizon everywhere furnishes in Central and Southern Ohio. The stone agrees in its composition, and in all of its characteristics, with the Cedarville beds, except that portions of it are highly fossiliferous.

An analysis of the limestone of the Eaton quarries has been made for the Survey by Prof. Wormley, and is here appended:

Carbonate of lime	49.75
Carbonate of magnesia	35.87
Alumina and iron	4.40
Silicious matter	9.40
	99.42

The fossil contents of these divisions require no extended mention, agreeing, as they do, very closely with the divisions of the same age in the counties to the eastward. The well-known shell, *Pentamerus oblongus*, is found in great abundance at Eaton, as is also the more common of the Niagara trilobites, *Calymene Blumenbachii, var. Niagarensis.* The latter fossil is more abundant here than at any other locality known in the State, and occurs in great perfection. The limestone is magnesian in character, and consequently all of the fossils are found as casts.*

A trilobite, new to science, described by Prof. Whitfield in the Paleon-

* Mr. James Nelson, of Eaton, made the interesting discovery, several years since, of a recent insect larva that had occupied the mould of one of these trilobites from which the fossil had been dissolved. The larva had adjusted itself in its growth to the space left for it in the deserted mould so accurately as to suggest almost irresistibly, at first sight, the idea that we had here the veritable remains of the soft parts of a trilobite. The larva belonged to the order of insects termed *neuroptera*, and probably to the particular species *corydalis cornutus*, which is a common insect in Southern Ohio.

tology of the present volume as *Encrinurus*, occurs not infrequently in the Eaton beds, but is known only in fragments. The most characteristic, and, at the same time, the most common, of the fragments thus far found, is the highly ornamented *pygidium*. The same fossil, in the same state of preservation, is found at various points in the Niagara series of this quarter of the State, as at Yellow Springs, Springfield, Cedarville, etc.

On Banta's Fork, three miles from Eaton, excellent quarries are worked in the lower beds of the Niagara. The quarries yield an unusually fine quality of flagging stone, the stone lying in very even courses of suitable thickness.

Similar courses are worked on the banks of Twin Creek, two miles above Euphemia. Slife's quarries are the largest here, and from them, in some years, nearly one thousand perch of building stone have been raised in a year. Some of the courses answer well for cutting, and all of the product finds a ready market in the quarryless regions to the east and north.

The most extensively worked quarries of the county are located at New Paris. The upper member of the Niagara series is well developed, and is easily reached. The building stone courses are also accessible. The main interest, however, is the production of lime. Large quantities of the best of lime are annually burned here, being distributed mainly to the westward by railroads leading out of Richmond, Indiana. Patent kilns are in use, and the business is economically and successfully managed. David Ireland manufactures three hundred bushels per day for eight months of the year, using one cord of wood for the burning of seventy-five bushels of lime.

The quarries of Christian Disher, on the east side of Twin Creek, opposite to Lewisburg, include, beside the building stone of the Springfield division, the lime-producing courses of the Cedarville section. Lime has been burned here for thirty years, and for the last few years the demand has largely increased, owing to the excellent character which the products of these kilns have acquired in the blue limestone areas to the southward. It scarcely needs to be added that the lime is identical in character with that furnished by this whole section of the Niagara rocks in south-western Ohio, and of which the Springfield lime can be taken as the proper representative.

An analysis of Disher's limestone is here appended (Wormley):

Carbonate of lime	55.20
Carbonate of magnesia	43.28
Alumina and iron	0.60
Silicious matter	0.60
	99.68

Sellers's Run, near the head of which these quarries are found, furnishes in its bed and banks an excellent section of the upper rocks of the county. Beginning with a fine show of the Clinton limestone, rich in its characteristic fossils, which is shown near Turner's distillery, the succeeding beds of the Niagara series to the Cedarville division, inclusive, are traversed and disclosed within the course of a mile.

DRIFT.

The Drift beds of the county, which may be said to cover its entire area, remain to be briefly described. In all of their general characters they agree perfectly with the same order of deposits in adjacent regions.

The bowlder clay, or unmodified Drift, is shown in very numerous sections, and is reached in the digging of many wells. In the northern half of the county this deposit is uniformly deep—so deep, at least, as never to be reached in ordinary sections or excavations. Its surface is often covered with the deposits of sand, gravel, and stratified clay which compose the modified Drift of this region, and when so covered it constitutes the water bearer for the area which it occupies. When the bowlder clay itself makes the surface, the water supply is found at easily accessible depths within it, in some of the seams of sand and gravel that are scattered at irregular intervals through its substance.

In the central regions of the county the bowlder clay rests directly upon the polished surface of the Niagara limestone, and in the southern regions it is not seen as distinctly or as often, its best exposures being confined principally to the deeper valleys.

The bowlder clay gives every indication of having been formed under the great glacial sheet which has been demonstrated to have covered the northern portions of the continent in the period preceding the present. It is filled with scratched and polished fragments of limestone and northern rocks, compactly laid in the dark blue clay which characterizes the formations of this age in every part of the world where they occur. The seams of sand and gravel interpolated in the clay, doubtless, result from partial meltings of the glacial sheet in some of the milder periods of its history. The ice-sheet in its southward advance must have found the face of the continent covered with a forest growth and other forms of vegetation. It seems certain that some remnants of this pre-glacial growth are preserved in the bowlder clay. Worn fragments of wood, at least, are often found deep in the clay, which it seems impossible to refer to any other source.

This *pre-glacial* vegetation must not, however, be confounded with the *interglacial* growths to which attention has often been called in the reports of the Survey. The latter is doubtless of much more frequent occurrence. It is to a wide-spread stratum of interglacial vegetation that the buried tree-tops, roots, leaves, and ancient soil, so often reported in the digging of wells and other like excavations, must be referred.

The *Forest-Bed*, as this stratum has been designated, is of much less frequent occurrence in Preble county than in the counties to the south and east of it, but there are still many evidences of its presence within this area. In Harrison township a tree top is reported to have been struck at a depth of thirty feet.

An ochre seam, which, it will be remembered, sometimes accompanies the Forest Bed and sometimes replaces it in the regions to the southward, is also occasionally met with in Preble county. It is generally found associated with a gravel seam, which it cements into a hard-pan, which must be penetrated in order to reach the water veins.

The beds of modified Drift, as the sand, gravel, and clay that overlie the bowlder clay in stratified deposits are called, occur abundantly in the county, not being confined to the deeper valleys, but being found as well over most of the uplands of the county. In the northern townships, and especially in the flat-lying districts, they have a general thickness of about twenty feet, of which the following may be taken as a representative section:

	FEET.
Soil	1½
Yellow clay streaked with bluish clay	10
Blue clay (sometimes brown), always fine-grained, and free from gravel	8

Underneath are found the seams of sand and gravel that cover the bowlder clay, and which constitute the water-bearer of much of this region.

In all of the above named particulars the Drift of Preble county is seen to be part and parcel of the great Drift field of Ohio, but there is a single feature that remains to be mentioned in which it has preëminence over all contiguous areas. A very remarkable bowlder belt traverses its central and eastern regions—more remarkable than any similar belt thus far reported in the State. There are various points in this general region where bowlders are very thickly strewn over the surface for limited areas, as, for instance, along the uplands that bound the Great Miami Valley for twenty-five miles above Dayton, on the west side of the valley, directly opposite Dayton, and also in the country that lies west of the Stillwater, in the vicinity of Union, Montgomery county, but none of these bowlder belts attain the proportions of that now under consideration.

Its northern boundary is not very distinctly defined, but there is a gradual thickening of the bowlders until we find them in the central part of Washington township so numerous as to render the tillage of the fields difficult. From this point the belt can be followed in a broad band to the south-eastward as far as to the county line and even beyond. Its length within the county will thus be seen to be at least ten miles. Its greatest breadth does not exceed three miles, but the east-and-west roads of the county cut across it diagonally so as to show sections of four or five miles in breadth.

The bowlders range in size from one thousand cubic feet downwards. Of one hundred and two blocks that were lying on the surface within a small compass, the greatest length in any bowlder was seven feet. A second gave a measure of five feet; four exceeded four feet; six exceeded three feet; thirty-five measured more than two feet, while the balance (fifty-five) were under two feet, none being counted that were less than one foot. It is probable that within the same area there were nearly as many more concealed by a shallow covering of soil. On the farm of David Potterf, near west Alexandria, 1,200 bowlders exceeding two feet in diameter were counted to the acre. There are points where they are certainly more numerous than this. The value of the land is diminished where it is so thickly covered, the expense of raising and removing them being considerable.

The bowlders lie upon or very near to the surface. Numerous sections of the Drift beds in this district are furnished in the banks of streams and in artificial cuttings, but they do not disclose any unusual number of these blocks at any great depth.

In their distribution they are irrespective of the elevations and irregularities of the surface. They cover the high ground and the low impartially. The central portions of the belt occupy a part of the great northern plain of the county, which has an altitude of about one thousand feet above the sea.

There is a considerable variety of composition among them. The kinds most largely represented are named below, in the order of their abundance:

1. Metamorphic slates, fine-grained, and very hard; in color, dark blue, reddish, and green.
2. Diorites, blue and green, frequently intersected by felspathic veins.
3. Silicious conglomerates, excessively hard, whitish, light green, and purplish.
4. Gneiss, two leading varieties, viz., orthoclasic or red-banded, and hornblendic or black-banded.
5. Granites of the ordinary types, many of the blocks intersected by felspathic veins, which often stand out in relief from the weathering surfaces.
6. Porphyries, comparatively rare, some with white felspar crystals, but more with reddish crystals.

Of these varieties, the conglomerates are, perhaps, the most characteristic, as they agree quite well with each other in their general composition, and differ in a marked degree from the conglomerates otherwheres met with in the Drift field of south-western Ohio.

It seems probable that they may hereafter give the clue to the exact location from which they were originally derived. Their peculiarity consists in their distinct stratification. Layers of coarse, silicious pebbles are separated from each other by four to eight inches of fine, sandy quartzite, which is very often light green in color, and which sometimes has a faint amethystine tint. The conglomerate character is sometimes but feebly shown, and then the blocks would be classed as ordinary quartzites. The composition of the bowlder belt is best studied in some of the newly made stone walls of this district.

The application of the bowlders to the construction of stone walls which provide permanent fencing for the lands on which they are found, is one of the most obvious uses to which they can be put, but little has thus far been done in this direction. They have been more largely turned to account in the foundations of buildings through the regions where they are plentiful. The few mechanics that use them skillfully are in demand, and bowlder walls are coming to be considered as the standard of excellence in the way of masonry.

These great surface stone quarries of the county are not to be held in light esteem. Every farm that lies within the bowlder belt here described has on its surface thousands of perches of the most enduring and attractive building rocks of the continent, and it is certain that with the increasing age and wealth of the country these supplies will come into demand.

The chief facts in relation to this interesting feature of the Drift formations of the county have now been given. The bowlders evidently belong to the last stage of the Drift period, viz., to the time of northern submergence which followed and closed the great ice age. They were floated by icebergs across the inland sea that stretched from the Canadian Highlands to Central Ohio, but no explanation is proffered of the fact that they occur just where they now lie rather than elsewhere. The present topography of the country furnishes some suggestions, but no adequate explanation of the phenomena is discerned.

Another of the more unusual phenomena of the Drift is to be noted in the obstruction of an old valley by the bowlder clay. This case is met with in the bed of a small tributary of Seven Mile Creek, one mile west of the village of Camden. The stream has been compelled to abandon its old course for a short distance, and to work out a new and very circuitous channel through the limestone rock. Attention was called to this interesting fact by the late Dr. Dunham, of Camden.

The geology of Preble county, it is to be remembered, is identical in its various elements with that of counties already treated at considerable length. To these reports the reader is referred who desires a fuller sketch of the history written in the formations that make up its geological scale.

As Preble county is the last one to be reported upon in the district, that contains the Upper Silurian formations, no more appropriate place can be found for the insertion of a list of the Niagara and Clinton fossils of Ohio. The appended catalogue contains such a list, no fossil being entered in it that has not been recognized or described by one or other of the Paleontologists of the Survey:

FOSSILS OF THE CLINTON LIMESTONE.

CORALS AND BRYOZOANS.

Astrocerium venustum....Hall.
Diphyphyllum cespitosum....Hall.
Chaetetes—undetermined sp.
Clathropora Clintonensis....H. and W.
Favosites Niagarensis....Hall.
Halysites catenularia....Linn.
Lichenalia concentrica....Hall. ?
Retepora angulata....Hall. ?
Streptelasma—undetermined sp.
Stictopora magna....H. and W.

MOLLUSCA.

BRACHIOPODS.

Atrypa nodostriata....Hall.
Merista—undetermined sp.
Orthis biforata....Dalm.
" circulus....Hall.
Streptorhynchus subplana....Hall.
Triplesia Ortoni....Meek.
Zygospira modesta....Hall.

LAMELLIBRANCHS OR BIVALVES.

Ambonychia—undetermined sp.
Cypricardites ferrugineum....H. and W.

GASTEROPODS OR UNIVALVES.

Cyclonema bilix....Hall.
Holopea—undetermined sp.

CEPHALOPODS OR CHAMBERED SHELLS.

Cyrtoceras—undetermined sp.
Orthoceras Jamesi........H. and W.
Orthoceras—undetermined sp.

ARTICULATES.

TRILOBITES.

Calymene—undetermined sp.
Illænus Daytonensis........H. and W.
Illænus—undetermined sp.
Proetus—undetermined sp.

FOSSILS OF THE NIAGARA GROUP.

GRAPTOLITES.

Inocaulis bella........H. and W.

FORAMINIFERA.

Receptaculites infundibuliformis........Hall.
" Ohioensis........H. and W.

SPONGES.

Astylospongia—undetermined sp.

CORALS AND BRYOZOANS.

Astrocerium venustum?........Hall.
Chonophyllum—undetermined sp.
Cladopora reticulata?........Hall.
Favosites Gothlandica........Lam.
" Niagarensis........Hall.
Fenestella nervata........Nich.
Halysites catenularia........Lin.
" " var. macropora........Whitf.
Ptilodictya—undetermined sp.
Strombodes Schweiggeri........E. and H.
" striatus........D'Orb.
Syringopora Danæ........Bill.
" —undetermined sp.

CRINOIDS AND CYSTIDEANS.

Apiocystites imago........Hall.
Caryocrinus ornatus........Say.
Cyathocrinus pisiformis........Roemer.

Eucalyptocrinus conicus	Troost.
" cornutus	Hall.
" crassus	Hall.
" ornatus	Hall.
" Phillipsi ?	Troost.
" splendidens	Troost.
" —undetermined sp.	
lyptocrinus armosus ?	McChesney.
" nobilis	Hall.
Gomphocystites glans	Hall.
Holocystites cylindricus	Hall.
" abnormis	Hall.
Icthyocrinus subangularis	Hall.
Lecanocrinus—undetermined sp.	
Macrostylocrinus—undetermined sp.	
Pentremites sub-cylindricus	H. and W.
Platycrinus prematurus	H. and W.
Rhodocrinus rectus	Hall.
" —undetermined sp.	
Saccocrinus Christyi	Hall.
" ornatus	H. and W.
" Tennesseensis	Troost.

MOLLUSCA.

BRACHIOPODS.

Anastrophia interplicata	Hall.
Atrypa nodostriata	Hall.
" reticularis	Dalman.
Dinobolus Conradi	Hall.
Meristina cylindrica	Hall.
Orthis biforata	Dalm.
" elegantula	Hall.
" flabellulum	Sow.
Pentamerus oblongus	Sow.
" occidentalis	Hall.
" pergibbosus	H. and W.
" ventricosus	Hall.
Rhynchonella acinus	Hall.
" cuneata	Dalm.
" Indianensis.	
" neglecta	Hall.
" pisa	H. and W.
" Tennesseensis	Roemer.
Spirifer crispus	Sow.
" eudora	Hall.
" nobilis	Hall.
" Niagarensis	Hall.

Spirifer plicatella—var. radiata .... Hall.
Streptorhynchus subplana .... Conr.
Strophodonta striata.
Strophomena rhomboidalis .... Wickl.
Trimerella grandis .... Bill.
Trimerella Ohioensis .... Meek.

LAMELLIBRANCHS OR BIVALVES.

Amphicoelia (Leptodomus) costatus .... H. and W.
Megalomus Canadensis .... Hall.

GASTEROPODS OR UNIVALVES.

Holopea—undetermined sp.
Murchisonia Laphami .... Hall.
" macrospina .... Hall.
Platyceras Niagarense .... Hall.
Platyostoma Niagarense, var. trigonostoma .... Meek.
Pleurotomaria Halei .... Hall.
" Hoyi .... Hall.
" idia .... Hall.
" occidens .... Hall.
Straparollus mopsus .... Hall.
" Niagarensis .... H. and W.
Subulites teretiformis .... H. and W.
Tremanotus Alpheus .... Hall.
" (Bucania) trigonostoma .... H. and W.
Trochonema pauper, var. Ohioensis .... H. and W.

CEPHALOPODS OR CHAMBERED SHELLS.

Actinoceras—undetermined sp.
Cyrtoceras dardanum .... Hall.
" ellipticum .... H. and W.
" brevicorne .... Hall.
" Herzeri .... H. and W.
" myrice? .... Hall.
Lituites Marshii .... Hall.
" Ortoni .... Meek.
Nautilus—undetermined sp.
Orthoceras abnorme .... Hall.
" annulatum .... Sowerby.
" crebescens .... Hall.
Phragmoceras ellipticum .... H. and W.
" parvum .... H. and W.
Trochoceras Desplainense .... Hall.

ARTICULATES.

TRILOBITES.

Calymene Clintoni .... Hall.
" Niagarensis .... Hall.
Dalmania limulurus .... Green.
Encrinurus ornatus .... H. and W.
Illænus insignis .... Hall. ?
" Iowense .... Hall. ?
Sphærexochus Romingeri .... Hall.

CHAPTER LXXIII.

REPORT OF THE GEOLOGY OF MADISON COUNTY.

BY EDWARD ORTON, ASSISTANT GEOLOGIST

Madison county is bounded on the north by Union, on the east by Franklin and Pickaway, on the south by Fayette, and on the west by Greene, Clarke, and Champaign counties.

Its surface is comparatively level. Its lowest land is found in the south-eastern corner, near Mount Sterling, in the valley of Deer Creek. Its highest land lies to the west and north-west of London, and is about 1,100 feet above the level of the sea. The range of the county does not probably exceed 300 feet. The altitudes of a few of the principal points in the county are subjoined:

London, 1,010 feet above tide-water.
West Jefferson, 830 feet above tide-water.
Mount Sterling, 865 " "
Midway, 950 " "
South Solon, " "
County Infirmary 1,100 feet above tide-water.
County line on Xenia pike, west of London, 1,100 feet above tide-water.
Ohlinger's Hill, west of Summerford, 1,100 " "

Of these altitudes, all but the first were obtained by the barometer, and must be taken as approximations only. They suffice to show, however, the very great degree of uniformity that prevails in the surface of the county. A very large part of its area lies at altitudes varying between 950 feet and 1,050 feet above the sea. Nothwithstanding this uniformity of level, there is but very little swamp-land in Madison county. The slopes, though very gradual, are so distributed that the water always knows which way to go. Between those sources of Little Darby Creek that lies within the county, and the point where the creek crosses the county-line, there is a fall of scarcely less than 200 feet. The distance is about 15 miles and the average descent is between 13 feet and 14 feet to the mile.

Deer Creek descends, from its head-springs near Summerford, 300 feet, in its diagonal course of 20 miles across the county—an average fall of 15 feet to the mile.

The surface of the county, however, has been greatly relieved by drains and ditches, and is susceptible of almost indefinite improvement by such agencies.

None of the streams have deep valleys, but the surface lies in gentle undulations between the channels of contiguous water courses. In the north-eastern corner of the county, the low summit that divides the waters of Little Darby from that of Big Darby, extends in the broad and productive tract know as the Darby Plains, one of the most famous grazing districts of the State.

GEOLOGICAL SERIES.

The geological scale of the county is very much contracted. But two formations besides the Drift occur here, viz., the Helderberg and the Corniferous limestones. There are in the county two exposures of the former and but a single one of the latter.

The Helderberg limestone (water-lime) has been quarried in small amounts for many years on the farm of Asa Hunt, Pike township, (survey 6,965). A branch of the Spring Fork of Little Darby know as Barren Run, has cut its bed down to the limestone for a number of rods and the stone is raised from the quarry at such times as the water is lowest. It has been used for lime and also for building stone. The first purpose it is very well adapted to; the second, it answers but indifferently well, as the stone is thin and shelly. It holds its characteristic fossils which, however, are not necessary for its identification—as the lithological characters are too plain to be mistaken.

The second exposure of this limestone is much more considerable. It occurs on the Stoner farm in Jefferson township, two miles south of the village of West Jefferson. A section of 15 feet of this formation is shown in the banks of Little Darby, very near the point where the stream leaves the county. The ledge is resorted to for the same purposes as the exposures first mentioned, viz., for lime and building stone. The same remarks as to quality will apply in this case as before. The lime has an excellent reputation, being much milder than the Columbus lime.

The principal interest of this locality, however, lies in the fact that it furnishes the junction of the Silurian and Devonian formations. A few rods from the exposure of the Helderberg limestone just mentioned, ten feet of another formation come in which it is easy to identify by all tests as the Corniferous limestone, known in this portion of the State as the Columbus or State quarry limestone. The beds furnish quite serviceable building stone, and are brought into neighborhood use.

On the opposite side of the creek, and a mile or two further down, there is a still more extended section of the same elements. It is found on the farm of the Roberts' brothers. It does not deserve to be called a new exposure, as the outcrop of the rock is scarcely interrupted from one point to the other.

A somewhat anomalous fact meets us in this section. There is interpolated in the Corniferous series a few inches of a very pure, saccarhoidal sandstone. The occurrence of such a deposit at about this point in the scale is not, however, named here for the first time. Rev. H. Herzer reported several years since a similar deposit in the Corniferous at West Liberty, Logan county, and Mr. Franklin C. Hill, in his report for the survey on this county, shows that sandstone holds the same relations there that it has in Madison county. It is not found at the base of the Corniferous series in either instance, but it occurs in thin beds distributed through five or more feet of the limestone at an elevation of about fifteen feet above the base of the series. It is underlain by undoubted beds of Corniferous limestone and can not therefore, in these instances, be considered as the southward extension of the Oriskany sandstone. It is rather the counterpart of the Hillsboro sandstone which, in like manner, is interjected into the Niagara series—in the southern part of the State. These two aberrant sandstones furthermore agree very closely in lithological characters.

The sand from the Roberts quarries has long been known throughout the adjacent country and has even found its way as far as Columbus. Whenever plastering of unusual excellence is attempted in this vicinity, recourse is had to this deposit. The sandstone is nowhere more than six inches in thickness and it lies between ledges of rock so heavy that it can not be profitably obtained except when the quarry is worked for other purposes. Its interest, in other words, is geological rather than economical.

These are the only known localities in Madison county in which the bedded rock is exposed to view. On the extreme eastern edge of the county, in Jefferson township, it has been ascertained in the driving of wells that the rock lies about forty feet below the surface. There are a few other points in the county in which the underlying rocky floor has been, in like manner reached, but these cases are of very rare occurrence. Borings of fifty or even sixty feet are often made which do not exhaust the drift beds.

There is no region of the State in which the basement rock makes a more insignificant show or exerts less influence upon the present surface of the country. Even the details of the topography are seen to depend very largely on the modification of the drift surfaces and these details can, in many cases, be very well explained without any recourse to the underlying beds. All of the questions that concern the county, whether relating to its topograply, its soils or its water-supply, connect themselves with the origin and history of the deep drift-deposits, by which its entire surface is now covered.

DRIFT AND SOILS.

The subject of the Drift has been taken up so many times, and from so many points of view in the reports of the survey already published, that it is unnecessary here to treat of it from a general or theoretical point of view.

The deposits of the Drift in Madison county fall under the ordinary heads. The lowest and oldest of these deposits is a heavy bed of bowlder clay, which covers the face of the country universally. It is a tough, waxy, dark-blue clay, in which scratched and striated pebbles and bowlders are abundantly distributed, and occasional seams of sand and gravel, varying in thickness from one inch to two feet are found, but without regularity or constancy.

This member of the drift series exceeds the rest very largely in volume and also in the importance of its offices. As has been before stated, borings of 60 feet are sometimes made without exhausting the bowlder clay. These facts seem to indicate that the average thickness of this member of the series is not less, certainly, than 60 feet.

In considerable areas of the county, the bowlder clay forms the present surface, or rather the bowlder clay as modified by the action of the atmosphere and of vegetable growth and other organic agencies, upon it. These areas constitute the coldest and most intractable lands of the county. The soil formed from their weathered surfaces is a black clay one foot or a foot and a half in thickness. The action of the atmosphere is shown to have reached below the surface in the conversion of one or two additional feet of the blue clay into yellow clay. These weathered deposits pass by insensible gradations into the underlying deposit. The lands of this description are less varied in the natural forest growth than the other lands of the county. They are susceptible, however, of considerable amelioration by underdraining, and possess all the elements necessary for long continued productiveness.

By far the larger part of the county is covered with another order of drift-deposit, viz., those that have been modified and re-arranged during a period of submergence to which the original beds have been subjected. If a bed of the yellow clay already spoken of as formed from of the blue clay, were exposed by a slowly advancing submergence to the action of waves or currents, it is easy to see that its clay, sand and gravel would be assorted and separated. The coarser materials would be moved the least distance and the finer clays the greatest distance from their original beds. As the submergence was gradually extended, then we ought to find beds of gravel overlying the blue clay, themselves overlain by sand, and finally covered with the finest grained clays. Such is precisely the general order of the arrangement in all of these districts. We ought furthermore to expect that on the highest grounds of the county beds of gravel and sand would abound. This also is exactly the case. Ohlinger's Hill, as high a point as is contained in the county, is the resort of the whole country for miles around, for plastering sand, extensive deposits of which occupy the highest parts of the dividing ridge.

The same line of facts is met with on the high ground west of London, a ridge scarcely inferior in elevation to the one already referred to. It is, in fact, a part of the same water-shed—separating the drainage of the Scioto from that of the Little Miami. Almost the whole of this region is occupied with heavy beds of well-washed gravel. The whole supply for London and its vicinity is derived from this locality. It must, however, be noted that these high grounds also contain remnants of the old glacial clays, which furnish, as at Ohlinger's Hill, a soil of entirely different properties from any other soils in the county. The difference lies in the fact that the high location of the masses has prevented the accumulation of vegetable matter in them. They produce fruit well and are good wheat lands when properly treated, but they are decidedly inferior as grass-lands to the rest of the county. In fact, but a thin sod establishes itself upon them unless special care is taken to secure this result.

The submergence of this district and the consequences resulting from such a fact have been spoken of. It is easy to see that the emergence which converted it into dry land again, must have been attended with equally marked results. As drainage systems began to be established or re-established, the accumulations of clay, sand and gravel of the re-arranged drift would often be withdrawn from the surface over which they had been distributed, and the broad valleys through which currents were moving, would be sure to receive them. The bowlder clay would thus be exposed on portions of these areas.

The northern and central districts of the county contain almost all of the exposures of this sort, while the southern tiers of townships which lie a hundred feet or thereabouts lower than the above named districts, hold by far the most gravel.

The facts now enumerated will be seen, upon a little reflection, to lay the foundation for an excellent scope of country in an agricultural point of view. Generous and lasting soils and an abundant water-supply are certain to be provided from such modifications of the beds of glacial drift in central and western Ohio. In accordance with these probabilities, Madison county is found to be one of the finest agricultural districts of the State. There is scarcely a foot of waste land in it and most of it, if not already highly productive, is easily susceptible of being made so. The surface clays are generally black, for at least one or two feet in depth. In land lying as nearly level as Madison county does, there would necessarily be enough detention of organic matter in the soil to produce this result. Even the lands underlain with gravel might have been swampy in their earliest history, but after a forest growth had established itself upon them and the roots had penetrated to the porous beds below, a natural drainage would be secured which would do much towards their amelioration.

The gravel washed out of the bowlder clay is largely limestone gravel. Whenever an insulated area of this gravel has been left uncovered by the finer clays, and has itself undergone atmospheric agencies by which it would be converted into soil, we find the productive belts known as "*mulatto lands.*" The reddish soils thus designated certainly have just such a history.

The forest growths on these several sorts of areas, are, in every case, characteristic. The last named division is the warmest and most fertile land of the county. It is occupied quite largely by Black Walnut, Sugar Maple, etc., and is therefore, frequently styled "Black Walnut land." It is confined to patches, and acres, and is nowhere extended in large tracts, or at least not in the central portion of the county. More of it is shown in the southern townships.

The division last preceding this, viz., the clays underlain by gravel or sand, are quite generally covered with Burr Oak (*Quercus macrocarpa*). This tree marks very definitely all the better portions of the areas now under discussion, and as this kind of land constitutes the most important element in the surface of the county, the Burr Oak may be said to characterize the county.

The colder lands referred to the weathering of the bowlder clay are covered for their natural forest growth with swamp oak (*Quercus palustris*), post oak (*Q. obtusiloba*), and occasionally white oak (*Q. alba.*) The natural differences between these soils, as attested by their original forest growths, are clearly shown in their subsequent history under cultivation.

The swampy condition of the land before drains and ditches provided an easy way of escape for the surface water, is the probable cause of a defective condition of the timber produced here. Many of the trees are hollow-hearted. Another explanation is offered in the fires that the Indians were accustomed to kindle annually throughout this part of the State. The sparseness of the timber can no doubt be attributed to the last named caused.

While some of these varieties of soil are much warmer and kinder than others, all of them form blue grass land. As soon as the surface water is withdrawn, this most valuable of all our forage plants—*Poa pratens*, or Kentucky Blue Grass, comes in to displace the wild grasses that have occupied the ground hitherto, and it comes to stay. This is not the place to take up in detail this great source of agricultural wealth. It is enough to say that all of its charact ristic excellences are here shown. The best rewards of agriculture in Madison county, have hitherto been drawn from this spontaneous product of its soil. The lands of the county have been turned into pasture-grounds since their first occupation. Under judicious management, cattle do well upon them throughout our ordinary winters, without hay or grain.

It is to be remarked that Madison county is a blue grass region not so much because of the composition of its drift-beds as from the fact that these drift-beds are extended, owing to the accidents of their recent geological history, in wide plains which allow the abundant accumulation of vegetable matter in the forming soil. These same drift-deposits when they lie on well drained slopes form a stubborn, yellow clay that can hardly be kept covered with sod of any description. It must not, however, be inferred that all level drift tracts will become blue grass land, irrespective of their composition. Clays derived in large part from the waste of limestone, as are those of Madison county, are especially adapted to the growth of blue grass. Madison county has no monopoly of this important product, but all the flat-lying tracts of the counties around it, as they have shared in its geological history, share also in its agricultural capabilities.

These districts were shunned in the early settlements of this general region on account of their swampy character—but discerning men soon came to see their great possibilities, and as the price per acre was scarcely more than nominal, they were bought in large tracts and have been so held until the present time. Farms of 2,000 acres are not unusual in the county, and fields of five hundred acres are common. The recently divided estate of William Wilson, in the Darby Plains of Canaan township, embraced 9,000 acres.

The county is famous not only for the number of cattle that it produces, but also for the quality. It holds some of the finest herds of improved cattle to be found in the State or country.

The lands of the second and third divisions, as might be judged from their constitution, are excellently adapted to the production of corn and other cereals and are coming to be used for grain-growing as well as for grass-growing. The varied elements of our ordinary American farming are thus becoming established here as elsewhere.

WATER SUPPLY.

The last point to be taken up in the geology of the county is its natural water supply.

Madison county may be said to have an abundant and excellent supply, but it does not show itself in the ordinary modes, in springs and frequent water-courses. The supply, indeed, is under ground and must, for the most part, be brought to the surface by artificial means. The ordinary rain-fall of central Ohio being granted, the geological conditions already described, necessitate an immense accumulation of water beneath the surface. Such an accumlation, we find, lying within easy reach. The surface of the bowlder clay is a common water bearer, though many wells descend into the clay to some of the irregular veins of sand and gravel to which reference has already been made. The porous beds above the bowlder clay, varying in thickness from five to fifteen feet, constitute an efficient filter for the surface water in most instances.

It must be remarked, however, that all of the dangers pertaining to such a supply show themselves here. The drift-beds are freely permeable. They have no power to shut out the products of surface defilement or to prevent cess-pools and other sinks of impurity from discharging their offensive and poisonous drainage into adjacent wells and springs. There is abundant and positive proof that drinking-water contaminated from such sources, is very often made the medium for distributing fever and pestilence through families and neighborhoods.

Of late years, the agency of the wind has been quite extensively utilized in pumping water from wells into reservoirs for the use of stock. The wind-pumps have been improved in so many ingenious ways that they work almost as if they were intelligent agents, matching supply with demand and adjusting themselves to the force of the wind.

The common method, however, of providing stock-water in those farms which are not traversed by living streams, is by means of pools which obtain their supply directly and entirely from surface accumulations of rain. The water of such pools is always foul with mud and manure and is heavily charged with vegetable and animal organisms in every stage of existence and decay, and yet it is claimed to be a safe and wholesome supply.

Still another source of stock-water is found in some sections of the county. The water delivered by draining tile in underground ditches is gathered and conducted to troughs in the pasture grounds. Where the make of the country admits of this system, a supply in every way advantageous, is secured.

Buried vegetation is less frequently met with in the drift of Madison county than in the regions further to the southward, but it can scarcely be said to be of rare occurrence. Considerable accumulations of vegetable matter are needed to explain certain facts met with in a little settlement called Kiousville, in Fairfield township. Several attempts to obtain wells have been made here without success. The trouble has been in every instance that after reaching a certain depth, choke damp or carbonic acid escaped in such quantity as to render further work impossible. Several lives have been lost in these attempts and one during the summer of 1872. The section traversed is:

	FEET.
Yellow clay	10
Blue clay—abruptly bounded on upper surface	20–31
Cemented sand and gravel.	

On breaking through the crust of cemented gravel, the gas issues in strong volume. No water has ever been found in the gravel. The section is somewhat anomalous, but it seems safe to conclude that some such accumulations of buried vegetable matter as have been described in previous reports as existing in Montgomery, Warren, and Highland counties, are to be found here.

The remains of a young mastodon were recently found in Range township on the farm of Daniel McClimans. The skull and its appurtenances were in the best state of preservation. The tusks were six feet long, measured on the outside of the curve. A part of the lower jaw had perished, but in the remaining, a small molar tooth was found in place. It was afterwards detached and found to weigh one pound and two ounces, while a larger tooth, but partially developed, lay back of it in the jaw.

The occurrence of remains of these past glacial mammals is, however, comparatively rare in this immediate area.

The principal points in the Geology of Madison county have now been briefly treated, and it is seen that although the story of its bedded rocks is very short, there are still geological questions of great interest suggested by its broad and fertile plains.

CHAPTER LXXIV.

REPORT ON THE GEOLOGY OF CLINTON AND FAYETTE COUNTIES.

BY JOHN HUSSEY.

PROF. EDWARD ORTON.—*Sir:* I herewith present my report on the geology of Clinton and Fayette counties.

In prosecuting this survey I have received the aid of many citizens, in greater or less degree, all of whose names I could not here take space to mention. I do, however, here acknowledge my indebtedness to Col. T. J. Caruthers, Dr. Welsh, and Clarkson Butterworth, for kindly assistance rendered me in Clinton county, and Mr. James McLean, county surveyor of Fayette county, and to Mr. William Vance, assistant in his office. I received suggestions and assistance from the editors of the papers—W. C. Gould, of the *Register*, and W. W. Milligan and Son, of the *Herald*—from George S. Fullerton, Esq., and Rev. J. P. A. Dickey, of Bloomingsburg; the Messrs. Hegler, and Mr. John Sollars. I found an intelligent interest, generally, in the minds of the citizens of both counties on the subject, and although there was no expectation of any discoveries of mineral wealth, still the object of my visit was generally appreciated and understood.

Truly yours,

JOHN HUSSEY.

Clinton county is bounded on the north by Greene and Fayette counties, on the south by Highland and Brown counties, on the east by Fayette and Highland counties, and on the west by Warren county.

Fayette county is bounded on the north by Madison county, on the south by Highland and Ross counties, on the east by Pickaway, and on the west by Clinton and Greene counties.

I propose to treat these counties together, partly because there is much similarity in the physical characteristics of the two, but particularly because there is comparatively little of geological interest in them. The formations are little exposed, being generally covered with alluvial and drift-deposits; and where they are exposed they do not present a great variety of material, such as imbedded fossils, to the geologist, by means of which he may read the history of the life and changes of the past, or of those products of the earth, which are so indispensable to mankind, as ores, fossil, coal, and valuable stone, which elsewhere offer such inducements to geological investigations. Still I hope that what I shall present of the geology of those counties will not be utterly devoid of interest to those most concerned, and none the less because I have not attempted to startle them by any inventions of my own, but tell only what I have seen, and that in a "plain, unvarnished" way. In these counties one will not fail to observe how the character and employment of the people depend upon the geological formations which underlie their habitations. Here are no rapid streams affording power for manufacturing purposes, and no iron or coal upon which to build the industries which depend upon them. No cities teeming with pressing throngs employed in the arts of busy life. The level surface of underlying rock, with the no less level superficial covering, the deep, black loam point to agriculture as the chief employment of the citizens of these counties. The character of the soil also determines the kind of agricultural products which may most profitably be produced; and thus the range of human employment is doubly limited. The soil of the larger portion of these counties, including nearly the whole extent of Fayette, is finely adapted to the growth of the most nutritious grasses, as well as the principal cereal grains. Hence stock-raising has very naturally been the chief occupation of the people. It is thus that the geological character of a country modifies the employments, and, to a certain extent, determines the character of those who dwell in it. Where good roads are easily constructed, and where ready access is had to all parts of a district, there is apt to be a high development of social qualities, and of the refinements of civilized life.

The land is held in large bodies, causing a sparseness of population, which has had, in times past, an unfavorable influence upon the character of public education. The great energy displayed in constructing public roads has rendered large school districts less inconvenient than they would be where good roads are impossible.

DRAINAGE.

The parting-line of the water-shed of the Little Miami and Scioto Rivers runs a little west of the line separating Clinton and Fayette counties. Consequently Clinton county is mostly drained into the Little Miami River, and Fayette county wholly into the Scioto. The drainage of Clinton county is mostly effected by Anderson's, Todd's Forks, and the East Fork of the Miami.

Anderson's Fork rises on the line of water-shed to the south of Reeseville, and flows in a circling channel, bending from north to west, and emptying into Cæsar's Creek, at a point without the county. No where in its course is this stream far above bedded stone, and at some points it runs upon strata of the Niagara formation, as at places in the "Prairie," at Judge King's, and at Port William it cuts through a portion of the *pentamerus* beds of this formation, where, besides the bed of the creek being wholly of this stone, the banks, from five to ten feet high, are also of the same. Above Port William the stream is sluggish, and traverses, for some ten or twelve miles, a district of marked character, known as the "Prairie," a tract of wonderful fertility, of deep, black loam, and which has been, at no very distant past time, the location of a shallow lake or swamp. The highest land, I suppose, in the county is north-east of this "Prairie," and is, perhaps, not far from seven hundred feet above low-water mark at Cincinnati. I was not able to obtain the elevations of the Cincinnati and Muskingum Valley Railroad, which traverses both the counties of Clinton and Fayette, and therefore lack some data necessary to state with exactness the elevations of the different parts of these counties. But by the kindness of Mr. J. H. Klippart, of Columbus, I obtained those of the Marietta and Cincinnati Railroad, and shall have to refer the elevations of the portions of these counties to those of this road. The highest point in Clinton county on the Cincinnati and Marietta Railroad is a point a little east of Vienna, which is 737½ feet above low-water mark at Cincinnati. Anderson's Fork receives but few tributaries in all its course, the tract which it drains being comparatively long and narrow. The bedded stone in its channel is of the Niagara formation as far down as the Lumberton quarries, where it strikes and cuts nearly through the formation known to geologists as Clinton, and at a point a few miles further down stream, at Ingall's Dam, just outside of Clinton county, it cuts about four feet of purple-red shale underlying the Clinton, and strikes the higher strata of the Cincinnati group, or Blue Limestone.

Todd's Fork, with its tributaries, drains the central and western part of the county. Running in a course in general parallel with the last named stream, and within three or four miles of it during the most of its course, it could receive few and unimportant tributaries on the side next to that creek, of which Dutch Creek is the only one worthy of being named. On the other side there are three, which I shall mention. The smallest of these is Lytle's Creek, draining the immediate vicinity of Wilmington, and along which the Cincinnati and Muskingum Valley Railroad runs. *Cowan's* Creek rises on the north of the "Snow Hill" ridge, and in respect of length and of alluvial bottom, is even more important than the stream to which it is nominally tributary. *East Fork* rises near Martinsville, and has cut for itself a channel in some places, as within three or four miles of Clarksville, nearly one hundred feet deep in the Blue Limestone.

The East Fork of the Miami drains that part of the county south of the Cincinnati and Marietta railroad, including the neighborhood of New Vienna, and the region south of "Snow Hill" ridge.

All these streams have in years past furnished motive power for grist and saw-mills, which have, in most instances, been suffered to go to decay upon their banks, on account of the failure of a supply of water sufficient to turn their wheels during enough months of the year to make it profitable to keep up the mills. This is due, in considerable degree, to the failure of the water in the streams during the late summer and early fall months. The water which fell during the winter and spring months, when the country was new and mostly covered with forest, was retained on the soil. The small streams were choked with rubbish, and the water stood on flats, protected from speedy evaporation by the dense foliage of the trees, and by the heavy coating of fallen leaves which covered the earth. No artificial drains were in existence. The water gradually trickled from these natural reservoirs, highly colored with the soluble elements of the partially decayed vegetable substances, and kept the streams with at least a partial supply of water during the most of the dry season. Then the mills and dams were less expensive than now, particularly the dams, which were no more than cheap structures of logs and brush, intended chiefly to be of use in changing the current upon the wheel of the mill, rather than in detaining the water in a reservoir. Then the machinery of mills was simple and inexpensive, and was suffered to lie idle without detriment during the season when water was insufficient to turn it. Now numerous improvements have been made in mill machinery, without which such quality of flour as is now in demand cannot be made, and these, being patented, are more expensive than the machinery which they displaced. More expensive dams are necessary to retain a large quantity of water. Formerly the miller was also generally a farmer, and could make profitable use of the dry season in tilling his farm. For such reasons as these, although the same quantity of water still flows through the same channels, the mills are in decay, and the mill seats abandoned.

DRAINAGE OF FAYETTE COUNTY.

A glance at the map of this county shows numerous water-courses traversing the county from its northern to its southern border, varying but little in direction. These streams are all somewhat sluggish in the upper half of their course, but they have quite sufficient fall to constitute an ample system of drainage. At an early day in the settlement of this part of the country, the greater portion of the county was too wet for the plow, but since the channels of the streams have been freed from obstructions, and the water has been carried into the water-courses by ditching, this county has taken rank as one of the first agricultural counties of the State.

The water-courses present a singular uniformity in respect of direction and tributaries. The main water-channels are nearly parallel with each other, and they take the same general direction, uniformly to the east of south. This is as true of Deer Creek as of Paint Creek and its tributaries. We notice another characteristic of all—the tributaries of all the streams put into them from the west. There is no exception in the county—no instance of any tributary, more than a branch a few hundred yards long, coming from the east; in fact, the tributary branches of all the creeks of the county rise within a score or so of rods of the bank of the next creek to the west. This shows to the most casual observer that the whole county sheds to east and south, and that as the lowest land in the county is at the point where the water leaves it, so the highest may be looked for in the region whence it flowed—to the north-west.

From Mr. James McClean, County Surveyor, I learn that Deer Creek is about 100 feet lower than North Fork of Paint on the line of the White Oak turnpike; that Compton's Creek, on the line of the New Holland and Bloomingsburgh turnpike, is 50 feet higher than North Fork, and that East Fork is 87 feet higher than North Fork, and Main Point 104 feet higher than the same stream—so that if this turnpike were a canal all the water north of Washington could be readily turned into North Fork. The rise in the land from Washington to the northern boundary of the county is estimated at not more than 50 feet; and from the extreme north to the south along Paint Creek the fall is not far from 210 feet. As the railroad bridge at Greenfield is 451 feet above low-water mark at Cincinnati and perhaps 75 feet above the bed of the creek at the Fayette county line, the point of Paint Creek where it leaves Fayette county would be 376 feet above low-water mark, at Cincinnati, add 160 feet, the elevation of Washington, the county seat, above Paint Creek at the southern line of the county, and the elevation of this town above low-water mark of the Ohio River, at Cincinnati, is about 536 feet or 968 feet above tide-water. It will thus appear that the average elevation of Fayette county is about 200 feet less than that of Clinton county.

If we trace the line of outcrop of the various formations from the point in the western part of Clinton county where Todd's Fork leaves the county, we shall find that the strata of stone seen under those we meet, proceed to the east, and if a well were dug deep enough at Washington or Wilmington, it would cut through all the strata found to the west as far as Cincinnati. A well sunk at Washington would first penetrate the strata overlying those exposed at Rock Mills, and passing through these would penetrate the strata represented on Paint Creek below Rock Mills, as at Rogers's, and at James's, and then would reach the stone so abundant on Rattlesnake from the line of the Washington and Leesburgh road to the south, and passing this would penetrate the water-lime building-stone of Greenfield and Lexington, and going deeper would penetrate the great Niagara system one hundred and fifty to one hundred and eighty feet thick, which is found immediately under the city of Wilmington; cutting through this it would next reach the Clinton iron ore and then the stratified stone of this formation, about thirty feet in thickness, and then after cutting through three or four feet of a ferruginous clay would reach the Cincinnati group or Blue limestone, and in about one hundred and twenty-five feet would reach the strata which are seen in Todd's Fork where it flows out of Clinton county.

It has been stated that the average level of Fayette county is some two hundred feet lower than that of Clinton county, while numerous formations overlie in Fayette county those found exposed in Clinton county. The explanation is easy. It is observed that all the strata which have been named dip to the east. They do, indeed, dip more, rather than less, than sufficient to make up the difference in the level of the counties, and it is likely I have understated rather than overstated the difference in level, as it was impossible to get the levels of the Cincinnati and Muskingum Valley Railroad, which would have enabled me to be more exact. I have calculated that the water-lime building-stone, as seen at Lexington and Greenfield, dips from thirty-five to forty feet per mile to the east (it dips also to the north). In fifteen miles the dip would be between five hundred and fifty and six hundred feet; subtracting two hundred feet, the difference in level, there would be left three hundred and fifty to four hundred feet to be made up in Fayette county by additional strata.

DENUDING AGENCIES.

After the deposition of the rocks now found in Clinton and Fayette counties, the surface was not long, at any early geological period, beneath the surface of the sea. While the deposit of sandstone which extends almost from the very border of Fayette county to the south indefinitely, and to the east, underlying the coal, was being made, the land to the north was above water, as well as when the deposits above the sandstone were made; at least, whatever material, organic or inorganic, was ever deposited here, has long since disappeared. We have some evidence, however, that the slate which immediately underlies the sandstone extended somewhat further north than the sandstone itself has been found. In Fayette county, near Rock Mills, about one hundred and twenty-five feet above the bed of the stream, on the farms of A. J. Yeomans and Aquilla Jones, as also on the farm of Mrs. McElroy, a mile west of Paint Creek, and near the southern line of the county, a slate formation is to be seen capping the highest point of land in the southern half of the county. This material must once have been continuous, and may have extended further than any traces of it are found at present. We have abundant evidence in both of these counties of agencies which have operated in comparatively recent geological periods, and which have worn away deposits formerly existing here. We find that the surface of the existing bedded rock has been worn away and channels have been cut in it. Where the loose material which now overlies the bedded rock has been removed, we find markings upon the surface of the exposed rock, if this is of such a nature as to resist atmospheric and other agencies which would cause the surface of the rock to disintegrate, which indicate that some agency has been at work to grind down and wear and smooth the surface. But unfortunately the nature of the stone underlying the clay in these counties is such that it would not generally retain any striæ of a delicate character. We do, however, find stone well polished and delicately striated in Paint Creek. The exact locality is in Ross county above Greenfield, on the Indian Creek road, about 300 feet up stream from the beginning of the head-race of Smart's Mill, the last place on the east side of the road where stone has been quarried and about 30 feet above low-water in the creek. I removed the sand and gravel myself from the exceedingly well polished surface of the rock. Mr. John Sollars reported striated rock in a locality on his place, and another locality was visited by me on the same stream above Rock Mills. At Roger's below Rock Mills the gravel contains many blocks of well smoothed stone, and at Rock Mills, just north of the village, many large bowlders of quartz and granite are mingled without stratification with the gravel, and constitute no inconsiderable part of the extensive beds. At J. C. Sinsabaugh's, near Bloomingsburgh, I saw a block of stone one foot thick, two feet long and sixteen inches wide, which had been taken from a gravel bank on his farm, and which was well worn on a portion of one side, was very smooth and marked with striæ, but the edges or corners were not rounded or broken. This was a hard, dark colored stone which gave out a ringing sound at the stroke of the hammer, and seemed to be of the same material as a drift-stone which I saw at Mr. Hegler's, on Herod's creek, in Ross county, which contained *Tentaculites* in abundance. Formations in Clinton county, which were formerly continuous, have been partially removed, as on Cliff Run the Clinton formation is seen in its full thickness, while excavations show that its continuity is broken to the east of this locality, so that the exposure of white limestone on Cliff Run is a mere island of this kind of stone.

Besides the wearing away of the general surface and the removal of particular parts of formations, there were causes at work which have excavated channels far below the general surface. Ice, in the form of glaciers, is generally regarded as the means by which the denudation above alluded to has been effected, and moving water has doubtless been the instrument by which the deep channels have been excavated. These channels are only traced by observing the excavations which are made for one cause or another, the sinking of wells, and borings for water. An instance of this channeling is noticed in that region in Clinton county know as the "Prairie," where it has been frequently observed that there are places apparently forming a continuous line, where rock is not found at any depth yet reached, although on each side it is but a short distance to the undisturbed strata. This channel has not been thoroughly, but, so far as observed, nearly, coincided with the direction of the present Anderson's Fork. Doubtless where the bottom of Anderson's Fork is the bedded rock, the old channel was cut to one side or the other of that in which the water flows at present. Connected with the fact of the existence of such deep drainage at a former period, is implied that the whole country was at a much greater elevation above the sea than it is in our time.

THE DRIFT.

The old channels became silted up, and other accumulations were made subsequent to the period of denudation. The surface of the land must have sunk down so as to be beneath the surface of the water. Every indication points to water as the medium by which the deposits were made. Upon the surface of the stone is everywhere found more or less of loose material. The study of this material in both these counties is full of interest. The Drift is composed of clay, with varying proportions of sand and gravel, with occasional rounded blocks of granitic rock, and with the remains of trees, and sometimes of other vegetation. The greatest thickness of the Drift in our district is in Clinton county, east of the "Prairie," where a deposit of over one hundred feet is found. Whether the whole surface of the county was once covered as deeply as this limited area, may admit of doubt; but there are reasons for believing that the surface was once covered with a heavy Drift deposit. In some places the soft material has been washed away, leaving large accumulations of sand and gravel; in other places, as in the level region between the East Fork of Todd's Fork and Blanchester, the material of the Drift was a finer sediment than is found in other places, and has not been removed or disturbed to such a degree as in other portions of the county, and, consequently, even if sand and gravel exist in it, such extensive beds of these substances as are found where the sediment had a different character or was subsequently washed in currents of water.

The clays of the Drift are both blue and yellow, the former apparently prevailing in both counties, as shown in the excavations for wells. There was considerable variation in reports of the strata penetrated in sinking wells, but blue clay, or, as it is frequently called, blue mud, from its appearance, was uniformly found, but there was no uniformity in the thickness of it. Sometimes it is but a few feet in thickness, and in another place, not a mile distant, it is no less than forty feet thick. It is generally interstratified with sand and fine gravel, but sometimes no such stratification is seen. Water is found nearly everywhere within a very few feet of the surface of the earth, so that it is seldom excavations were carried further than from ten to twenty feet below the surface, and our knowledge is limited of the material underlying to this slight extent. Near Washington, on the farm of Mr. D. Waters, the blue clay is interstratified with sand, while on that of Mr. Noah Evans, adjoining, there is a continuous deposit of the same material of forty feet in thickness, with gravel. This blue clay being impermeable to water, it is when beds of sand in it are reached that water is obtained, and usually in abundance. In some parts of our district, particularly those which are flat, there does not occur, within the usual range of the wells, much, if any, yellow clay. If it is found, it is just below the soil for from three to ten feet, where fine-grained blue clay invariably occurs, interstratified with sand.

BOWLDERS.

These are found scattered over the surface of both counties, and seem to belong above the blue clay deposit, rather than in it. The largest bowlder, perhaps, which is found so far south in this State, is found in Clinton county, on the county infirmary farm, near Wilmington, and this lies on the fine-grained blue clay, upon which it would seem to have fallen by the washing away of the clay in which it was formerly imbedded, and which, at a higher level, lies near it on all sides. This bowlder contains about twelve hundred cubic feet, and weighs upwards of ninety tons.

Other large bowlders are found in the extreme northern part of Fayette county, scattered numerously over the surface of the ground, and weighing from twenty to thirty tons. Besides these large erratic blocks, smaller ones are found more or less abundantly everywhere throughout these counties, especially in the northern half. They are found lying on or near the surface, where they have been left by the removal by water of the material deposited with them.

GRAVEL AND SAND.

Mingled with the drift is always found a considerable proportion of these substances, but being scattered throughout the whole mass, or at most, showing only a slight tendency to be distinct in strata, more or less mixed with soft material. Where the original drift is in quantity and undisturbed, the sand and gravel in it are not available for economic purposes. A few years ago these counties were thought to be lacking in these important adjuncts to civilization. It was not until within the last five years, when the demand for gravel for road-making became exceedingly urgent, that thorough and exhaustive, and, as the result proved, successful search was made for it. It is now known that no real deficiency exists. People have learned where to look for it. When the currents of water carried away the lighter material of the drift deposit, those constituents which were heavier were left behind. We may regard the highest land as the former level of the region we are speaking of. There was then a deposit of loose material, sometimes a hundred feet in thickness above the bedded stone. This material was manifestly deposited from water. And to account for the character of the markings upon the rock surface and the promiscuous intermixture of clays, sand, and gravel, and sometimes a certain limited measure of stratification, or assorting of the material according to their weight, and for the evidently remote origin of the stony constituents requiring that they should have been brought hither, and especially for the numerous bowlders conspicuous both for their size and clear marks of foreign origin, we unhesitatingly come to the conclusion that ice in some form contributed to the same end. Water in a liquid state alone could not carry such material so far without having an enormous velocity sufficient to move before it not only the loose material, but the very stone beneath it. When the water subsided, new lines of drainage appeared, corresponding more or less, depending upon the physical features of the country, with preëxisting ones. The emergence of the land was gradual, and the subsiding water stood for greater or less periods of time at different levels, which may be pointed out to-day with more or less distinctness. During the emergence of the solid earth, the currents of water carried away some of the material constituting the drift sediment of the former period. The channels of drainage mark the direction of the current. Within these channels the drift deposits were removed sometimes to the bedded rock. The varying force of the currents distributed the material as we now see it. Strong currents carried all before them; weaker currents only the more refined sediment. Any current bearing substances along will deposit the heavier material first when the current becomes checked. It is thus that matters carried in currents of water become assorted and distributed. When a current bearing sediment finds a wider channel and expands, the current is checked at the side upon which it finds room to spread out. Here will be a deposit of the heavier part of its freight. If two currents meet at the point of intersection, the currents will be retarded, especially if one be more swollen than the other, and the heavier material carried will be deposited. Where now are mere brooks, the ample extent of the washing, the broad valleys, show that rivers once flowed. Wherever the drift clays were not washed, the gravel lies interspersed through it; but where the clays are broken, where valleys have been cut in them, on the sides of these cuts, on the escarpment of the broken clay and gravel drift, the clay has been removed and the gravel is left in beds. Following the principles before referred to in regard to the laws of sedimentary deposits, the road-maker of to day may find the deposits of gravel he needs. Along the declivity, where two former currents met, far back from the meeting point of the diminutive stream of the present time, on a point and looking from the higher land, he who seeks this useful material need not look in vain. As there were various levels of the water at that far distant period, so are there several elevations at which gravel is actually found. In addition to those beds on the escarpment of the hills, there are found hillocks or natural mounds of gravel which represent eddies, or places in which for some cause the water was more quiet, and hence, unable to carry forward all its load of sediment. Besides these, the soil of the present bottoms is in many places underlaid with ample deposits of gravel.

Drifted wood is found in the blue clay in all our district. The instances in which wood has been found in the clay beds, penetrated in well-digging, are by no means few, nearly every neighborhood furnishing one or more. A kind of jointed grass or rush was obtained from a well near Reeseville, in Clinton county.

Bones.—The gravel, which lay so long hidden from the knowledge of the present inhabitants, was almost uniformly made use of as places of interment by some former race of people. Scarcely a gravel bed ha been extensively worked in either of these counties in which abundance of human bones have not been discovered. The skeletons are usually found within two or three feet of the surface. We are left to conjecture in giving any reason why this material was used in which to make interments of the dead. Trinkets of any description are extremely rare in such graves, although not entirely unknown. In none, of which I heard, were there any indications of unusual care or elaborateness in the interments. Possibly the ease of excavating a grave in such a material may have determined the choice. But is it not a little singular that the inhabitants of a long-past age should have known the position of these gravel beds, covered, as they were, with a dense forest; while two generations of the intelligent people of this age had not any thought of their existence until within a half dozen of years?

Stone implements.—Flint, arrow and lance-points, stone-hammers, bark-peelers, hematite fishing bobs or sinkers, and other articles of this class are found especially along the water-courses. As no value and but a passing interest have been attached to these articles, they have not been preserved, but have been broken up or lost. Still many are found yet by persons engaged in working the soil. No one locality has furnished more than the borders of Deer Creek, but they are common on all the streams, and, indeed, over the whole surface of the county are they found. As the soil in Fayette and in parts of Clinton has not been subjected to the plow as much as in other places, and, of course, some of it not plowed at all, there perhaps remain more still to be gathered than have ever been heretofore. Some persons, seeing in these articles a story of a former race of human beings, who have left but little else to tell of their manners or civilization, are gathering them up to preserve them from destruction. Nothing more amazes one in contemplating these relics of a people of a long past age than the immense number of them scattered over the surface of the earth. Perhaps no single acre of ground in Central or Southern Ohio but has furnished at least one flint arrow-point; but the average would be much greater than one to the acre, and it is not too much to say that every farm, at least, has furnished sometime a stone hatchet or bark-peeler.

Hematite bowlder.—In Clinton county, near the residence of Samuel Lamar, one of the county commissioners, I found a hematite bowlder weighing about two hundred and fifty pounds. This was extremely hard and seemed to be of the same material from which the sinkers, referred to in the last paragraph, were made.

Flow-wells.—There are several wells in each county, from the mouth of which the water constantly flows. The well at the fair ground, near Washington, is a good illustration of the principle of the *artesian* well. It was sunk through a stratum of blue clay to one of sand, from which the water rises and comes to the surface. About one mile distant is a well on the farm of Mr. D. Waters, in which the water rises to within six feet of the surface of the ground. The use of a level shows that the ground rises about the same number of feet between the fair grounds and Mr. Waters's, and this person must dig as much deeper to penetrate to the water bearing stratum of sand. The water stands on the same level in Mr. Waters's well as at the fair grounds.

THE BOUNDARY LINE OF CINCINNATI GROUP.

The line separating the blue limestone and the Clinton white limestone is easily distinguished. It may be distinguished in all the streams in the western part of Clinton county, which all cut abruptly through the Clinton and into the blue limestone. I shall here indicate where that line runs, beginning just without the county, on Anderson's Fork, near Ingall's Dam, where the upper beds of the Cincinnati Group and the Clinton formation are seen at one glance. To the west a mile or two, on Cliff Run, as well as on Buck Run, the Clinton stone may be seen forming low cliffs, cut off from the main body of the formation; but the true line is on Anderson's Fork, as mentioned above. On Todd's Fork, just above the crossing of the Lebanon road, near the line which divides the surveys, 1554 and 1556 (H. Gates), the same formations are seen in juxtaposition. Further south, on Lytle's Creek, was not seen; but on the next stream, Cowan's Creek, the line of the Clinton sweeps around to the east and appears above the village of Antioch, on the farm of Mr. James Gregory, and does not here rise above the surface of the earth. The next point in the line is back to the west, about one mile north-east of Martinsville, where it is quarried, and then its next appearance is at a point about one mile south of Farmer's Station, on the Cincinnati and Marietta Railroad, on a tributary stream of the East Fork of the Miami. The last point at which the blue limestone is seen on the East Fork of the Miami, is near Pitzer's meeting-house, on the edge of White's survey. The very interesting fossils of the blue limestone of the Cincinnati Group will be figured in volumes of this survey, devoted to the subject of paleontology.

THE CLINTON FORMATION.

This is seen on Anderson's Fork, at Oglesby's quarry, and in Todd's Fork from the point of its first appearance, near the Lebanon road, to

Babb's quarry in the base of the Niagara. At either of these localities the whole of the formation may be studied.

The lower strata have the distinctly sandy constitution characteristic of this formation, from which the stone is frequently called sandstone. These strata are good fire-stones, and resist the action of fire as a back wall in fire-places, for a generation, without softening or crumbling. But the strata a few feet higher are burned into lime, and make a medium quality for building purposes, and, no doubt, a very good quality of caustic lime for softening straw in the manufacture of paper. Some part of the ten feet of massive stone furnishes good building material. This stone has been obtained in Todd's Fork, but is expensive on account of thickness of superincumbent stone of a poor quality which must be removed before good stone can be reached. On Anderson's Fork, at Oglesby's quarry, the same stone is more accessible, and is the best building stone obtained from this formation. The quality of this stone at Oglesby's has led some to refer it to the Niagara. But it has the hardness and gritty character of the Clinton, and on surfaces which have been exposed in the quarry to the action of atmospheric agencies for a period of several years, it is seen to be composed almost wholly of a solid mass of broken encrinitic stems. Aside from lithological characters, this stone at Oglesby's is in the Clinton horizon about mid-way from top to bottom, exclusive of the iron ore in the upper part. The twelve feet from the top of the Clinton is well seen from the under-strata at Babb's quarry, on Todd's Fork, down stream to the locality of the iron furnace formerly erected to work the ore. This twelve feet is highly fossiliferous throughout, but it is only in a few feet at the bottom where the proportion of iron is large enough to entitle it to the name of iron ore. In this part the imbedded fossils are deeply colored by the iron. For some reason the furnace erected here about twenty-seven years ago did not prove a success, and was soon abandoned, although the quality of iron was regarded as very good. The richest ore is a brittle stone, mostly composed of small, exteriorly smooth and shiny lenticular grains, reminding one of flax-seed. The ore is easily crumbled in the hand, and contains numerous disjointed crinoidal disks, partially eroded. The species of fossils become more numerous as we approach the higher strata. Sometimes the stone is highly granular or crystalline, while still crumbling easily in the fingers, and is less ferruginous, and the imbedded fossils become light-colored. The iron ore occurs in considerable quantities, being exposed in an outcrop along the slopes for several miles, and large quantities could be obtained by stripping. If it were more convenient or nearer furnaces in operation, it might become valuable to mix with other ores in making certain qualities of iron, particularly if it should be found to serve likewise as a flux. The fossils in the upper beds are better preserved than in the lower, but good cabinet specimens are difficult to obtain. That locality alluded to before as Grubb's quarry, in the southern part of the county, abounds in fossils, and I recommend it as a promising field for palæontological research. It was but little opened at the time of my visit, but as the stone obtained seemed to answer well for building purposes, it will doubtless be further developed and furnish many fossils, and possibly some that are new to science.

	FEET.
Highly fossiliferous courses	12
Massive courses, hard and gritty, showing crinoidal stems on weathered surface	10
Strata alternating with clay	5
Ferruginous clay, separating the limestone from the blue clay below	3

THE NIAGARA FORMATION.

This designation, as well as many others in our geology, including the subject of the last paragraph—the Clinton—are derived from the account of the geology of the State of New York published some years since, and are taken from the occurrence of these strata in well known localities in that State.

The Niagara formation is not exposed very extensively in Clinton county, and dips far under the surface in Fayette. It lies immediately on the iron-stone or ore just referred to at Babb's quarry, on Todd's Fork. Here, proceeding from the upper strata of Clinton in the bed of the creek, near Babb's quarry, we find, commencing at the Clinton, thence upward:

Blue clay with purple tint	4 inches.
Blue clay	4 "
Stone stratum	1 inch.
Purple or red clay, unctuous feeling	4 inches.
Blue clay	4 "

The best Niagara building stone in the county—smooth, fine-grained, even-bedded limestone—approaching in quality some sorts of marble.

The supply of this building stone, however, is limited and much below the demand. In the inferior strata no trace of organic remains were found, their fine, even texture suggesting that they may have been deposited as calcareous mud in quiet water. In no part of the twelve or fifteen feet here exposed were organic remains found, except in the most meager quantity, here and there occurring a small mass of coral which is completely incorporated in the substance of the stone, being unbroken and standing upright as it was formed, having been silted up by fine, sedimentary deposits. Above this building stone the system assumes that loose and porous character so often observed in this formation, full of casts of large *Pentamerus oblongus* and other fossils, with numerous small cavities stained with carbonaceous matter. At Port William the exposure on Anderson's Fork was perfectly characteristic of this formation, the jagged and cavernous masses being worn and corroded by the elements into fantastic shapes.

But the most interesting exposure of this formation in the county is that known as Black's quarry, near Snow Hill, where the strata belong to the upper portion of the Niagara. This is a highly fossiliferous stone, but unsuitable for building purposes, as it is soft and porous and can be crumbled in the hand. The stone used in constructing the Vienna and Wilmington turnpike was obtained here. The fossils are difficult to obtain without being broken, but many of them are very good specimens, the most delicate markings being preserved. The stone is so fragile that the specimens are greatly injured by handling, and can not be packed in the usual manner without detriment. Among those I brought away I find a *Rhynchonella cuneata*, an *Athyris*, a *Polypora* and *Striatopora*, and a *Favistella plumosa*. The molluscous fossils obtained were casts of the shells, the interiors being entirely empty and showing the muscular impressions with great distinctness. It will doubtless repay the palæontologist richly to make a thorough exploration of this quarry. If there is any economic value in the product of this quarry, not heretofore discovered, I suggest that it may be as material for lime. The best quality of building lime is manufactured in other localities from stone obtained in this horizon of the Niagara formation. There may be a question of its practical utility for this purpose on account of the liability of the stone to break up. There were indications that in some portions of the quarry the quality of the stone might be less liable to this objection. So far as my observation extended, this portion of the Niagara occurs nowhere else in our district. All the bedded rock eastward of the localities I have named, where the Niagara may be found, belong to the same formation, as all places where stone in position is found along Anderson's Fork, near Wilmington, and also near Reeseville.

THE LOWER HELDERBERG, OR WATER-LIME.

This formation occurs next above the Niagara, and overlies it in Fayette county. The Niagara dips to the east and the Lower Helderberg overlaps it. On Rattlesnake, in Fayette county, about one hundred feet in perpendicular thickness of this stone are accessible to observation. The exact locality where the greatest thickness can be observed is on the Washington and Leesburg road, west of Rattlesnake Creek—the hill in the rear of the school-house has an exposure near the summit. Going from the Falls of Rattlesnake, near Monroe, in Highland county, against the stream, after leaving behind the Niagara at the Falls, and some distance above, the next stone in position is the Lower Helderberg. The fine building stone of Lexington and Greenfield belongs to the lower strata of the Water-Lime. The same quality of stone has not been found on the Rattlesnake; whether it occurs there or not remains to be seen. Within the Fayette county line, along the creek, from one hundred to one hundred and twenty-five feet in perpendicular measurement are found. In the lower strata of this exposure numerous bivalvular mollusks were obtained which I have not identified. On Paint Creek, near Smith's Mill, a profusion of a small mollusk, in a broken and confused condition, was noticed. These I did not find on Rattlesnake. In the higher strata no organic remains were obtained. This stone, through the entire one hundred and twenty-five feet, maintained strikingly the same characteristics. When exposed to the air in masonry, this stone resists the weathering influences on the *surface*, but is liable to shell off and actually becomes fissured, through and through, until massive blocks become nothing more than a tottering collection of loose splinters and fragments. This stone is not now approved as material for bridge abutments or foundation walls. If a slab from eight inches to a foot in thickness is struck a few smart blows with a hand hammer, it not only fractures through and through, but breaks into pieces often not more than one or two inches in any dimension. The fracture is, in every instance, conchoidal. The stone is of an uniform texture, new fractures having a velvety appearance, with a fresh, brown color. It has been burned into lime, but I could not ascertain anything definite as to its quality. As the stone contains lime and alumina, there may be some portions of it adapted to the manufacture of hydraulic lime. Some of the higher strata resemble the Rittenhouse stone in the northern part of Ross county, which makes a good quality of water-lime. The striated rock on Paint Creek, near Smart's Mill, spoken of heretofore, is referred to this formation as the equivalent of that on Rattlesnake. There does not occur any more bedded rock on Rattlesnake above this development not referred to. But above the exposures near Smart's Mill, on Paint Creek, occur strata successively as one ascends the stream. In fact, all the bedded rock which occurs in Fayette county, except a limited exposure on Deer Creek, in the extreme eastern part of the county, is represented in that which is encountered on Paint Creek from near the southern boundary line to the vicinity of Rock Mills. To keep the continuity of strata, as we proceed in our investigations, we shift the scene from Rattlesnake to Paint Creek.

The next outcrop ascending this stream, above the striated rock in the vicinity of Smart's Mill, in Ross county, is above the bed of the creek and one or two miles up stream from the last locality on the farm of Mr. Evan James. Here, we observe, a marked change has taken place in the lithological character of the bedded rock. I had no instrumental equipment which would enable me to ascertain whether or not this stone was conformable in dip with that of the last exposure. A considerable difference in altitude existed between the two exposures, but the intervening formations were not visible. The stone at James' is a limestone, light in color, and fine grained, a good quality of stone for building purposes. The quarry was but little worked where the building stone had been procured, but a short distance further up the stream, the strata near the creek are very thin, often not more than one-half an inch thick and none more than two inches thick, nearly white in color, and show finely sun and water cracks. These marks are delicate but distinct, and roughen the surface but little. They seem to have been formed on the beach of a shallow, quiet water. The stone is fine in texture and soft to the touch. These strata are traced along the creek for about two miles, getting somewhat thicker in the upper part of Rogers' quarry. In no part of this distance were any organic remains discovered, but on the Washington and Greenfield turnpike, fifty or more feet higher on the horizon and about west from the point of first appearance of the bedded rock in the creek, in the ditch by the road side, occur strata which show clearly marked indications of a lamellibranch mollusc less than a quarter of an inch in its longest measurement, also very distinct and beautiful fucoidal impressions. The fractures showed delicate markings of *dendrites.* This is perhaps the same stone which occurs west of this locality at Mrs. Doster's on Walnut Creek, and has a local reputation as a fire-stone.

Another and more massive exposure occurs two miles above Rogers', a harder stone than any found below on Paint, and in some respects reminded me of the Clinton.

The locality of Rock Mills presents more points of interest to the geologist than any other in Fayette county. Below is a section of all the strata visible in this vicinity.

	FEET.
Yellow clay, seen on ridge east of the creek	5
Blue clay, " " "	5
Shale or slate, " " "	10

	FEET.
Strata of stone unconformable with those next below, seen best just above "Lower Cedar Hole," contains a stratum of breccia	50
Fossiliferous, top strata at west end of bridge, thin strata one-half an inch to six inches thick, said to be	10
These, with the 11 above non-fossiliferous	15
"Fossiliferous ledge," all the fossils in the quarry obtained here	1
To creek bed not seen	40

The fifty feet or more of strata near "Lower Cedar Hole" did show about one foot in ten to the south. The upper strata contained no fossils so far as seen, but near the bottom occurs one stratum which is composed in part of breccia. The fragments are about one-eighth of an inch thick and are clearly defined, and imbedded in a matrix of a lighter color. A portion of one of the strata was almost wholly composed of what seemed to be internal casts of a small shell—probably *Loxonema hydraulica.* Hall.

I shall add no further remarks to those which have been made above, except that the stratum marked as being fossiliferous above, contained many fragments of *orthoceratites.* No good cabinet specimens of any kind of fossils were secured here. The strata above the fossiliferous one are nearly all water-marked, or rather sun-marked as if dried or baked in the hot sun. They exhibit no signs of fossils, either animal or vegetable. From this locality the building stone used in Washington and vicinity is mostly obtained. The pavements are flagged with the thin sun and water marked stones.

The only strata in the county higher than those at Rock Mills are found on Deer Creek, in the eastern part of the county. It would be difficult to assign these strata to their exact position without tracing them down stream on Deer Creek.

CHAPTER LXXV.

REPORT OF THE GEOLOGY OF SHELBY COUNTY.

BY JOHN HUSSEY.

This county is situated in the second tier of counties from the boundary line between Indiana and Ohio, and about half-way of the State from north to south. It is bounded on the north by Auglaize county, on the east by Logan and Champaign, on the south by Miami, and on the west by Darke and Auglaize. The county seat is Sidney. The water-shed between the Maumee and Miami River systems is partly in the northern part of this county. The road known as the Kettler turnpike, in a general way, may be regarded as marking the line of the water-shed, at least for some miles of its course, nearest the Laramie Reservoir. The water-shed bears to the north-east, after leaving this county, into Hardin and Wyandot counties.

ELEVATION OF THE COUNTY.

At Cincinnati, low water in the Ohio River is four hundred and thirty-two feet above tide-water, and the water in the Sidney Feeder is five hundred and twelve feet above low water in the Ohio, or nine hundred and forty-four feet above tide-water. The greatest elevation yet measured in the county is one hundred and thirty-four feet, on the Towana turnpike, east of the Miami River. The line between this county and Champaign, on this turnpike, is one hundred and twenty-one feet above the water in the feeder. The greatest elevation on the line of the Stewart turnpike is one hundred and twenty-one feet, and on the line between Shelby and Logan counties one hundred and eleven feet above the water in the canal. On the Infirmary turnpike the greatest elevation is eighty-seven feet, and at the end of this road, on the line between this county and Miami, it is forty feet below the level of the canal. On the St. Mary's turnpike, about two miles from Sidney, the highest point is reached at one hundred and twelve feet above the water in the canal. The bottom of the reservoir is about eight feet above the water in the canal. The main canal extends entirely across the county, running in a north-westerly direction from a point on the southern boundary line about midway of the county, from east to west. The Sidney Feeder is twelve miles in length, and extends from Port Jefferson to Lockington, and is the channel through which the water from the great reservoir at Lewistown reaches the summit level of the canal. The Sidney Feeder and the main canal above Lockington are on the same level, and the water from the Lewistown Reservoir flows indifferently north or south. The Summit level of the Miami and Erie Canal is, therefore, the same as that of the Sidney Feeder—nine hundred and forty-four feet above the level of the sea. The highest land in the county (so far as any measurements have extended) is one thousand and seventy-eight feet above tide-water, and six hundred and forty-six feet above low water in the Ohio River at Cincinnati. To aid in the comparison of the elevations in this county with other portions of the State, I will here give a few measurements taken from Prof. Orton's Report of the Geology of Highland county, in the volume for 1870, p. 258. At the head-waters of the Scioto and Miami Rivers, in Logan county, an elevation is given, on the authority of Col. C. Whittlesey, of one thousand three hundred and forty-four feet, which is two hundred and sixty-six feet greater than any in Shelby county. A measurement still greater is given of a summit in Richland county, one thousand three hundred and eighty-nine feet above the level of the sea. The highest land in the State, so far as known, is a point about three miles north-east of Bellefontaine. Its elevation above the sea, as determined by Prof. F. C. Hill, for the Geological Survey, is fifteen hundred and forty-four feet. The summit level of the canal in this county is four hundred feet lower than the water-shed between the Miami and Scioto Rivers in Logan county. This statement will show the resources of the canal for water-supply in this direction. The surface drainage and spring-water of a surface of about nine hundred square miles, must be available at the head-waters of the Miami as a supply for the canal above the summit level—one-half of which, with other resources, would float a tonnage greater than was ever floated in the canal.

TOPOGRAPHY OF THE COUNTY.

From the preceding statements it will be seen that the surface of the county is little diversified in regard to elevation. There are no hills or deep valleys giving variety to the climate or the productions, or producing picturesqueness of scenery. While the surface is everywhere rolling and well drained, the difference in level from the lowest to the highest point within the limits of the county is but little over two hundreed feet. The water from the summit level is locked down southward from

Lockington altogether by six locks, an aggregate of sixty-seven feet, in detail as follows, commencing at the lowest lock: No. 48, from the Ohio River, the lift is ten feet; passing over the Loramie by an aqueduct, Lock 49 has a lift of eleven feet; the 50th and 51st have each a lift of eleven feet; the 52d and 53d each twelve feet—in all sixty-seven feet. If the water in the bed of the river at the county line is twelve feet below the level of the canal, that would make the lowest point in the county seventy-nine feet below the highest level of the canal; add one hundred and thirty-four feet for the greatest elevation of any point in the county above the canal, and we have the difference in level between the lowest and highest points in the county, which is two hundred and thirteen feet. This calculation includes the valley of the Miami. If we leave this out of the calculation, the variation in level of the upland, the larger part of the county by far, would not be more than about one hundred and twenty-five feet.

The surface of the county, excluding the valley of the Miami, would average about seventy-five feet above the water in the canal. Before the water-courses had worn their channels in the drift, the surface nearly level, sloped gently toward the south from the dividing ridge; north of that line still less toward the north.

The drainage is very simple. The water which falls on the surface of the county is drained off by the Miami River and its tributaries, with the exception of a strip north of the Kettler turnpike, of a width of about two miles, and but little greater in the other dimension. This is drained into the Maumee. The Miami flows from the county on the south at a point about midway from east to west. Near this point it receives its most important tributary, the Loramie, coming from the northwest, along whose course in the county the Miami Canal is conducted. This tributary, besides performing an important part in the drainage of the county, is immensely valuable in relation to the canal, the Laramie Reservoir being formed in this stream. Coming into the county about centrally on the north, a small stream, it moves sluggishly over the flat district which forms the dividing ridge, and gradually moving its course to the west, reaches a point in its journey far to the western part of the county, where its course is turned to the south in connection with important accessions to its volume of water, cutting a decided channel and receiving important accessions from both sides, it gradually returns eastward to midway of the county, where it debouches into the Miami. It is in the upper part of its course, just where it leaves its sluggish meanderings on the high land of the watershed, that the important reservoir which receives its name from the creek is situated. There is a descent of seventy-five or eighty feet from the bottom of the reservoir to the mouth of the Loramie. The eastern part of the county is drained by other tributaries of the Miami. The Towana, formed by the junction of the Leatherwood and Mosquito creeks, is an excellent mill stream, and drains the principal part of the county east of the Miami River. From the appearance of this stream in the dry months of July and August, I conclude it is largely fed by springs, as the volume of water was kept up to a good stage when many other streams had failed. There are some copious springs in the county, but they do not form such a feature as they do in some other counties situated at a lower level. As might be expected, the high land west of the Miami has fewer and less copious springs than are found in less elevated localities in the county. In conclusion of this subject, the drainage of the county by natural channels is ample.

The Soil.—The character of the soil out of the river and creek bottoms depends upon the nature of the underlying drift. The drift will be spoken of more particularly further on. The soil in the river bottoms is composed largely of partially decompose vegetable matter. There is nothing peculiar about this class of soils in this county, except that on some of the tributaries of the Miami, as Plum Creek, there is an unusual body of it compared with the size of the creek. The explanation of this seems to be that in the upper course of this stream especially, the fall in the bed of the creek is often very slight, and the drainage was very imperfect. Before the country was cleared the water was still more impeded by rubbish and undergrowth, and it stood on the ground for at least a portion of the year. Large accumulations of vegetable mould took place, which the size of the streams, as seen to-day, do not seem adequate to produce. This mould is not alluvium, but the result of vegetable growth on the spot. It has not been washed thither by the water, but the vegetation which made it grew up in the swamps which existed along this sluggish water-course. The upland soil in the county is naturally divided into two classes, one called *black soil*, composed of the clay of the drift, mixed with a greater or less proportion of vegetable mould; the other is a *light-colored*, "thin" soil, with little vegetable matter. The dark-colored soil is related in origin to that of the creek bottoms or flats, just referred to. Wherever the water formed swampy districts, there accumulated vegetable matter. Some of these places were yet swampy at the first settlement of the county, and were shunned as unhealthy localities; but others, often extensive, were no longer swampy, but from channels being worn through them or out of them, were dry, and invited, not in vain, the early settler. The face of the country may have changed so that the land is readily drained at present, and this still be the true explanation of these black lands in this and adjoining counties. Moisture made rank and abundant vegetation, while it also impeded its entire decay. The partially decayed vegetable products accumulated, and mingling with the clay below, formed that rich, dark-brown loam. But there is unfortunately a larger area of thin and light-colored soil in the county than of the soil just described. This thin soil is not peculiar to this county, but is found in other counties situated in like manner. Its color shows it to be quite destitute of the products of vegetation. It differs equally from the yellow clay soils of the uplands of Butler, Warren, and Hamilton counties, and seems less capable of being made productive. The clay of this class of soils is impermeable to water, and is so situated that water has drained off readily, and has not stood upon it in natural swamps. The soil is composed of a fine-grained material and is compact, and sheds water like a roof. How the circumstances in which the fine-grained material was deposited differed from those in which other drift deposits were made, I will not undertake to state. This soil seems to have been exhausted rather than enriched by ages of primeval vegetation. What chemical analysis would show it to lack of fertilizing material, I cannot say, but the deficiency of limestone pebbles in it would indicate that it might be lacking in lime, and it has not had the advantage of being overspread with decaying bowlders, which add to a soil potash and other fertilizing ingredients. It seems to have been the least fine sediment deposited from receding water—lifeless water.

This soil, lying so as to drain away water, and not of a nature to absorb and retain it, became covered slowly with vegetation. But it always lacked that rankness and exuberance of vegetation which lower and moister places possessed. Still many, countless, generations of plants and unknown crops of trees have grown and decayed here without leaving behind them much vegetable matter commingled with the soil. What has become of the substance of plants that it has not accumulated in the soil? The answer must be that the growth upon this soil have passed back to their original elements—have gone as they came—in the form of water and gases. The bulk of vegetation is composed of water (oxygen and hydrogen), carbonic acid (carbon and oxygen), and nitrogen. When vegetation decays these materials are evolved, and pass off into the atmosphere. It is when decay is impeded that vegetable matter accumulates in the soil. Mould is partially decayed vegetation. When vegetable products are protected from the atmosphere by water their decay is retarded and impeded, and certain compounds are formed of a complex character, which do not so readily undergo decomposition. This is what we call vegetable mould, mixed with clay—loam. In dry situations, exposed to the action of the atmosphere, logs, grass, leaves, straw, utterly disappear and leave no trace behind. The same material heaped together, in wet situations, does not entirely decay, as every one must have observed, but gradually disintegrates, and becomes a uniform mass of dark-colored matter. A cool situation makes this process more sure and complete. Partially decayed vegetation becomes mould, muck or peat, according to the material, the location and extent of the process of decay. These vegetable compounds do not decay readily, but do gradually, and hence results a common experience in the use of muck as manure. Until a dissolution of the muck occurs, it will not nurture vegetation, hence it is often necessary for it to be exposed a season or two to the action of the atmosphere before it becomes sufficiently advanced in decomposition to give up its elements of fertility to vegetation. My conclusion is that this light-colored soil, not being a good absorber of water, and being so situated as to drain it off readily, the vast amount of vegetation, in different forms, which has grown upon it has entirely decayed and passed off in the forms in which its elements first came to it, namely, as gases.

Here is the place to speak of one of the most interesting features of this upland soil in the county—the fine beds of peat which mark the line of the water-shed. Peat is a vegetable product—it is an accumulation of vegetable matter in circumstances in which decay is arrested. A cool climate, and a moist situation are the conditions in which peat is formed. On the scarcely sloping tract, lying just where the drainage, being both ways, was effective neither way, and where the surface was formed of a soil quite impermeable to water, we find to-day several extensive beds of peat of good quality. They lie in Van Buren township, and near the line of the new Kettler turnpike. Mr. William Kettler owns about one hundred and forty acres of peat; in section ten of the same township are one hundred and forty acres more; in section fourteen, ten acres; in section twenty-two, about thirty acres, and smaller quantities in one or two other places, being over three hundred acres in all. It is not certainly known how deep these beds are; it is supposed they will average at least ten feet. I did not learn the facts upon which this belief rests, but, from the character of the men from whom I obtained the information, I feel that the statement can be relied upon. Where I examined the peat, on Mr. Kettler's farm, although large ditches had been conducted through it to drain it, there was no place where the bottom could be seen, nor the distance to it from the bottom of the ditch be ascertained, by such explorations as we could make with a fence-stake.

On this water-shed the effect of continued washing is seen in a slight furrowing of the surface into broad and shallow troughs, leading toward the drainage of Loramie Creek. Suppose that at a time when all the region was densely covered with forest and protected from the sun's rays, the falling of a tree, or the erection of a dam by beavers should have cut off the passage of the water, bogs of greater or less extent and depth would have been formed. In these vegetation would soon flourish suited to such localities—plants which flourish in and near moisture—coarse grasses and vines, luxuriant ferns, and particularly the sphagnous mosses which are known to compose so large a proportion of peat-beds. We can hardly conceive of the rapidity with which the accumulation of vegetable material takes place in such circumstances. The remains of beaver dams are still confidently pointed out by residents there, and the traditions of the county are numerous, and corroborative in regard to the existence of these ingenious animals at a time not long antedating the memory of the "oldest inhabitant." In complete confirmation of this general conviction, I have in my possession teeth of the beaver found in the county.

The peat is of a uniform consistence, and of a drab color, where freshly exposed. On the surface, where it has been drained, it is sufficiently decomposed to nourish the most luxuriant vegetation which I saw in the county—vines, grasses, briars, bushes and ferns, and, where under cultivation, the finest of corn crops. The beds are purely vegetable; neither on the surface, nor beneath it, could there be distinguished a particle of earth mixed with the peat. Being about at the Summit, there was no source from which earth could have been washed into the forming peat. When dry it burns readily with a cheerful blaze and rather strong odor, glowing like the embers of leaves in a draft. It is not, however, used as fuel, on account of the great abundance of wood in that region and its distance from any market, and doubtless the day is remote when it will be in demand as fuel on account of the abundance of coal even more convenient to the great markets than these beds of peat. The great productiveness of the porous, friable upper crust, where the beds have been drained, suggests a use for this material of great interest. It is contiguous to these great beds of peat that the thin, light-colored soils, so destitute of vegetable mould, abound. Here is a supply, not easily exhausted, of the very material which that soil needs. If these beds average ten feet in thickness, there is enough vegetable matter in them to cover, to the depth of one-half a foot, nearly ten square miles of land. I pointed out to Mr. William Kettler a danger which threatens the destruction of those beds which are perfectly drained. He has dug large trenches through his extensive beds for the purpose of drying them to bring them into cultivation. Where the peat becomes dry it is porous, light and friable. It requires no breaking up to receive the crop, but is only furrowed out to secure precision in the rows of corn that it may be worked with the plow. The process of drying must continue from year to year where the system of drainage is complete. The result may be disastrous if such a bed of inflammable matter is exposed, as it must be, to the malice or carelessness of any one who might set fire to it in the extremely dry weather of our late summer seasons. Already, imperfectly dried out as the beds are yet, where persons have carelessly allowed fire to catch in the surface of the peat deep holes have been burned, extending, doubtless, to the undried substratum. No means that could be brought to bear in those regions would be effectual in quenching a fire in one of those peat beds if they are once thoroughly dried out. The remedy I would suggest is one of prevention—it is to close up the system of drains during the winter, allowing the water to stand in them, saturating the beds completely. The drains being opened in the spring, the beds of peat would not become fully dried out during summer. By retaining moisture they will bring better crops and be safe from conflagration.

THE RAIN-FALL.

This county is near the border of the area marked in the "Rain-Chart" of the Smithsonian Institution in which the average of rain-fall is forty inches. In the absence of other reliable data, any indefinite impressions that the amount is less than this must be disregarded. We are apt to judge by the effects; for example, the state of the crops, whereas the larger portion of the rain-fall is at a season when no visible influence can reach the crops from it. Plainly, all that rain and snow-water, which runs off the frozen crust of the ground in the winter, does not affect, one way or the other, the crops of the ensuing summer. The same can be said of the most of the rain, which runs off as soon as it falls, at any season.

An interest attaches to the amount of water which falls, in various forms, in this and the adjoining counties, particularly to the north-east, on account of the requirements of the canal. Data are wanting for determining the amount of water carried off by the canal and the river from the area above the Summit-level of the canal in this and the adjoining counties on the north-east. The nature of the soil is such that it will shed as large a proportion of the water which falls upon it as any other soil in the State. An immense quantity flows from above the highest level of the canal without any advantage to the canal. It is equally true that a much greater proportion of it could be utilized than actually finds its way into the canal—enough, certainly, to remove the question of the supply of water out of the discussion concerning the abandonment of the canal.

THE LORAMIE RESERVOIR.

This body of water, covering at present but little over 2000 acres of land, lies wholly in Shelby county, and although not one of the largest of the State reservoirs, nor the most important, still it is exceedingly valuable to successful navigation in the summer and early fall. The bottom of the reservoir is about eight feet above the summit level of the canal. It is supplied by the drainage of about sixty-five or seventy square miles. Being near the water-shed, the surface from which water can be collected into the reservoir is limited, and less water comes from springs than would be the case in many other localities not so high. While the main reliance is on drainage from a limited surface, still such is the nature of the surface soil, that a much larger proportion of the water which falls upon the surface runs off at once than would run from soil of a more porous character, or one underlaid by large beds of clean gravel, or sand, or porous rock. The construction of roads, drains and ditches, as well as the clearing away of the timber and the cultivation of the soil, cause a more rapid flowing away of the water which falls upon the surface. Formerly the reservoir received more water from the gradual draining of the surface; this maintained it at a good stage for a longer time, and enabled it to furnish a greater supply during those months of the dry season when water is usually low in the canal. If the capacity of the reservoir could be increased so as to hold more of the water which falls in the winter months, its usefulness might be greatly increased, for instead of being maintained in good stage until late in the summer by the gradual running out of the water from the extensive swamps of an early day, it is now filled up by the rapid surface drainage, and to furnish as much water when most wanted must have a capacity to hold at once all that comes into it in the winter and spring. In 2000 acres of land there are 87,120,000 square feet. If it is filled, during the year, with eight feet in depth of water, there would be 696,960,000 cubic feet; allowing that one-half is lost by evaporation, soakage and waste from imperfect bulkheads, there would remain 348,480,000 cubic feet for the uses of the canal—enough to lock down, with the present size of locks, eighty boats from the summit level every day of the year. With sixty-five square miles of drainage, from which the reservoir must receive its supply, how much of the forty inches annual rain-fall would be necessary to furnish this amount? Less than five inches. A much larger proportion of the forty inches than this certainly flows from the surface of the ground.

It is but justice to the people of the county to call attention to some facts connected with the history and present condition of Loramie Reservoir. As it is, the people of the county do not feel kindly disposed toward it. The ground covered by the water of this reservoir was covered in part by the original forest when it was constructed. The forest was not removed, but the trees surrounded by water died, and in the course of time fell down, and now lie in great numbers beneath the water when the water is high, and partly out of it when the water is low. This exposure of the timber to the air in the late summer and the autumn months causes, it is believed, the generation of a miasm which pervades the whole region, rendering it unhealthy. The exposure of the logs to the atmosphere, it is believed also, has been the cause of the destruction of many tons of fine fish during the past two seasons. It seems, and who will not say with justice? to the people of the county, that the State should do something to remedy the evils which they suffer from the causes just mentioned. They think that the reservoir should be an attractive rather than a repulsive body of water, that it should be a benefit rather than an injury to the interests of the county. Now, when it is borne in mind that there are hundreds of thousands of cubic feet of logs and other sediment in the reservoir, and that all displaces as many cubic feet of water, it is after all a question worthy to be considered, whether it would not be economy to remove all this rubbish to have its room occupied by water every year. How many hundred, perhaps thousand, times would the water-soaked forest which lies beneath the reservoir, with the other vast accumulations of vegetable matter and mud, fill one of the locks of the canal? This would be the measure of gain each year resulting from the removal of all this material from the reservoir—for every lock-full of logs a lock-full of water would be gained. This would remove a nuisance from the county, and in some degree compensate for the withdrawal of so large an area of land from cultivation, from improvement, from tax paying. The importance of the reservoirs of the State as sources of supply of fish, deserves to be mentioned here; not only the actual amount of fish for the table to be procured from them, but as sources from which the waters of the State may be re-stocked and kept supplied with young fish. The reservoirs are at the head waters of our principal rivers, and, with the present knowledge of artificial fish-breeding, could be made of immense value to the State as sources of supply of fish for the rivers of the State.

The amount of water which could be made available for the canal depends upon the area of land which is above the level of the canal. All that part of the county, embracing about nine townships, which lies on the east and north-east of the main canal, and west and north-west of the Sidney Feeder, is above the highest "level" of the canal—it will average about seventy-five feet above the canal. Of course it would be possible to gather many times more water from this area than could be contained in Loramie Reservoir. While all this area could not be made available, yet there must be much of it which could be, were it considered a matter of sufficient importance to have it done. Considering, then, alone, the great area, both in this county and in the counties above this, about the head-waters of the Miami River, there should be no question as to the abundance of the supply of water above the summit-level of the canal to continue it as one of the important avenues of commerce of the State.

THE DRIFT.

The level of the canal at Sidney is about thirty feet above the rock surface. Add to this distance the ascertained elevation above the canal of any point in the county, and it will give approximately the thickness of the Drift or clay, gravel and bowlder deposits. This would make the greatest thickness of the Drift on the Towana turnpike one hundred and sixty-four feet above bedded rock. Within about two miles of Sidney, on the turnpike to St. Mary's, the elevation measures one hundred and twelve feet above the canal at Sidney. Add to this thirty feet and we have one hundred and forty-two, which may be very confidently considered the depth of the Drift at this place. It is true these figures may not be the exact measure of the distance from the surface down to the solid rock. Other formations which are known to occur north of this county, and which overlie the formation which occurs here, may underly the deep drift of the northern part of this county, but this is not certainly known to be the case. On the south, at the line between this and Miami county, on the Infirmary turnpike, the grade falls forty feet below the level of the canal, which is ten feet lower than the top of the rock near Sidney. By the course of the river it will be seen that there is a dip on the surface of the rock as we go southward. The canal rises one hundred and fifty-two feet from Tippecanoe (below Lock 39) to the feeder at Sidney. While accurate measurements were not taken of the difference in elevation of the top of the Clinton Stone in the neighborhood of Tippecanoe, and the surface of the canal, yet some measurements which I recorded make the distance about sixty feet. Taking this from one hundred and fifty-two makes this formation about ninety-two feet at Tippecanoe below the level of the Sidney Feeder; whereas the top of the Clinton, where this formation is last seen above Bogg's mill-seat, near the end of the bridge over the river, as before stated, is near sixty feet below the canal, these figures would give to the Clinton a rise in level with horizon of about thirty feet in that distance.

The surface of bedded rock underlying the Drift in Shelby county is doubtless worn unevenly, in some places rising above the level indicated by the top rock, on the Miami, below Sidney, in others sinking more or less below that level—perhaps, in places, greatly below.

Rising sometimes to one hundred and sixty-four feet, maintained generally at a level ranging from figures but a little lower than this, down to seventy-five feet (seldom going lower), we may conclude that there is an average depth of Drift in the county of one hundred feet. This depth of Drift is not equaled in any of the counties which lie south of this. We are here on the line which bounds the deep Drift on the south.

The opportunities to ascertain the nature of the Drift are numerous in the excavations made in constructing the canal and railroads, especially the Indianapolis and Bellefontaine branch of the Cleveland, Columbus, Cincinnati and Indianapolis Railroad, which runs at a considerably lower level than the Dayton and Michigan road, which runs through the county in a north and south direction. At the point where the east and west road runs below the track of the Dayton and Michigan, on the western border of Sidney, a good opportunity is afforded of seeing the nature of the Drift for a distance of thirty or forty feet below the surface. About one mile east of the bridge over the river, on this road, is a still deeper cut. There is little stratification observed in the deposit as seen through these deep cuts. Sand and gravel largely predominate in the composition of the Drift as seen here, mixed with clay and numerous granitic or quartz bowlders, varying in size from mere pebbles to masses containing from ten to twenty cubic feet. The gravel, sand, and bowlders are distributed through the clay, and all are lying in confusion. It seems to me safe to say that fully twenty-five feet in thickness of clear gravel, were it separated from the clay, would be found in the Drift throughout this county—a quantity so inconceivably great that I will not undertake to express it in figures, more than to say that it would yield twenty-five million cubic yards to the square mile. But this gravel is too much commingled with clay to make it available, in general, for ballasting or road-making, and with all this the county is not abundantly supplied with good gravel for such uses, well distributed in different localities. Enough has, however, been found to construct a system of free turnpikes not surpassed, in extent or excellence, by those of any county of similar size and situation in the State, although the material has had to be hauled, in some instances, for inconvenient distances. I will make special mention of one of the roads, constructed by Mr. D. W. Pampell as engineer—I refer to the one called at Sidney "the St. Mary's road," on the line of an old road formerly projected to connect Sidney with the town of St. Mary's. This road, of excellent width, careful and full grading, and well graveled, is carried on *a perfectly straight line* for a distance which falls short by but a few rods of thirteen miles, wholly in this county. The numerous excellent roads which have been recently constructed through all portions of the county must have an important influence on its future development.

The total number of miles of turnpike roads in Shelby county, at the present time, is one hundred and fifty-nine, of which only eighteen miles are toll-roads. The free turnpikes extend to all parts of the county and intersect nearly every important neighborhood, and are the means of the development now seen in progress of the material, moral, and intellectual interests of the county. The cost of these roads I ascertained, from the county auditor, Mr. Guthrie, who kindly furnished me with the statement, to be about $4,000 per mile, or an aggregate of $564,000 for the one hundred and forty-one miles of free turnpike road within the county. While there has been found an abundance of gravel for these roads, it has not always been convenient, and the distance it has been necessary to haul it has enhanced the cost considerably. But for this expense the people of the county have obtained good roads, carefully laid out and well graded and drained.

Washed gravel.—Wherever the drift has been washed into troughs or valleys, more or less gravel has been deposited in beds, generally at the junction of two such valleys. Usually these depressions are far from any water-course that could in the least affect them at present. They are on the higher levels where no streams of water exist now, and show the effect of the washing of the water which once covered over the whole surface as it ebbed and flowed when it was gradually subsiding, or they are more visibly related to the water-course of to-day and serve to mark the stations where the water stood successively during the time in which the deep valleys, in which the streams now flow, were being excavated. In this county, the gravel of the higher beds is less abundant, is not so coarse or so free from clay. This must have resulted from the condition of the higher deposits of the drift, in which a gravel of a a smaller grain was found; as if there had been coarser gravel in this portion of the drift, not it, but the finer, would have been the sooner washed onward, and the coarser would have been left in the higher beds. Above and separated from the portion of the valleys of the water-courses, particularly of the river, affected by the action of the water at any stage, at the present time, are some fine beds of washed gravel, showing the effect of moving water in varying circumstances of force and velocity. Near Port Jefferson is the best example of gravel beds of this description in the county. It occurs at the junction of two valleys now threaded by two brooks, the shrunken successors of broad streams of former remote ages. Here are the wide channels which they cut, wide compared with the small paths of the creeks which now meander by a struggling course to reach the river channel. At the point of land where these two waters joined, and where their streams mingled with that of the Miami, is a grand deposit of alternating layers of gravel and sand, heaped up thirty or forty feet deep and exposed now, by the removal of the extreme point to a width of about one hundred feet. When one or the other, or both, the streams which excavated the unequal channels (for one greatly exceeds the other in magnitude) which join at this point, were swollen and were carrying onward a load of sand and gravel, as well as clay, and meeting here, and one spreading over the valley of the other, if unswollen, or both widening as they entered the broad valley of the river and losing a part of their momentum and carrying-power, they deposited a portion of their freight at the point of junction where the rapidity of the current was first checked. In these strata can be read the history of the currents which flowed here, and left their records, not in rocks, but in sands. There is first, in nearly horizontal layers, a succession of strata composed of clean gravel (the lowest exposed at the time of my visit, the lower had been covered previously), then one of coarse, gray sand; another next of fine sand; then ten feet of sand finely stratified; then to the top alternating layers of gravel and sand. After these layers now referred to were deposited, another deposit of clean gravel was made, not parallel with these, but covering the ends of all of them from the highest to the lowest. I will simply refer to another deposit of gravel, near the south end of the iron bridge over the river south of Sidney. This large accumulation is less available for road-making than it would have been had it not become so cemented together by a deposit of carbonate of lime. I distinguished from these beds of gravel that large accumulation, at a lower level, and underlying the "river bottom," or the "second bottom," exemplified by an accumulation of clean sand, used for building purposes, just below the west end of the railroad bridge, east of Sidney, over the Miami River, and perhaps underlying more or less the town of Sidney.

The broad excavation made by the Miami River through the drift of this county and the counties above, has exposed to the transporting action of water countless thousands of perches of sand and gravel which have been removed down the course of this river, and even into the Ohio and far down it, strewing its beaches with these materials so useful to man. Perhaps no water-course in the State has borne so much sand and gravel along its course and lodged it in places where it is accessible to man. This is a striking peculiarity of the Miami River; its broad terraces are underlain with a bed of the cleanest, finest gravel for road-making in quantities practically inexhaustible. I have but to cite the immense deposits beneath the alluvium at Middletown, on both sides of the river, at Hamilton, and indeed along its whole course, culminating in that bed at Harrison Junction, cut and exposed by the Indianopolis and Cincinnati Railroad.

Bowlders—While the transported rocks do not constitute a marked feature in Shelby county, still there are many of them; but as Miami county contains so much greater a proportion, they will receive special attention in the account of that county. The largest bowlder, however, that has yet come under my observation in the State lies near the railroad, one mile east of Sidney. It contains twelve hundred and fifty cubic feet, and weighs about one hundred and three tons.

Human remains.—As in other counties, in nearly every instance where gravel beds have been opened to obtain gravel for road making, skeleton remains of human beings have been discovered. They lie invariably near the surface of the ground, and soon crumble to dust when exposed to the influence of the atmosphere. Careful observations do not seem generally to have been made as to the mode of placing the body in the earth, but enough was learned to induce the belief that no one custom of sepulture was invariably adhered to. It is not a little singular that these dry places were chosen as places of interment for the dead of that race, whichever it was, whose dead are found decaying in them. With imperfect means for opening graves for their dead in the earth, it is perhaps not unreasonable to suppose that they buried their dead in the gravel because, with their tools, the task was more easily effected in such localities than in the harder clay. This supposition seems to derive force from the appearance of carelessness in these interments. The bodies are thrust in a hole feet foremost, and forced into a small space. It is very seldom that trinkets were buried with these dead, though sometimes it is the case. But we must notice that keenness of observation, which detected, so unerringly, the hidden beds of gravel, which, though needed, were in many instances entirely unsuspected by those who ploughed and reapt above them, until the exigencies of road-making caused more thorough search to be made by those who searched without certain indications, by tentative methods, and often without hope of success With the forests cleared away, and the soil under cultivation, and often dug into for various purposes, and with more or less light from modern science, we did not suspect gravel in a thousand localities where it has been found; we had no indications of it, and when many beds were discovered, there were yet no certain marks to point out others, and two generations have passed, traveling on mud roads unwillingly, and now, when we are stimulated to road-making, and search has been made under strong incentive and competition, behold, it is no new discovery we have made—every gravel pit is a place of human sepulture. I make the suggestion here, that possibly, in a primitive forest, there were some growths which were an indication of the nature of the underlying deposits, some which the men of the forest had learned to regard as indicating gravel. It is well known to us that some plants, some trees, are very choice in regard to the kind of soil in which alone they will flourish, especially as retaining moisture or not.

Remains of Human Art.—I did not see as many flint and stone implements among the people in this county as I have in some others, though such articles are not uncommon even here. There may be ancient mounds in the county, though I did not see any. Along the Miami River and other water-courses are localities where a variety of flint arrow-points and spear-points in considerable numbers have from time to time been found, though but few seem to have been preserved. Other classes of implements, as stone hammers and pestles, seem not to be common, and I did not see any place where indications were found which would lead any one to suppose that these or other implements had been manufactured there. The most favored localities for arrow-points are along the water-courses and on the highest points in the county. But the larger number are found on the river and its tributaries. It is worth remark that the indications in the position of the flints, do not point to an extreme antiquity as the time of their manufacture. There are many places along our larger water-courses in the west where extensive manufactories of arrow-points, stone axes, and pestles, etc., have existed, and where pottery ware has been manufactured and burned. These localities have never before been disturbed by the inroads of the rivers, but are now being undermined and washed down for the first time. The implements in all stages of manufacture are found in great numbers; old bark-peelers and pestles, which had been injured by use, or from some fault in original construction did not give satisfaction, were undergoing repair or remodeling; heaps of chips are found, and great numbers of lap-stones, hammers in connection with hearths, and remains of fire together with crockery, are found in these localities at no great depth below the present surface of the soil, where over-flows are still a common occurrence. A very remote antiquity could not be ascribed to these remains of human art and industry from anything in their situation. In the course of a few centuries the rivers in the secular oscillations which they execute from bank to bank, a result of laws in constant operation, must disturb and redistribute, by the constant eating away of the bank, the whole of the alluvial deposit near its own level. Nothing is more constant, nothing more certain than the wear of an abrupt alluvial bank during high water, with a regularity which admits of calculation. The great number of such stone-tool manufactories, which are now disclosed along the course of the Ohio River, afford evidence that their age was not far back in gray antiquity. A few banks that are now crumbling might have escaped the erosion of the surging waters for a very long period; but it is incredible that so many as are now delivering up their relics of human art, their evidences of human industry and ingenuity, places in which for the first time since the ancient workman finally laid down his tools or kindled his fire upon his well-made hearth of bowlder pebbles, for the last time, should have escaped for indefinite ages just such action of the water as they are now yielding to.

Remains of Extinct Animals.—A few bones of animals not now found in the State—as a few teeth of the beaver, and portions of the antlers of one or two elks, and some reports of discoveries of mammoth or mastodon remains—were all that came to my knowledge of fossils of this character. We may be prepared to hear of the discovery of such fossils in the peat beds, if they are ever much worked. Peat seems to possess the property of preserving the bodies of animals which become mired in it.

BEDDED STONE.

We come now to speak of the underlying consolidated strata which are exposed within the county. The only bedded stone found within Shelby county, lies in a narrow strip bordering the river, extending from the southern boundary of the county to within a mile of the town of Sidney. From the county line to a locality known as Boggs' Mill, wherever stone is seen *in situ*, it belongs to the formation called, by geologists, the Clinton. It is the stone which immediately underlies the building stone in the suburbs of Piqua, in Miami county, and which is burned into lime so extensively just south of that town. It possesses, in the locality in Shelby county referred to, all the characteristics by which the stone of this formation is so surely detected. The physical characteristics of being unevenly bedded, highly crystallized, of sandy texture, and of a rust color from the presence of iron, and, withal, a hard stone, here show themselves. The fossils common to the Clinton in the vicinity of Piqua, are here abundantly seen — *Halysites catenulata*, *Stromatopora*, *Asyringipora*, and some species of *Favosites*. These were exposed on the surface. No fossil shells were to be seen. Fragments of crinoid stems seemed to compose a considerable portion of the rock, and several species of Fenestella abounded. This formation has never been quarried here, apparently, for any economical purpose. It is in the neighborhood of an excellent limestone belonging higher up, and which furnishes lime of the first quality. The Clinton formation furnishes no good building stone in this part of the State, and, while it makes the strongest kind of lime, it is hard to burn, and heats greatly in slacking, and sets rapidly when mixed. It is highly esteemed in paper-mills, where a strong lime is desired, as it more readily softens the material used in the manufacture of paper.

The next formation ascending, is that known as the Niagara. It is not seen here in actual contact with the preceding, as the exposure is not continuous; but within about a mile of the river, an out-crop of stone is observed on and near the banks of the river. A casual examination shows that a great change has taken place in the character of the stone. We have not only passed to a new formation, but into the upper strata of it. The stone is neither well stratified nor compact, and not suitable for building purposes. It is porous, comparatively soft, and very fossiliferous, and of a light blue color. It is burned here into an excellent lime, known locally as the Pontiac lime. The strata of the Niagara, so much prized for building purposes, found at Piqua, and also those found at Covington, Miami county, belong below this horizon. The superposition of this quality of stone upon that of the Covington quarries, is ocularly demonstrated on the Stillwater. This river rises gradually up to the level of and above the stone of the Covington quarries above Covington. At the village of Clayton, on the Stillwater, about two miles north of Covington, the banks of the river are formed of the same strata as those from which the Pontiac lime is made, within about a mile of the last exposure of the Clinton, on the Great Miami. The last exposure of the Clinton on the Stillwater, is several miles south of Covington; and a familiar example of the Clinton stone may be given in the falls of the Panther Creek. It will be seen that all that thickness of building stone about the town of Covington, and exhibited so well at the falls of Greenville Creek, as well as that of the Piqua quarries, belongs above the Clinton and below the strata which first appear above it on the Miami, near where the "Pontiac" lime-kilns are situated. The inference follows, that if there is any good building stone within Shelby county, it will be found somewhere between Boggs' mill-seat and the Pontiac lime-kilns. The shortness of the distance, together with the slight fall in the river, would preclude the existence of any extensive strata in this locality. There may exist here a few feet of evenly layered rock, corresponding with the upper layers of the Covington stone; but the hope of very much good stone, even if any is found, is too slight to encourage much expense in searching for it. It will be thus seen that the Niagara thins out in this direction, especially the lower strata, while the upper strata maintain a considerable thickness. Indeed, it is possible that the upper strata of the Niagara lie here immediately upon the Clinton. The thickness of the strata is not known with certainty, but can be approximately made out. The Pontiac limestone is but little, if any, above the surface of water in the river in its lower layers, and a mile south of Sidney the top of it is about twenty-five feet above the water. With a fall of fifty feet in that distance, there would be a thickness of seventy-five feet of this quality of limestone. I think there is as much as this. We do not know that this is its greatest thickness, for it may rise higher under the Drift in some places. It is a soft stone, and has, no doubt, been plowed down by the forces which deposited the Drift. It would not retain any marks of wearing forces on its surface. Although not valuable for building purposes, it contains an inexhaustible store of the best quality of lime. The lime manufactured from this stone is of a pure white when slacked, and is suitable for all purposes for which lime is used. From a previous volume of this Survey (1870, p. 449), I make an extract, showing the composition of the limestone taken from one of the quarries of this county. I will add the remark, that the locality from which the specimen submitted to examination was taken, is about midway between the lowest and the highest strata. I will say, also, that from the appearance of the weathered surfaces of the stone at Dugan's quarries, I concluded that there was a larger quantity of oxide of iron in the stone of this locality, than would be found either above or below, especially below. The rusty color indicated the presence of iron. From the porous nature of the stone, I supposed the iron may have been filtered out of water which has run through it. There was an entire absence of that rust color in the Pontiac quarry, and the same might be said of the quarries near Sidney.

	Silicious matter.	Alumina and sesquioxide of iron.	Carbonate of lime.	Carbonate of magnesia.	Total.
Niagara, Sidney, Dugan's..	trace.	1.60	55.00	42.92	99.52
" " " ..	.20	.50	54.40	44.58	99.68
Holcomb's limestone, Springfield	.10	1.70	55.10	43.05	99.95
Frey's limestone, Springfield	.10	.20	54.70	44.93	99.93

It will be seen that there is little to choose between the best Springfield lime and the Shelby county lime. The former is a little nearer the best markets in Ohio, and enjoys the additional advantage of the competition of several independent lines of railroads leading to the best markets. The Shelby county lime could perhaps be burned a little cheaper on account of the lower price of fuel, but not enough so to overcome the disadvantage before referred to. When it shall be burned more extensively, which will be done when it can find a market at less expense of freight, it will become an important article of commerce between this county and other places.

Fossils.—This rock from which the lime is made discloses, when broken, an abundance of fossils, but from the nature of the rock they are not very perfect. There were species of *Orthoceras* of a large size, a trilobite, viz.: *Calymene Blumenbachii*, corals of the genus *Fenestella* and numerous shells and crinoids and cystideans, whose names I have not been able to ascertain.

CHAPTER LXXVI.

REPORT OF THE GEOLOGY OF MIAMI COUNTY.

The undulating surface of Miami county, is characteristic of, and dependent upon, the underlying geological formations. We find a bed of loose material of greater or less thickness overlying a not very uneven rock bed beneath. This condition determines the gentle slopes which prevail throughout this section of the State. The blue limestone in the southern part of the county, on the two principal water-courses, is a thin-bedded stone, inter-stratified with thicker courses of blue marl or shale, which do not resist the action of atmospheric agencies in a sufficient degree to form precipitous bluffs, but wear down into those rolling slopes so characteristic of south-western Ohio.

What abrupt unevenness of surface exist, are partly covered up by the loose material, composed of gravel, sand, and clay, which commonly receive the name of *Drift*, spread over the surface. If this Drift were not present, we should be able to trace the line of outcrop of the cliff formation wherever it occurs throughout the county. There would be a chain connecting the cliffs near Charlestown with those two miles east of Tippecanoe, at Col. Woodward's, and onward, marking the course of all the tributaries of the Miami, and showing the course of this river, limiting the valley, to the point where the Miami enters the county on the north. In most instances the beds of the water-courses would be greatly deepened, and there would be rapids or even precipitous falls in some places in most, if not all, of them. The same remark applies to the Stillwater, which would be lined by a series of cliffs throughout its entire course in the county. But the Drift now smooth, in a great degree, the unevenness of the surface and the transitions from one geological formation to another, are only by gentle undulations of surface, instead of abrupt cliffs. The origin of this Drift material is discussed at considerable length in other portions of these reports, and no further allusion to it is required of me in this place.

It will be seen that the character of the surface depends upon the geological formation of the region. And so geology determines, in no small degree, the occupation of the people of any land, and also the character of the people, in so far as character is dependent upon occupation. In one region agriculture is indicated as the chief mode of livelihood; in another, stock-raising; in another, mining and manufactures. The full development of these natural conditions depends upon still other physical conditions—the direction and extent of a country's drainage, the oceans, bays and gulfs, which give rise to commerce.

The character of the surface and soil is such that an average proportion of rain-fall is retained in the soil, and there are numerous springs in the county which afford an ample supply of water throughout the year. The farms are generally supplied with an ample quantity of good water from the springs, and water-courses which abound in all sections. This county, lying on a lower level than Shelby, has a better supply of water from springs. The outcrop of the cliff limestone, whether concealed by Drift or not, could be readily traced by the occurrence of fine springs of water, and those farms which lie along this outcrop have fine perennial springs. As the cliffs lie on a horizon about midway between the highest and lowest parts of the county, it happens that the places are very numerous where excellent water is obtained. There are some springs in the county whose supply of water is sufficient to be of service in propelling machinery for manufacturing purposes, taken in connection with the fall, which is available. The principal one of these springs is at the town of Milton, where considerable manufacturing is carried on. The question has been often asked, Where such a large supply of water comes from? The water falls as rain on the surface and is held in the porous rock and given out gradually. The idea, which is sometimes entertained, that there is an underground reservoir, is untenable; the force of the issuing stream is so nearly the same for weeks and months together. In the case of the fine springs at Milton, there is a large extent of surface west and north above the place where the spring issues. There is indeed but a very thin soil and little Drift in the immediate vicinity, but the surface rises and the bedded rock thickens to the north-west; while in the same directions, especially north, the Drift thickens to nearly one hundred feet. The upper portion of the Niagara, which is found north and north-west, may reach a considerable thickness, perhaps a hundred feet, and is composed of a very porous limestone. These springs, unlike the greater number which furnish water to the farms throughout the county, issue near the base of the Niagara formation, and not at the base of the Clinton, in which most of the cliffs are. When we consider the large extent of surface, which rises above the place of the springs, upon which falls throughout the whole year about thirty inches in perpendicular height of water, in the form of snow or rain, and the suitable character of the deep Drift and porous rock for absorbing and retaining this, to be yielded gradually, we need not be surprised at the quantity of water which flows from these springs. The surprise, which is often expressed, has not been at the absolute quantity of water, for this is not great compared with many other springs, but at the quantity which should issue from a locality which seems to be so near the general level of the country immediately in the vicinity, whence the supply must apparently come. But the supply may be drawn, as I have endeavored to show, from a much greater distance than we might at first suppose.

Wells.—Where there are no springs, water is readily obtained by sinking wells, either in the Drift or solid rock. The sinking of wells is a means of exploring the earth to a moderate depth, and some interesting facts are often obtained by inquiry into the character of the material penetrated. For example, in some places in the county no wells have ever penetrated beyond the Drift, or, at least, reached bedded rock; while on each side, sometimes at no great distance, other wells have to be sunk in the rock. Generally, perhaps always, it will be found that a line can be marked out by such excavations, within which no rock is ever reached by the deepest wells, while the excavations on each side show bedded rock near the surface. Here, then, we have traced for us the channel of some ancient water-course which has been filled in with Drift at some time in the past. There were rivers, and a river system, cut far deeper in the rocks of a former age than any we now have in this region. The whole surface was sunk down under deep water and gravel; sand and clay covered up all inequalities of surface. When the surface emerged again, the drainage began to excavate channels, the general character of the surface remaining the same; the streams would take courses in general the same as before, but from local causes would be deflected in places. The old, filled-up channels are now traced by means of excavations. I will mention that at Mr. Murray's, on the Troy and Covington turnpike, no bedded rock is found in sinking wells, while to the east, within a half mile, and to the west, stone *in situ* is encountered in well-digging.

The influence of the character of the surface on the soil can be noticed in various parts of the county. This may be illustrated by comparing the soil and surface on the east of the Miami River with that on the west. East of the Miami the surface is rolling, and gravelly ridges abound.

This gives a good drainage in general, and the soil is composed of drift material, with accumulation of mould composed of vegetable substances partially decomposed. There is a good proportion of clay mingled with the mould. Not only does this clay affect the character of the soil, but the free drainage, and the gravel beneath, also affect it. Where local causes obstruct the free drainage, there are local swamps whose soil, when cleared and drained, is entirely different from that of the rolling land. Somewhat like the swamps, is a wide scope of land between the Miami and Stillwater rivers. Here the land was not rolling, and hence not naturally well drained, but was flat and moist. The result was that a different vegetation sprung up here. Rough sedge-grasses, mosses, and kindred vegetation, flourished in this region, growing and perishing successively, until several feet of deep, black soil had been accumulated. At a certain time, trees suitable to a wet region, such as elms, soft-maple, and shrubs such as button-bush, and, finally, bur-oak and ash, began to grow. The vegetable material perishing, underwent a process of decay, or, rather, a process of preservation. The substance of the vegetation broke down into a number of compounds, which, situated as they are in moisture, do not undergo further decay. This material was arrested in a stage of decomposition different from that of the drier substances on the rolling drift-land east of the Miami River. In the case of much of the vegetation east of the river, it passed back by complete decomposition into "thin air," into invisible gases, and left no trace behind. A certain other portion was arrested in the process of decay, and forms the mould, which, with the clay commingled, constitutes the soil. On this side flourishes the oaks, beeches, walnuts, sugar-maple, with an undergrowth of dog-wood, red-bud, haw, pawpaw, with a peculiar vegetable growth which sprung up and perished annually. The most of the growths of the east side differed entirely from those in the swampy district, of a former day, where the deep, fibrous, black soil is found west of the Miami River. The moisture retained on the surface has a two-fold influence—one to favor a vegetation, as I have said, of a peculiar class, the other to prevent its decomposition, in fact, to preserve it. The two classes of soils differ in four respects: (1) In the quantity of vegetable substances; (2) in the condition they are in as regards the extent of decay which they have undergone; (3) in the character of the vegetable substances which make up the material, and (4) in the different proportion of clay they contain—that on the east being composed largely of clay, while very little clay is found in the swamp soil. The black soil, not being so completely decomposed, does not, *at first*, until exposed to air by being worked and drained, yield so well, while the mold of the upland woods is in condition at once to yield abundantly. I refer, in the foregoing remarks about the differences in the soils of the east and west sides of the Miami River, to the characteristic soils, and not to every part of each. On the east, there are swampy places where the soil approaches in character to the black soil of the west side, while on the west side of the river, as in the southern part of the county, the soil has the character of that on the east. There are some places west of the Stillwater, where the Drift does not exist at all, or very little of it is seen, but the soil, only a few inches or feet in depth, rests immediately upon the lime-stone of the Niagara formation. This soil is largely derived from the underlying rock. This is not usual in the region of the Drift. In most places, our rocks have but little influence upon the surface soil, except so far as fragments of the rocks are mingled with, and, by decomposition, give their strength to the soil.

The Drainage.—All of the drainage finally reaches the Miami River. The county slopes from north to south, with two subordinate systems of drainage pouring the surplus water into the two outlets—the Miami and Stillwater rivers—to be united after they leave the county. The longest tributaries of the Miami come from the east, as those of the Stillwater come from the west. On three sides, the county receives accessions of water from other counties, while the streams from the general water-shed on the north, contribute the drainage of several counties, all, together, making a large and constant volume of water flowing across the entire county, furnishing water-power for great and profitable industries. The Miami canal is a convenient conduit for the utilization of this immense power. The advantages of this situation are becoming appreciated in this county, and companies have been formed, aided by municipal appropriations, to make use of this power, which has been largely allowed to pass by without making contribution to the wealth of the county. The success of the enterprises, undertaken and partly completed at the time of my visit, are assured by the natural and physical advantages of the situation of the county, if no engineering blunders are encountered, or financial embarrassments delay the completion of the works. The breadth of country lying above the horizon of the northern boundary of Miami county, will furnish a drainage ample enough for an immense water-power, if it is directed into proper channels. It may be necessary, as it is practicable, to detain the water in a reservoir, on the Miami, in the southern part of Shelby county. The two State reservoirs, the Loramie and the Lewiston, could be greatly improved and rendered both more effective as a supply for the canal, and useful for holding a supply of water, especially the one on the Miami, for manufacturing purposes. There can be no question of the ability of the breadth of country drained by the Miami and its tributaries above the northern line of this county, to give a supply of water for the uses of the canal, far beyond any demand which has ever been made upon it. This power, which has been going to waste, will some day be turned to good account, and Miami county will become known for its manufacturing industries, as it has been for its agricultural thrift. The foregoing remarks regarding water-power have referred to the Miami River. On the Stillwater we find water-power of no mean proportions. This river is fed from source to mouth by numerous fine, living springs, which keep up a constant flow of water along its channel. It has also several good mill-streams tributary to it. In addition, its bed is deep, and large dams are practicable, both for giving a good head and holding water in reserve. This stream alone would be a fortune in many localities, and we may confidently anticipate the time when industries of great importance to the county will spring up on its banks. Taken altogether, Miami county has natural advantages superior to many, if not all its neighbors, for becoming a manufacturing center, since no power is so economical in application as water.

THE DRIFT

The entire surface of the county, as has been said, is covered with loose material, composed of gravel, sanded clay, with a great number of granitic and other rocks of similar origin, whose origin we must look for away from this region. The commonly received opinion is that these materials have been *drifted* hither by the agency of water, either fluid or as ice, and the facts observed all point to the north, mostly beyond the chain of great lakes, as the source whence it has been brought. In the several volumes of this survey, the reader will find the whole subject of the drift agencies discussed, and many interesting statements made as to the probable method of transportation, the relative age, the phenomena, and physical history of the Drift. It so happens that our soil, where the Drift exists, does not depend altogether—in general not at all, or very little—upon the nature of the underlying rock for its qualities, but upon material transported from distant regions. In some places the thickness of Drift amounting to thirty feet or more, renders the influence of the underlying rock utterly without influence upon the soil. I have already referred to some soil west of the Stillwater, which is influenced by the underlying rock, lying, as it does, within a few feet of it. Much of the gravel is calcareous, and has been derived from rock broken up in the course of the movement of the Drift. The sand is silicious, and has been derived from the grinding down of masses of igneous rocks.

This county lies south of the area of thickest Drift, which may be regarded as extending no further south than about the latitude of Sidney, the county seat of Shelby county. Thence it begins to thin out southward. The Miami River, where it enters the county in the north, cuts through a perpendicular thickness of about seventy-five feet of drift-clay, gravel, and bowlders, and all the water-courses which intersect the northern portions of the county cut through the Drift to a depth of from thirty to fifty feet. As might be expected, the material of the Drift varies greatly in different localities. In some places it is composed of blocks whose nature and condition show them not to have been transported far, and commingled with them are gravel, sand, clay and quartz, and granite bowlders in varying proportions. Some times the Drift is composed of sand and gravel, with a small proportion of clay, or none at all, arranged with more or less stratification. An illustration of this character of Drift may be seen well developed on the new hydraulic works two miles north of Piqua, where they form a bed some forty feet in thickness, cemented in great masses. The same formation is seen across the country, on the Stillwater, about one mile from the town of Clayton. The Drift being largely composed of gravel and sand, there is no deficiency of these valuable materials for all purposes. The streams wash out the clay, and leave the gravel and sand, assorted in beds, along their entire course. In other cases, the large accumulations, left by floods of former days, afford convenient material for road-making in localities distant from water-courses. Advantage has been taken of the abundance of good material for road-making. The county is threaded in every direction with the finest of roads, most of which are entirely free of toll-houses.

Striated and smoothed rock-surfaces.—At Piqua, on both sides of the river, where the quarries are exposed to view by the removal of the superincumbent Drift, it is observed that the surface of the rock upon which the Drift was lying, is worn smooth and polished, and variously striated and grooved. At no point, I understood from quarry-men, does this character fail to present itself. Lying upon the smoothed surface of the bedded rock is a confused mass of yellow clay, with blocks of limestone, not worn, of various sizes and in great confusion of position, together with well-rounded gravel, both of limestone and granite, and other igneous rocks, with larger bowlders of igneous rocks distributed throughout the mass. All these have the appearance of having been arrested in the midst of their course, in which they were grinding, marking, and polishing the surface of the bedded rock, as well as each other. There are no indications of assortment according to specific gravity, or by any stratification. On the east side of the river, at French's "Old Railroad Quarry," at the time of my visit, an instructive observation could be made of the action of the drift on the bedded rock. The stripping of one portion was composed of drift clays, bowlders of quartz, granite and kindred rocks, and blocks of limestone, all commingled in a mass, and the surface of quarried rock beneath, here only four feet in thickness, was everywhere smoothed; while in another portion of the same quarry there is an additional four feet of the upper portion of the rock, not worn away by the same agency which was acting close to it, nor was the surface of this portion smoothed. Deter's quarry, near the mouth of Panther Creek, illustrates the character and condition of the drift which I have just referred to.

There are unworn blocks of limestone, rounded masses of the same material, rounded and smoothed bowders of granite and quartz rock, gravel, sand, and clay, commingled without any kind of selection according to quality of material or specific gravity.

Bowlders.—While this class of detached rocks is to be found in all portions of the country, scattered here and there, there are some special belts of them extending in a direction somewhat west of south, through the entire extent of the county. The finest collection, in a continuous belt, occurs in a line which passes within three and one-half miles to the east of Troy, passing through the farm of John La Fevre, on Lost Creek, where, as well as both north and south, in a line, it may be observed. It continues in a nearly direct line throughout the county. A fine locality to observe it is on the turnpike-road, leading from Tippecanoe to New Carlisle, between three and four miles from the former place. Here a portion of the bowlders have been removed from the field to make room for the plow, and besides being ample for the construction of good fences are heaped up in long rows on each side of the road, reminding one of a region of igneous rocks. Here one may see nearly all varieties of granite and quartzose rocks. The variety is astonishing, as if gathered from a hundred sources, many of them of very brilliant colors. They have been removed to adorn the grounds of residences in the adjoining towns.

They vary in size, some of them reaching a weight of several tons. This line extends to and beyond the southern boundary of the county, passing about one mile east of Tadmor, where the Dayton and Michigan Railroad intersects the National road. The belt is fully one mile in width, and altogether contains a mass of bowlders to be greatly wondered at, whether we consider their combined weight, their variety and beauty, or their regular distribution and direction. There is another belt, either an independent one or a spur of the foregoing, which passes by the line of the new hydraulic works, near Troy. This has many bowlders of great dimensions, and often those of unusual interest; some composed of rounded quartz pebbles, imbeded in a matrix of dark mineral; some, again, formed of angular fragments of various colors, imbeded in like manner. Some of these have been taken to their private grounds as adornments by the citizens of Troy. Rev. D. Tenney has one of the finest-marked bowlders I have ever seen, on his grounds. About one mile north of Troy some very large bowlders of this composite character may be seen. One bowlder in this locality measured about six hundred and forty cubic feet. The large bowlder, east of Sidney, mentioned in my report on Shelby county, is nearly in the line of this belt east of Troy. Another great belt of bowlders, but, perhaps, inferior to that in the eastern part of the county, occurs west of the Stillwater, where it may be observed in the neighborhood and north of the town of Milton. This belt is about 100 feet in altitude above the bed of the Stillwater. Here, also, are very large and beautiful specimens of igneous rocks.

Remains of a Former Race.—It will be necessary to notice but briefly the remains which a former race have left. The usual stone and flint implements, which are so abundantly scattered over the country occur, also, here in about equal rate of distribution as elsewhere. Heretofore those who have picked them up, when engaged in working the ground, have either broken them or lost them again, and but a very small number can be obtained. But as attention has been called to them, more care will be taken to preserve them, and collections of them will be made with greater ease hereafter. There are many persons in the county who take an intelligent interest in these relics of a people who once dwelt upon this soil, and of whose history so little is yet known that every thing which will reflect light upon them should be carefully treasured up. The cabinet of the public school of Troy contains a number of these flint and stone tools, and should be made a depository of many which, in private hands, are subject to all the vicissitudes of our uncertain lives. Many private collections fall into the hands of unappreciative persons when those who have gathered them pass away. This school cabinet is an admirable one for purposes of instruction, and will doubtless continue to receive from the friends of the schools in Troy additions of value from time to time.

Remains of Mammals.—These are by no means abundant in the county. A fragment of an elk horn, of about eight pounds weight, about ten inches long, and without the prongs, and six inches wide, which was found on the land of Mr. Isaac Sheets, I saw in possession of Mr. Ira L.

Morris, of Troy. This gentleman has many specimens of natural history in his cabinet, and some relics of a past race of men. I saw the tooth of a mastodon in possession of Mr. C. S. Coolidge, of Troy. The tooth was found on the farm of Mr. Abram Beadle, about north of Troy.

PUBLIC IMPROVEMENTS.

The account of these works does not properly belong to the purpose of this investigation, but as they depend largely upon the physical character of the country, it will not be out of place to speak of them. Reference has already been made in these pages to the admirable system of graded and graveled roads, which connect all parts of the county together. The Miami and Erie canal passes through the county from north to south, near the right bank of the Miami River, and affords water-power for manufactories at Piqua, Troy, and Tippecanoe, and at some other points. At Piqua and at Troy there were in process of construction, at the time of my visit (1872), extensive works to make available the large water-privileges of the canal and river for manufacturing purposes. While the actual success of these enterprises remains to be seen, there seems to be no reasonable doubt in regard to it. If success does crown these efforts, the result will show itself in greatly increased prosperity in all the interests of the county. The urban population must already be, as compared with the rural, rather beyond the average of that in the agricultural counties. The town population of Miami county is distributed among several prosperous cities and towns, instead of being collected into one larger city. To this report there is lacking the statistics of the cities as well as the figures of the comparative elevations of the various portions of the county, above the sea-level, or as compared with the Miami River, the canal, railroads, and the turnpike roads. I made several efforts to obtain these figures, but have failed. Those who have them, and have failed to furnish them, are responsible for the lack of fullness of the report in this respect.

BEDDED ROCK.

Niagara.—There are three distinct geological formations exposed, in Miami county, below the Drift, belonging to era known as Silurian. The lower Silurian is seen at all exposures below the horizon of the base of the cliffs at Charlestown, and Col. Woodward's, at Tippecanoe. The rock composing the cliffs, the next to that just mentioned, is that known, in geology, as Clinton, called, often in the county, sandstone. The cliffs at Ludlow Creek are in the same formation. Next above the Clinton, and the only remaining bedded rock in the county, is that known as Niagara. The Niagara extends on a horizon throughout the county, from the upper parts of the abrupt cliffs mentioned, to the Drift above. The falls and bluffs on Greenville Creek, near Covington, are in the Niagara. The upper surface of the Niagara is made uneven by the wearing away of portions of it by the action of the Drift period. When it was formed, it extended over the entire county in a bed of a thickness, no doubt, much greater than the thickest portion which remains. How much of its original thickness was abraded by Drift action, we have no means of ascertaining. But a small part remains of that which formerly existed. The water-courses have worn off both Niagara and Clinton. In some places all the Niagara is abraded, and the Clinton is the surface rock, as at all horizons below that of the top of the cliffs named as composed of Clinton. In other places the Niagara is but a few feet thick, as at the Piqua quarries. At Kerr's quarry, in the south, at those in Ludlow, Panther, and Greenville creeks, and at the lime-kilns, north of Clayton, the formation remains of considerable thickness.

The fragments of the upper beds of Niagara which escaped the denuding effects of the Drift period, are of a soft, porous rock, highly fossiliferous. This portion of the formation makes building lime of the best quality. At Brant, in the south, and at Clayton, in the north, exposures of this upper portion of the system remain, and a large quantity of lime has been manufactured and commands the highest price in the market. Practically the quantity is sufficient for all demands likely to be made upon it. The lack of transportation hinders the development of the resources of the localities named for lime-making.

The quarried stone of this county comes mostly from the Niagara. I place the Piqua stone in the Niagara. I am aware that it is in lithological characters anomalous when compared with this formation as developed in this section. It is equally so with the Clinton. It is extremely local and lies, without any transitional strata, immediately upon undoubted Clinton. It may represent the transition of Clinton to Niagara. It is a fine-grained, mostly sedimentary stone, without a large proportion of fossils. It probably thins out in all directions. It dresses extremely well, and is a stone of rare excellence. The Clinton underlies this stone, and has an uneven upper surface. This unevenness consists of mound-like elevations, sometimes twenty feet in diameter and four feet high in the center. Upon these little mounds, composed of species of branching corals, the Piqua stone lies, conforming to its unevenness of surface. I have spoken of the worn surface of this stone by the action of the Drift. The Drift has removed the Covington type of stone from the top of this at Piqua.

Passing to the other quarries in the Niagara, for a connected view of the whole, with the subjacent formation, I refer the reader to sections at the end of this article, showing the thickness of the stone at several of the best exposures in the county.

The other exposures of the Niagara are those at the quarries at Covington, and at Kerr's, and at Ellis', on Ludlow Creek. Good building stone is obtained at all of these. At Kerr's and Covington, fine blocks are obtained, containing very large and fine specimens of *Pentamerus oblongus;* trilobites of the species *Calymene Blumenbachi* occur frequently here. The quarry of Mr. Ellis, on Ludlow Creek, not many feet above the upper part of the Clinton, contains stone in its lowest part approximating more nearly to that of the Piqua quarries than any observed in the other quarries. I am inclined to believe it may be of the same age, and that it really lies lower than the lowest beds quarried at Covington.

Clinton Formation.—The horizon of this formation has been already indicated. Whether the Clinton rises somewhat to the north or not, I had not the instruments to ascertain. A plane drawn through the upper portions of the cliffs at Charlestown, Col. Woodward's, Milton, Ludlow Creek, and extending to the rock-bank of the Miami River, at Bogg's Mill, in the edge of Shelby county, would nearly show the upper limit of the Clinton. Whether this plane would be horizontal or not, remains to be ascertained. I shall mention the principal exposures of the Clinton. The cliffs referred to several times are in this formation; the sections given will show its thickness at the places named. The lime-kiln quarry of Mr. John Brown is in the Clinton. The lime burned at these kilns is very pure lime, strong, and valued highly by paper-makers, who make use of lime to soften the straw used in the manufacture of paper; at Mr. Rudell's, on the Tippecanoe and Carlisle road, and on the farm of Mr. J. H. Harter, north of Honey Creek, can be seen good exposures of the Clinton. On the roadside, at his gate, a very friable stone may be seen, called sandstone; it is of a reddish color, and may be easily crumbled in the hand. On this farm are cliffs of the Clinton about fifteen feet in altitude.

On the farm of the Messrs. Nooks the Clinton has been quarried for their own use. Here a *Syringopora* coral was highly developed and some masses of *Favistella stelleta.* The quarrying has been carried to a depth of about fifteen feet, every where characteristic rock of this formation.

The highest locality, in Lost Creek, where the shale underlying the Clinton can be seen, is in a ravine on Mr. John Lefevre's farm, below the old dam on the creek.

In all exposures observed, the lower strata of the Clinton are of a coarse and sandy nature. The characteristic unevenness of the bedding renders the quarrying of it difficult, and makes it necessary, before it can be used for masonry, to cut it on all sides. The lower strata are used for fire-stones and hearths, and endure the greatest heat of the ordinary fire-place, as lining stones, for many years.

At Mr. S. D. Green's, one mile east of Lost Creek, the Clinton appears about twenty feet above the bed of the creek, and attains a thickness of some thirty feet on his farm. While the lower exposures are composed, in a large measure, of fragments of encrinites, the upper is made up of various species of coral. At the highest exposure, on Mr. Green's farm, is a very good quality of stone for lime. Very fine specimens of *Syringopora* can be obtained in the old quarry, as well as of *Halysites.*

Between Troy and Piqua the new Troy hydraulic was cut for several hundred feet through the solid Clinton formation. Near this point the same stone may be seen exposed on the river bank.

The lime-quarries, on the south of Piqua, are in the Clinton. The lime has nearly the same properties as that burned in Mr. Brown's quarries. Here the Clinton seems to be but a mass of fossils, mostly corals of the genera *Stromatopora*, *Halysites*, *Favosites*, and *Syringopora.*

At the falls of Ludlow Creek, attempts were made to open a quarry, a few years ago, to obtain building stone, particularly of a fine quality. It is called the "marble quarry." The stone is of a good quality, crystalline, even-grained limestone, which takes a fine polish; but its hardness, and the frequent fractures and unevenness of strata, made it unprofitable as a business operation. I have given enough instances of the occurrence of this stone. Any one observing with care the horizon of each formation, and the character of the stone, can readily decide as to any exposure where it belongs.

The Blue Limestone of the Cincinnati Group.—I shall attempt to do nothing more than indicate the horizon of this group, and refer the reader to the volumes of these reports in which this formation is specially treated of.

The *Blue Limestone* comes in below the base of the Clinton. In some places heavy beds of shale intervene. It will be observed in the sections given, that various transitional strata exist between this formation and the next above. Whether these represent formations which are more distinctly developed in other localities, I do not undertake to decide.

The Blue limestone may be regarded as practically, in this county, coming in next below the Clinton. The Clinton is succeeded downwards by blue or red shales. These may be observed at the base of the Charlestown cliffs and then at Col. Woodward's. On the same line of cliffs, further south of the National road, the blue shale is manufactured into a good article of drain tile by Mr. Mark Allen. It is to be seen in the railroad cut north of Tippecanoe. On the Stillwater, near Milton, the same shale is seen at the base of the cliff, and on the east of the river on the hill-side opposite. From the horizon of these localities, all below belongs to the Cincinnati group. All the streams below this horizon, cut through the upper strata of this group. The outcrop of the blue limestone must be looked for up all the streams, far enough above these localities to allow the rise to reach the horizon of the base of the cliffs.

Section at Kerr's Quarry.

	FT.
Flinty courses overlying Springfield stone, containing *Pentamerus oblongus* and characteristic corals	20
Niagara shales—covered	25
Clinton limestone—partially exposed	53
Cincinnati group	40
Level of Miami and Erie Canal.	

Section at Woodward's.

Clinton limestone—top of cliff, near residence—corals abundant in upper beds	35
Iron-stained limestone—firestone, called "sandstone," 6-inch course, fine-grained	..
Light blue clay... { dividing strata between	5
lower and upper silurian	4
Red shale.	
Blue shale, of Cincinnati group	20
Blue limestone, of Cincinnati group, in solid layers	15
Level of Miami River.	

Falls at Milton.

Clinton limestone, with characteristic fossils—*Chætetes, Favosites, Halysites, etc.*—layers often iron-stained—encrinal	20
Cincinnati group—blue shale and limestone, containing *Orthis occidentalis, Orthis biforata,* and other characteristic fossils	18
Unseen at this locality	55
Level of Stillwater River.	

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CHAPTER LXXVII.

REPORT ON THE GEOLOGY OF LOGAN COUNTY.

BY FRANKLIN C. HILL.

SITUATION AND AREA.

Logan county lies just north of the middle of the western half of the State, and is bounded on the north by Auglaize and Hardin counties, on the east by Union, on the south by Champaign, and on the west by Shelby and Auglaize. Its boundaries are chiefly section lines, and its general form is that of a rectangle, about twenty-four and one-half miles long, east and west, by eighteen and a half miles north and south, and its area is about four hundred and fifty-three square miles, or two hundred and ninety thousand acres.

NATURAL DRAINAGE.

The boundary lines of the county are all nearly level, and hold an elevation of between one thousand and twelve hundred feet above tide-water, falling where the Miami River goes out on the west to about nine hundred and seventy-five feet, but the center has been upheaved until the summit, on John W. Hogue's farm, one and one-half miles east of Bellefontaine, has reached the height of one thousand five hundred and forty feet, which equals one thousand one hundred and eight feet above low-water at Cincinnati, and nine hundred and seventy-five feet above Lake Erie, and is the highest point yet measured in Ohio.

Thus the general form of the county is that of a flat cone, about five hundred feet in height.

This cone has been cleft from north to south to the depth of some three hundred feet by the valley of Mad River, leaving a summit on the east, at Wickersham's Corners (called "Jerusalem" on the county map) only twenty-five feet lower than the one on Hogue's farm.

The waters falling on Hogue's summit, and flowing through the streets of Bellefontaine, as "Possum Run," fall into Blue Jacket, thence into Buckinjehala, and so into the great Miami, whence they are taken, at Port Jefferson, into the Summit-level of the Miami canal, and these are divided, part flowing southward into the Ohio and the Mexican Gulf, and part going northward to Lake Erie and the St. Lawrence.

The main body of the Central valley is drained by Mad River, flowing southward, while the waters of the extreme northern part flow through Rush Creek into the Scioto, which also receives, through Mill Creek and the Darby's, the drainage of the eastern edge of the county.

The Great Miami, rising in the southern part of Hardin county, flows southwardly through the western half of Logan until within two and one-half miles of the southern boundary, and then suddenly turning to the west by north flows out into Shelby county.

Scattered over the surface of the county are numerous small lakes, or ponds, as Rush Creek Lake, Silver, Black, Dokes, Twin Lakes, etc.

Several of these ponds are valuable for their ice-crop, and some furnish considerable numbers of fish. One, the Indian Lake, in Stokes and Richland townships, is now included in the Lewistown Reservoir, which was designed to collect and hold in reserve the rainfall of that region for the benefit of the State canals.

Although the center has been upheaved and split in two, and time and the elements have fashioned the fissure into the lovely valley of Mad River, heading in some rugged, rocky ravines south of Wickersham's Corners, yet the general surface of the county is so level, or modulates so gently, and the rocks are so well covered by the gravel and clays of the drift that the untillable land, if all collected into a body, would scarcely cover one section. The very summits are wheat-fields, and, though now, in the wet beech woods of Bokes Creek and Stokes townships, the first clearings are being made, and log-cabins built, it will be but a very few years until the whole county is brought under the plow.

SOIL AND TIMBER.

The soil is almost entirely derived from the drift-gravel and clays. Although much of it is at first wet and heavy, yet, under proper drainage and tillage, it proves rich and generous.

In the valleys of the Miami and Mad Rivers, oaks and hickories prevail, but on the higher lands sugar-maples take their place, mixed with, and, on the flat clay lands, overpowered and driven out by, the beech. Tulip, or, as it is often called, poplar or white wood (*Liriodendron tulipifera*), elm, ash, sycamore, basswood, dogwood, sassafras, and other trees are found in large numbers, but oaks and hickories, sugar, and beech largely prevail and give character to the forests.

At no time of the year is this so apparent as in the early spring, when, in passing from an oak region to a maple one, as in going from West Liberty to Zanesfield, points of view may be chosen so that the landscape on one side will appear bleak and bare as midwinter, while on the other the hills are clothed with the verdure of June, and the dividing lines will be as sharp and well-defined as if the woods had been laid out and planted by the art of the landscape gardener.

GEOLOGICAL STRUCTURE.

Although the entire surface of the county is covered deep in drift, or its derivatives, yet the upheaval of the center exposes three formations of rock, and there is good reason to suppose that a fourth would be visible but for the immense deposits of gravel in the Miami Valley. These formations are Huron shale or black slate, shown in the hills about the heads of Mad River, the Corniferous limestone, best seen in the Bellefontaine, Macachack and Middleburg quarries, and the water-lime rock, exposed in one place on the Machachack, and in numerous ones in the neighborhood of Belle Centre and Northwood, while it is the Niagara that is supposed to lie under the drift in Miami Valley.

The Huron Shale, lying highest, and being from its soft, laminated structure most subject to the wear of the elements, has been cut down by frost and water until only two irregular islands are left, where outlines are shown, approximately, on the map.

The smaller of these islands, lying directly east of Bellefontaine, in Rush Creek, Lake, and Jefferson townships, is the last outlier of its formation east of the anticlinal axis of the State, or rather, it is directly on the crown of the arch. Its northern end is hidden under the Drift, but must lie some where near Harper, and the southern is found about three miles south-west of Zanesfield, where a deep cut was begun through it some years since on the line of the Delaware Railroad, giving a length of about nine miles, with an average width of some two and one-half or three miles.

The second and larger island lies east of Zanesfield and West Liberty, and underlies Pickreltown and Wickersham's Corners, in Rush Creek, Jefferson, Perry, Monroe, and Zane townships, with a spur extending into the northern edge of Champaign county. It is about twelve miles long by three wide, and within its limits are to be found the finest and most characteristic exposures.

The thickness of the slate on the line of section A B is 110 feet under the western or Hogue's summit, by actual measurement with the level, and 136 feet, by careful barometrical estimate, under Wickersham's Corners.

Immediately below these Huron Shale islands lies one large island of Corniferous limestone, which can be traced through Rush Creek, Jefferson, Perry, Zane, Monroe, Liberty, Lake, Harrison, and McArthur townships. Its thickness is probably between sixty and one hundred feet, but no where in the county have both top and bottom been exposed at the same place, and the records kept of borings are so imperfect as to be worthless. The largest quarries are those of Messrs. Scarf, at Bellefontaine, of General A. S. Piatt, on the Makachack, in Monroe township, and Mr. J. B. Sharpe, at Middleburg. Messrs. Scarf's quarry has been worked for a depth of over twenty feet, chiefly for lime, one thousand bushels of which are produced by twenty-five cords of wood. The product is of good quality and color, but difficult to ship, on account of the rapidity with which it air-slacks, only three or four days being required to reduce it.

Some courses show hydraulic qualities, but no systematic experiments have been made with it, nor could any estimate be had of the amount of business done.

General Piatt's quarry has been worked to about the same depth, and the lime produced by the same expenditure of fuel, and of perhaps rather better quality. The building stone has been all consumed in the neighborhood. It is capable of being worked to fine effect, as the General's own mansion abundantly testifies. Mr. Sharpe's quarry, at Middleburg, has been worked to about the same depth as the others, but with more system, and exposes the rock better. The section may be described as—

	FEET.
Covering of Drift	2
1st course, much broken	6
2d " solid	4
Ocherous seam.	
3d course, firm, thin layers	3
4th " solid	4
5th " "	6
	23

Numerous small quarries have been opened all around the edges of the island, both for stone and for lime, but they are only worked occasionally and for local purposes.

The geological scale of the State calls for a bed of Oriskany Sandstone under the Corniferous, and of Hamilton above it, but there are no traces of either to be found in Logan county. Dr. Newberry (Vol. I., p. 141) speaks of Oriskany Sandstone at West Liberty, but this is most probably a mistake. In General Piatt's quarry, on the Makachack, a bed of fine sandstone exists, that has been quarried and reduced to sand for plastering, with excellent success, but it is only a local deposit in the *upper* layers of the Corniferous, fifty-five feet above the top of the Helderberg, in the same field. These small sandstone deposits are quite common in that neighborhood, and, in fact, the whole appearance of the rocks is so sandy that Mr. George G. Shumard reported the following section in the prospectus of the "Logan and Champaign Petroleum Company," in 1865:

		FEET.
1.	Drift, gravel, and bowlders of sienite, gneiss, red feldspar, hornblende and mica schist, quartz, grindstone, etc.	20
2.	Black and dark-brown bituminous slate	40
3.	Hard, fine-grained, light-gray *silicious sandstone* (as far as exposed)	3
4.	Black and dark-brown bituminous slate	60
5.	Hard, light-blue, fine-grained, silicious sandstone	4
6.	Black and dark-brown bituminous slate, containing large septarian segregations and nodules of iron pyrites	150
7.	Hard, light-gray, *calcareo-silicious sandstone*, thickness as far as exposed	20
		277

Mr. J. M. Inskeep, who worked the drill for the said company, reports the section obtained on B. Ewing's land, in southern part of Monroe township, as follows:

	FEET.
Slate	6
Flint	5
Sandstone	639
Red slate	12
Blue limestone	43
	705

At that point patience, hope, and funds failed, and the project was abandoned. It is much to be regretted that a more careful or more skillful record was not kept of this boring. The "flint 5 feet" evidently was the upper course of the Corniferous, but it is difficult to understand what could be included in "639 feet of sandstone." Mr. Shumard's second, third, and fourth divisions evidently refer to the Huron shale, and his fifth to the upper courses of the Corniferous, but his sixth and seventh would seem to be purely imaginary or very much confused.

There are traditions of a former sandstone quarry on the hill top east of Zanesfield, from which the neighborhood was supplied with grindstones, and some still hope that it will be rediscovered. But Dr. B. S. Brown, of Bellefontaine, whose retentive memory carries the treasures of nearly three-quarters of a century of close observation, dissipates this hope and vindicates geology by remembering how the ancient mason hewed his grindstones from an immense (Waverly) sandstone bowlder, and split his millstones from granitic ones. There is now another large mass of Waverly sandstone lying on the side of a slate valley on Mackachack, half buried in gravel and the debris of slate, and it has been proposed to open a quarry in it. Doubtlees it will yield fine blocks of beautiful stone, but as soon as fairly opened the quarry will fail from exhaustion.

The Oriskany sandstone should be dropped from the Logan county scale.

Below the Corniferous lies the great sheet of Helderberg or water-lime, the lowest formation yet seen in the county. It has been worked on General A. S. Piatt's land on the Mackachack, and at Northwood, Huntsville, Richland, and Belle Centre. At the latter point is Anderson's quarry, probably the best and largest in the county. Much of the stone in this quarry is in thin and smooth courses, and makes excellent flagging. The yield of stone is stated at about 1,000 perches annually, worth $1.25 per perch in Belle Centre. Some of it is shipped on the Sandusky Railroad, but local demand consumes the greater part of it and all of the lime burned.

At the depth of fifteen feet a course is reached that is of so little value that it is avoided. As there is only two feet of "stripping," it is easier to extend the work sideways than downward.

he conformation of the surface of Logan county indicates that under Miami, Pleasant, and Bloomfield townships perhaps the Helderberg stone has been scoured off, and that, were the masses of drift penetrated, the first fixed rock found would be the Niagara. But the highest point where the Niagara has been worked is Tremont, in Clarke county, and the location of that formation on the Logan county map is a matter of pure conjecture.

MATERIAL RESOURCES.

The chief source of wealth in Logan county must ever be its agriculture, for which the valleys of Miami and Mad River are especially adapted, while even the hilliest townships are by no means barren.

The rocks yield building stone in sufficient quantities for all local demands, although peculiar circumstances and a freak of fashion at present bring stone from distant counties for the more important structures, and they can supply lime for building or farming purposes in such quantities and at such prices as to defy competition from abroad.

The islands of Huron shale are, perhaps, capable of supplying hydraulic lime, though at present entirely unused.

Beds of clay exist in every township, suitable for brick, tile, and coarser pottery, and are now worked to some extent. At East Liberty, Lewistown, Rushsylvania, and other points are good tile works, fully equal to the local demand.

Underlying the marsh, at the head of Rush Creek Lake, is an immense deposit of white shell marl, that would be of great value to the poorer lands of the hills, and doubtless similar beds exist in other parts of the county.

The vast beds of gravel scattered over most of the townships will furnish metal for extending the good roads, now common in the older districts, to every farm in the county.

In conclusion, I desire to express my acknowledgments to the many citizens of the county who aided me in the prosecution of my work. There are a few that rendered such service as to deserve special mention here. Among them may be named Gen. A. S. Piatt, of Monroe township, Dr. J. A. Doran, of Rushsylvania, and Mr. W. Barringer, of Bellefontaine.

The following interesting statement in regard to the Archæology of Logan county will here find appropriate place. The collections referred to are now in the cabinet of the Ohio Agricultural and Mechanical College at Columbus: E. O.

Prof. TON, *Assistant Geologist:*

SIR: In accordance with your instructions I secured "all the stone relics possible," during my stay in Logan county, and herewith transmit them to your care. Of the whole number, one hundred and two pieces, only one was found by myself, the others being presented by various individuals throughout the county. For more than half of them the Survey is indebted to Dr. J. A. Doran, of Rushsylvania.

It is almost impossible to describe these relics without drawings, nor is it easy to classify them, as the dividing lines between axes, hatchets, and hammers, and between arrow and spear-heads, etc., are by no means sharp and clear. They may, however, be roughly divided as follows:

Grooved axes	11
Ungrooved axes	12
Hammers	
Spear and arrow-heads	44
Pestles	7
Rolling-pin	1
Grindstone	1
Slate ornaments (?)	9
Flint fragments	14
	102

By far the finest and best among the axes is the large one of polished black gneiss, presented by Mrs. J. Fry, of Washington township. It measures seven inches by four, with a cutting edge two and five-eighths inches long, and for symmetry of form and finish of workmanship will rank with the best of its kind, though not with the largest. It weighs but five pounds; while Dr. H. H. Hill, of Cincinnati, has one weighing fourteen, and we have an account of one weighing eighteen pounds. The next in point of size is an axe of pale bluish slate, as remarkable for eccentricity of shape as the other for symmetry. Cut obliquely to the stratification of the stone, its edge is thrown to one side as if for "hewing to line," and the body is curiously twisted, so that the edge makes quite a decided angle with the poll, as if to produce the effect of the bent helve of the broad-axe. But this is probably accidental rather than intentional, and is due either to defects o the stone or unskillfulness of the maker. This axe was donated by Mr. R. Reid, of Lewistown.

The other axes are as variable in size and shape as in material. Some have cutting edges, others are sharpened to points, and others still are blunted until there is almost no distinction to be made between them and the "hammers," which are simply ovate stones with shallow grooves cut around them. The term "ungrooved axe," though constantly met with in print, is not often used by the people. Their ideas of an axe imply a handle passing through or lashed to the head. But the relics from the Swiss Lake dwellings show axes passing through their helves. A knotted club has a hole mortised through its heavy end, into which the upper part of an ungrooved axe is fitted, and as every blow on the edge serves to drive the axe more firmly into its handle, the implement or weapon must have been a very efficient one. The term "skinner," usually applied to these axes, is probably a misnomer.

The most noticeable of the arrow heads is the large flat one, made of flint, that resembles moss agate. It measures four and three-fourths inches by two and one-eighth, and is about one-fourth of an inch in thickness. Its size and regular shape make it conspicuous in the collection, but its full beauty can not be seen until it is held up against a strong light.

The arrow head of blue and white flint is also worth notice. It measures four inches by one and five-eighths, and is very regularly formed, while the edges are sharp and beautifully serrated with notches of about one-twelfth of an inch long. It must have been a very efficient weapon, capable of giving severe wounds.

The fine black spear head was presented by Professor Wright, of Rushsylvania. Unfortunately it was broken into three pieces, and the middle one, about one inch in length, was lost. When entire, it measured six inches in length.

The seven pestles, or mullers, show as many different forms, all well adapted to their purpose, which was, doubtless, to grind grain.

The stone described as a "rolling pin," for want of a better name, is, perhaps, the poorest specimen in the collection, and the one most liable to be distrusted. Made of a micaceous and crumbling stone, it seems scarcely fit for any use. Its length is nine and three-fourths inches, and its diameter varies from one and one-fourth to one and one-half inches, its general shape being that of a cylinder with rounded ends.

It is by no means clear to me for what purpose the mass of brown sandstone, which I have called "grindstone," was intended. In shape, it rudely approaches the ordinary grindstone, having a diameter of about six inches and a thickness of three. On each of its flat sides are two confluent hemispherical cavities of about one and one-half inches in diameter. The two pairs of cavities happen to be placed at right angles with each other, though probably by accident. Dr. H. H. Hill, of Cincinnati, has several similar stones in his collection, and suggests that they were possibly used to round the ends of horn and bone implements. This stone, with several others, was presented by Mr. Wm. Barringer, of Bellefontaine, who dug it up in that town.

The nine "slate ornaments" differ entirely in shape and workmanship from the other relics, and seem to have been made by a different race of men. I have called them ornaments because unable to imagine any use to which they could be applied, and yet they seem equally foreign to our ideas of decoration. Four of them are simply oblong slabs, of about four inches in length by two in breadth, and one-fourth of an inch in thickness, pierced with one or two holes each.

One is apparently intended to be suspended by one end, as shown by the position of the hole. The other end is shaped somewhat like an arrow-head. Its length is five inches, breadth one and a half, and thickness five-sixteenth. Possibly it was a Phallus. A sixth piece is almost semi-circular, being about five inches by two and a half. It seems to be half of the original instrument, which must have had the form of an ancient double-edged battle-ax. The break has been through the eye, which was bored very truly, the hole being about two inches long by half an inch in diameter.

The other bored fragment is too small to warrant much conjecture as to its shape or use.

All these pieces are of light-colored slates, but the remaining two are darker, and are of very peculiar shapes.

One might be described as a Spanish saddle with the skirts cut off. It measures three and three-eighths inches by one and a half inches high. At each end a hole is bored through the lower edge, as if for crupper and holster strap.

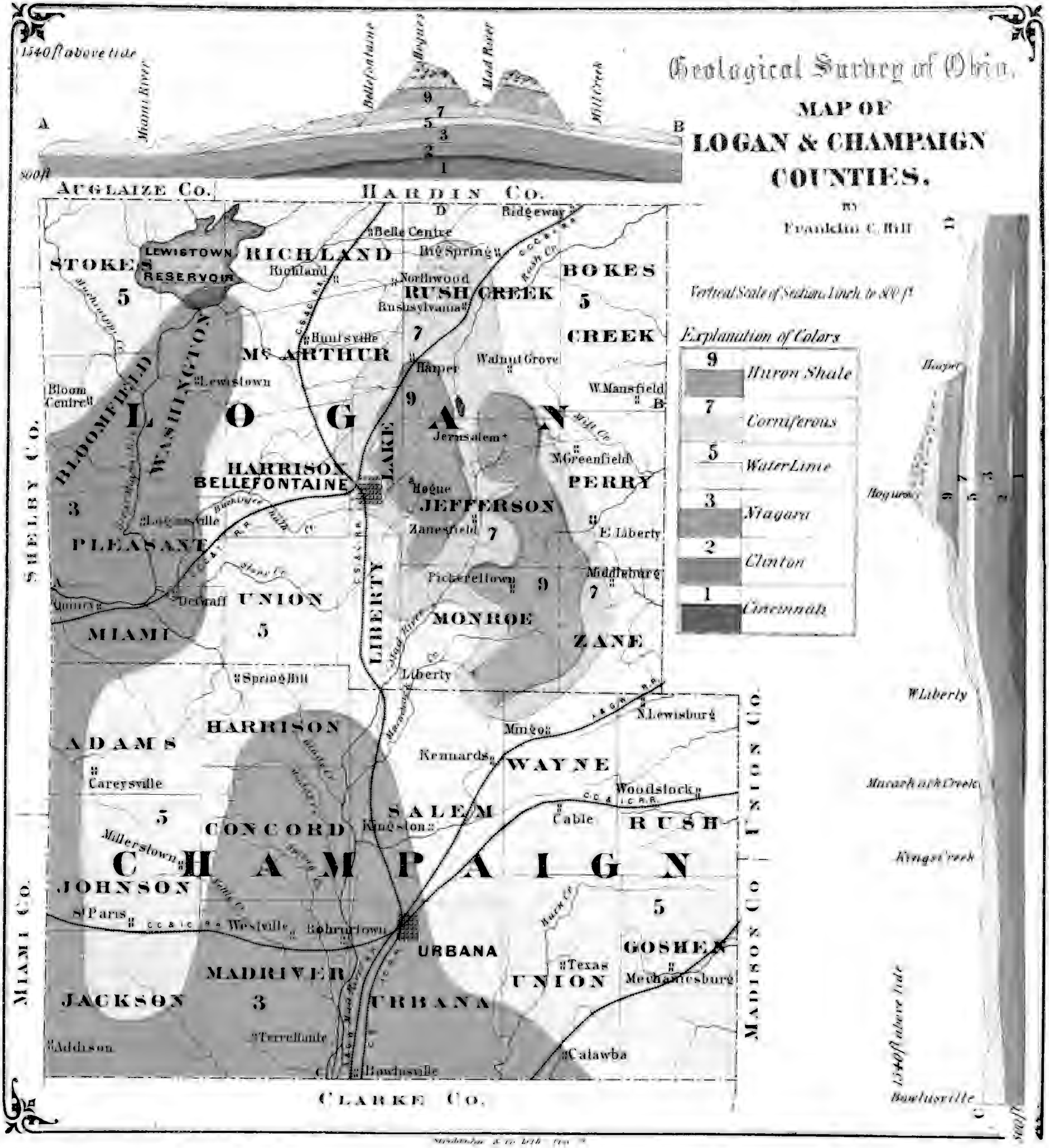
The other piece is not quite so stout, but the pommel has been extended forward, until it is as long as the body, and the end is turned downwards as if in rude imitation of an animal's head. The same holes occur as in the last piece. This piece measures four and three-quarter inches by two and a quarter. A cross section through any part of either of these "saddles" will resemble the diagram of a spherical equilateral triangle. These forms are not very uncommon in collections, although I have not found any suggestion as to their use or meaning. As many specimens have a raised circle on either side of the "head," as if to represent eyes, the idea may have been derived from some animal.

This collection must, by no means, be supposed to have exhausted Logan county. No doubt great numbers of the relics are still scattered there, and were it generally known that you propose to keep the collection displayed by itself in the Agricultural College museum, the number of specimens would be largely increased by donations.

Respectfully,

FRANKLIN C. HILL.

GEOLOGICAL MUSEUM OF COLLEGE OF NEW JERSEY,
PRINCETON, N. J., May 1, 1876.



Geological Survey of Ohio.
MAP OF
LOGAN & CHAMPAIGN
COUNTIES.
BY
Franklin C. Hill
Vertical Scale of Section, 1 inch to 800 ft
Explanation of Colors
9 Huron Shale
7 Corniferous
5 Water Lime
3 Niagara
2 Clinton
1 Cincinnati
1540 ft above tide
800 ft
Miami River
Bellefontaine
Hogues
Mad River
Mill Creek
AUGLAIZE CO.
HARDIN CO.
SHELBY CO.
MIAMI CO.
MADISON CO.
UNION CO.
CLARKE CO.
LOGAN
CHAMPAIGN
LEWISTOWN RESERVOIR
STOKES
RICHLAND
RUSH CREEK
BOKES CREEK
McARTHUR
BLOOMFIELD
WASHINGTON
HARRISON
BELLEFONTAINE
LAKE
JEFFERSON
PERRY
PLEASANT
UNION
MIAMI
LIBERTY
MONROE
ZANE
ADAMS
HARRISON
CONCORD
SALEM
WAYNE
RUSH
JOHNSON
MADRIVER
JACKSON
URBANA
UNION
GOSHEN
Belle Centre
Ridgeway
Big Spring
Richland
Northwood
Rushsylvania
Huntsville
Harper
Walnut Grove
W. Mansfield
Bloom Centre
Lewistown
Jerusalem
N. Greenfield
Hogue
Zanesfield
E. Liberty
Logansville
Pickereltown
Middleburg
Quincy
DeGraff
Liberty
Spring Hill
N. Lewisburg
Mingo
Kennards
Careysville
Woodstock
Cable
Kingston
Millerstown
Paris
Westville
Urbana
Texas
Mechanicsburg
Terrehaute
Addison
Bowlusville
Catawba
Harper
Hogues
W. Liberty
Macachack Creek
Kings Creek
Bowlusville
1540 ft above tide

CHAPTER LXXVIII.

REPORT ON THE GEOLOGY OF CHAMPAIGN COUNTY.

BY FRANKLIN C. HILL.

SITUATION AND AREA.

Champaign county lies south of the middle of the western half of the State, and is bounded, on the north, by Logan and Union counties; on the east, by Union and Madison; south, by Clarke, and west, by Miami and Shelby counties. Its boundaries are mostly the section lines, and its general shape is that of a rectangle, of about twenty-three miles in length, east and west, by an average width of fifteen and a half miles, north and south, including an area of about 356½ square miles, or 228,160 acres.

The name, "Champaign," admirably expresses the character of the country; for, although in a few places a little hilly, as a whole, the surface is very level, and made up of plains.

DRAINAGE.

Although a small part of the eastern edge of the county drains into the tributaries of the Scioto, and the waters of a still narrower strip on the west flow into small branches of the Great Miami, by far the greater part of the county is drained by the Mad River.

The main stream of Mad River, rising among the slate hills of Logan county, crosses the north Line of Champaign, at a point about one-third of a mile west of the middle, flows in an almost straight course southward, and leaves the county at a point about two miles farther west.

Mackachack Creek, escaping from Logan county, about a mile east of Mad River, flows almost parallel to it for several miles, making its junction about a mile below the north line of Concord township; and King's Creek comes in, from the north-eastern townships, about two miles farther southward, and about one and a half miles north of the middle of the county.

These streams, rising in the highest and most rocky parts of Logan and Champaign counties, and fed by unfailing springs, are strong, constant, and rapid, furnishing many good mill sites.

South of King's Creek, Mad River receives no large branches from the east, in Champaign county, the greater part of the south-eastern townships draining into Buck Creek, which, rising in Madison county, flows across the corner of Champaign into Clarke county.

From the west, the Mad River receives three large tributaries—Glady, Muddy, and Nettle creeks—though the latter is really two streams, Spring Creek joining it only a short distance above its mouth.

Each of these creeks has innumerable branches, which cover Harrison Concord, and Mad River townships with a net-work of small streams.

Storms, and Blacksnake creeks flow into Clarke county, before reaching Mad River.

SURFACE FEATURES.

A glance at the map will show the different character of the surface on the east of Mad River, and on the west of that stream. On the east, the long branchless streams mark prairie lands below, with narrow valleys above, and springs flowing from under the hills, while on the west, the multitude of small, crooked streams shows the swampy nature of the country.

It is in these swamps, lying on deep beds of clear gravel, that Mad River finds those stores of bright water that keep up the force of her wild stream in the driest seasons. But the valuable timber, and rich soil of these swamps, are tempting the owners to clear and drain, and in a few years the whole character of the surface will be changed.

In this liberally watered region, wells are sunk only deep enough to reach the clear gravel below the level of the river, where a full supply of water is obtained. Hence, there is among the people no knowledge of the underlying rock. In fact, there seems to be but one place west of Kingston, where stone has been found in position. In the south-west quarter of section fifteen, Jackson township, a quarry was worked some forty years ago, but it has not lately been used.

The general form of the surface of the county is that of a broad, shallow trough, lying north and south, Mad River running through the middle, and draining the main body of the land, while the edges shed their waters eastward to the Scioto, and Westward to the Miami River.

The highest and roughest lands are in the north-east corner, in Rush and Wayne townships. The south-east is largely made up of prairie, and the Western edge is composed of table-lands, deeply cut by the tributaries of Mad and Miami rivers.

SOIL AND TIMBER.

On the higher lands, the soil consists of drift, clays, and gravel, while, in the bottoms, the gravel is buried deep, under alluvium and peaty matter.

Every township has beds of clay, valuable for brick and tile-making; and considerable quantities of those articles are made for local use.

Tile-works are in operation at several points—as Woodstock, St. Paris, and Addison.

On the higher lands, sugar, and beech trees flourish well, while the central part is more occupied by oak and hickory. Elm, poplar, and many other kinds, exist in considerable numbers, but the four genera mentioned, give character to the forest, and are typical of it.

In the north-western townships, there were, until lately, large numbers of poplar trees (*Liriodendron*), but they have now been almost exterminated.

In the south-eastern part of Mad River township is a large tract known as "Cedar Swamp," from the fine growth of white cedar, or arbor vitæ, covering it. Being too wet for the pasturage of either swine or cattle, its peculiar flora throve unmolested, and made the place a favorite resort for botanists. But the cedars are being rapidly felled, and the swamp drained, and in a few years will disappear entirely.

The white cedar (*Thuja occidentalis*) of the swamps, and the red cedar (*Juniperus Virginiana*) of the hills, are the only conifers native to the county.

GEOLOGICAL STRUCTURE.

The Drift overlies the whole county, excepting those low lands where its own waste and the swamp growth have covered it with alluvial soil. The highest rock formation, only seen in small parts of two townships, the north-east corner of Salem and the north-west corner of Wayne, is the Huron shale or black slate. The larger shale island of Logan county sends this spur down into Champaign. Under the shale the Corniferous limestone is exposed in a few places in the same townships, and though it has only been quarried in a very small way, for local purposes, it would doubtless prove valuable if more thoroughly worked.

Southward and westward the Helderberg, or water-lime rock, has been opened in numerous places, though but one quarry, Mr. McCoursey's, in section 2, Salem township, is now worked to any extent. It was from this quarry that most of the building-stone of Urbana was taken, and much of it was used for flagging, until the better stone of Berea superseded it. The numerous "sun cracks" in the Champaign county stone interfere with its use as flagging.

The only quarry west of Mad River is in the center of Jackson township, but it has not been worked for years. The fragments of this rock which are obtainable now, have every appearance of Helderberg, and its presence there argues that under the higher lands between Mad and Miami Rivers that formation still remains, although it was probably eroded in the valley of Mad River by the Drift, and the Niagara exposed. The most northern exposure of the Niagara is at Tremont, in Clarke county, but the conformation of the surface warrants this supposition.

The gravel in the hills and under the meadows is composed of almost every variety of rock, the limestones largely predominating, but the surface bowlders are almost entirely granitic, and have evidently come from a different source and by different means.

The dividing ridge between Mad and Miami Rivers, in Adams township, and running up to Quincy, in Logan county, is especially well provided with these granitic bowlders, and their angular shapes seem to show that they have been subjected to very little rolling; were wrenched from their places by frost, and transported by ice.

MATERIAL RESOURCES.

The one great source of wealth in Champaign county is, and must ever be, her unsurpassed farming lands. Nowhere east of the Prairie State can such broad expanses of meadow be found, and even Illinois can not furnish richer soils, while in the important matter of water-supply few places can compete with her. Her springs and streams are clear and strong, and her wells unfailing. Whether she uses her vast fields for pasture or for tillage, their capacity for producing wealth is unbounded. At present there seems to be a tendency to enlarge farms and devote them to grazing rather than to tillage. Whether this is wise and profitable, is a question for the political economist, and for time. Certainly the fear that many entertain, that this course will diminish population, seems to be justified by facts, the census returns showing that the population only increased by 1,490 from 1860 to 1870, while in the previous ten years the increase was 2,916, and between 1840 and 1850 the growth was 3,061.

In stone, the county is not rich, though her wealth in that direction is not fully developed. The Corniferous limestone of the north-eastern townships has scarcely been touched, and very few of the Helderberg quarries have been worked to any extent, and though the quality of stone yet found there is not such as to justify the hope of any extensive commerce, yet there is no doubt that all local demands can easily be met, both for building stone and for lime.

Of clay, the supply is large and well distributed, and the quality is good enough for brick, drain-tile, and the commoner wares. Probably with skilled labor much better results could be attained, but at present the number of potteries is very small, and the product unimportant.

In many of the swampy valleys quantities of marl are found, which, when burned, yield excellent lime.

The large deposits of gravel distributed through the county insure a perfect system of good roads within a few years.

CHAPTER LXXIX.

REPORT OF THE GEOLOGY OF DARKE COUNTY.

BY A. C. LINDEMUTH.

I. SITUATION, AREA, ETC.

Darke county lies in the extreme western part of the State, a little south of the centre, adjoining Indiana on the west, bounded by Mercer county on the north, by Preble on the south, and on the east by Shelby and Miami. It is nearly rectangular in form, and embraces an area of 376,390 acres; 203,782 of which are cultivated land, and the remaining 172,608 acres are uncultivated or woodland.

II. TOPOGRAPHY.

Geologically speaking, this county is situated upon the western terminus of the great divide, lying rather upon its southern slope; hence is properly reckoned, both as to its physical and political position, as belonging to Southern Ohio. The summit ridge enters the county in the north-eastern part, bearing south-west through the northern part of Patterson township, through the southern parts of Wabash and Allen, and passing out near the middle of Jackson township. This, at once, affords an idea of the general topography of the county as regards the dip of the land and the configurations due to water agencies; to which might also be added much other information derivable by analogy from similarly situated counties, of the contour or surface features due to other erosive and accumulative agents.

The numerous springs which occur along this water-shed, as well as the surface streams, would naturally give rise to many avenues of drainage; but, owing to the proximity of their origin, could certainly not attain to any considerable magnitude within the limits of the county. The natural system of drainage, nevertheless, is by no means an imperfect one. Greenville Creek, the largest of the streams, takes its rise in the northern water-shed, a little without the county. Following the general slope of the country, it flows south-east in an almost uninterrupted course, until coming in contact with the large kame upon which Greenville is situated, flows around it in a north-easterly direction, and then, with many windings, flows directly eastward to its junction with Stillwater in Miami county. It receives its principal, in fact, all of its tributaries, from the south, being hugged close on the north by a somewhat prominent highland, which throws all the streams occurring on its surface into the valley of the Stillwater. This, with Painter's Creek, which drains the region immediately south of the former, constitute one system. There are evidently four; though rather insignificant, they are very distinct and noticeable.

Stillwater Creek has its origin in the northern part of the county, in the summit ridge, and occupies the shallow valley between the divide and the highland, separating it from Greenville Creek. Like the latter, it takes an easterly direction, following the natural bent of the surface. Its principal nourishing streams arise in the same clayey drift deposits of the divide. This, which may be regarded as the second system in importance, and the Greenville system just described, it may not be out of place to notice, drain a region of extreme fertility. Though a score or more years ago the great "Spread of the Stillwater" was anything but an inviting agricultural district, by a little artificial drainage and enlarging of the natural capacities of the streams, it now includes some of the richest and most productive farms in the county.

Upon the northern slope of the divide rise the Mississinawa and Wabash. These, which a little farther east would be thrown into Lake Erie, are reflected, as described by Professor Winchell, by Wabash Ridge, and directed westward into Indiana. However, but little territory is drained by these streams in this county, being but the beginning of a narrow gentle valley, which expands into a broad fertile tract in North-eastern and Central Indiana. The Wabash, which at first flows south-east, as if attempting to cross the summit ridge, probably marks the course of one of the ancient breaks or gaps that discharged its waters and floating icebergs into the valley of the Stillwater. In the extreme south, and indicating a different declivity from the rest, originate Miller's Creek, Twin Creek, Whitewater, and several other streams of lesser importance.

All of the streams flow in comparatively shallow and modern basins, the banks of Greenville Creek nowhere exceeding twenty or thirty feet in height. However, there are several exceptions in this respect, together with several important topographical features, which will be spoken of under the head of the Drift.

The general surface of the county is for the most part flat, being almost a uniform slope south-east and north-west from the summit line. Consequently, no marked topographical features meet the eye, and only escapes being monotonous by the shallow basins of the Stillwater and Greenville Creeks, the frequent picturesque kames, and such other variations as are due to local causes. Occasionally, however, striking evidences are observed upon the underlying rocks of a wonderful erosive power, but, being covered on an average of probably one hundred feet of drift, little of the truth is manifest upon the surface contour of the country. It is true, the southern part of the county is in many places undulating and hilly, but it is evidently the result of the last submergence, and such agencies as are now at work all over the State.

Contrary to what one would at first suppose, the summit ridge nowhere presents a prominent and rugged outline. Being subjected to the denuding and erosive influences of past ages, it has become a broad, rounded belt of high land. Its varied alkaline clays have been distributed over the low, moist lands of the Stillwater and Wabash, supplying the black, loamy soil with many of the necessary elements of productiveness, and ameliorating the former irregularities of the country. Yet it still stands, marking the southermost shores of the northern lakes, a prominent feature in the topography of the State.

The highest land, manifestly, is found in the north-western part of the county, about the region of the divide. The highest altitude accurately known is a little north of Union City, being six hundred and sixty-five feet above low-water mark in the Ohio River at Cincinnati. On the summit ridge between Stillwater and the Wabash, the land has an elevation of six hundred and thirty-five feet above the same point. The county line between Mercer county and Darke is six hundred and thirty-four feet, though there are other points about this locality which possibly attain an altitude of seven hundred feet. At Greenville we descend to about five hundred and ninety feet; and still farther south, at the county line between Darke and Preble, in Harrison township, we descend to five hundred and fifty one feet. Ithaca, in Twin township, has an elevation of five hundred and fifty-seven feet above the Ohio. But the lowest land is probably to be found along the bottom of Greenville Creek, in Adams township, where five hundred and twenty feet marks the altitude, and five hundred and forty feet the elevation of the neighboring bluffs or kames. The Ohio River being one hundred and thirty-three feet lower than Lake Erie, these elevations must be lessened by that amount when compared with surface level of the lake. This would make the highest land about five hundred and sixty-seven feet above Lake Erie, or about one thousand one hundred and thirty-two feet above the level of the sea.

In regarding the surface features, it is noticeable that but one remnant of those ancient lakelets, abounding so numerously upon the water-shed in several of the counties farther east, remains here, namely, that which is known as "Black Swamp." It is situated in the north-eastern part of the county, and is fast becoming, through artificial drainage and vast accumulations of organic matter, what all will ultimately terminate in—a great bog.

Several peat bogs of considerable area exist in different portions of the county, which will receive more special attention in speaking of the soil. But of one, however, showing their peculiar character, it might be well to give a brief history here. Many years ago, in the construction of the Cleveland, Columbus, Cincinnati and Indianapolis Railroad in the northern part of the county, the route of the railroad necessitated the running over of one of these peat bogs. To the apparently dry loam or peat, with its dense growth of vegetation, was added sufficient gravel and other material to complete the bed of the road, and in due time the track laid and used. But one morning, not long after, as the train came along, a great break was espied; the track had evidently disappeared, and upon investigation the truth was revealed. The track, instead of crossing over a dry peat bog, was the rather crossing over a hidden lake. Vast quantities of mosses and aquatic plants, together with branches, trunks of trees, and other *debris*, had collected until they had formed, as it were, a super-aquatic soil of several feet in thickness, and of such a remarkable density and buoyancy as to support, for a time, the weight of a train. Some idea may be obtained from this incident of the vast accumulations of organic matter that have been and are now going on to produce these peat bogs. No wonder, too, that an occasional mastodon, or the remains of other extinct animals are exhumed from the extensive organic deposits, when we meet with such instances as the above. Having now enumerated the principal topographical and surface features, we will now notice the

III. DRIFT DEPOSITS.

The Drift deposits, or Quaternary formation, of Darke county, stands preëminent above all other geological features presented within its borders. While its structural geology offers but a single simple, rocky formation, there is afforded in its great Drift deposits not only a variety of very interesting phases, but a source of untold wealth and comfort to its inhabitants. Through it are to be solved many deep and interesting industrial questions, as well as a successful pursuit, or the contrary, of numerous other enterprises lying nearest to the hearts of the people.

As previously mentioned, the whole county is underlaid with but one geological formation, viz., the Niagara limestone, and of the Upper or

Guelph horizon. Of course, surface rock is here alluded to, for, beneath the Niagara group undoubtedly occur all other Paleozoic series. Hither the great glaciers of the north, at a very remote age, have transported and deposited all over this rocky floor, in varied depths, vast quantities of clay, sand, gravel, and bowlders, on an average of a hundred feet or even more. Through the action of water, or the hand of man, where there was no other impediment than a few feet of soil, in five different localities, small areas of the native rock have been exposed. Consequently little or nothing can be known of the topographical features of the underlying beds of rock, though the character and constituents can be as perfectly known as were the whole open to view. We must know, however, that being a limestone of somewhat irregular texture, in many places soft and sandy, in others hard and crystalline, and subject to the violence of enormous glaciers, that it would certainly present a very haggard, cut-up surface were its covering not so complete. In those few insignificant areas the beds appear perfectly horizontal and unbroken, save one exception, and that is unusually interesting, as indicating the relative situation of Greenville, and the ancient channels of Greenville and Mud Creeks.

In visiting Dr. Gard's quarries, which are about a mile and a half south-west of Greenville, between the fork of Greenville and Mud Creeks (but a little nearer the latter), it is first noticeable that the beds of rock are considerably folded, dipping toward the south and east; and also the fact, that in quarrying, the rocks suddenly stop in the adjacent Drift, the strata being traceable for a short distance by scattering fragments of limestone as torn off and left. In the digging of the public cistern on the corner of Fourth Street and Broadway, the Niagara ledge of rock was struck at a depth of ninety-five feet below the surface. The cistern, though a failure, so far as obtaining an abundant supply of water was concerned, inadvertently furnished knowledge that has proved useful in other ways. This measurement may also be regarded as the minimum, for at no place in the vicinity, in the sinking of wells, has it been reached at a lesser depth.

Gard's quarries lie about twenty-one feet below Greenville, consequently seventy-four feet above the rocks underlying the town. The same ledge of limestone crops out at Bierley's, about four and a half miles east of Greenville, and fifteen feet higher than the beds last mentioned.

At Weaver's Station, about five miles south of Greenville, Mud Creek runs over the horizontal Niagara limestone thirty-five feet higher than the same. Consequently, all these facts, together with much other concurrent testimony which might be given, go to show that Greenville is situated upon a large kame of detritus, heaped up in a great glacial valley. Moreover, Greenville being elevated about thirty feet higher than the creek, the present bed of Greenville Creek must lie sixty-five feet above its ancient rocky channel. The indications, too, are such as to warrant the belief that the junction of the two streams centered somewhere beneath the present location of the town, or a very little to the east. As to the truth of this conclusion, the most forcible evidence is Gard's quarries, which stand up there a solitary rocky pier, dividing the two great currents of Drift, which, ages ago, carved out this rocky basin with the channels of the two streams.

In three instances, within the county, the streams have cut down through the superficial material to their former beds. At Bierleys, Greenville Creek runs over the Niagara limestone for a quarter of a mile. Mud Creek, at Weaver's Station, flows over the same rock about half that distance. And Stillwater Creek, in Wayne township, a short distance east of Webster, reveals a smaller extent.

The excavation above described has evidently been the work of glaciers. Though the dip of the rocks at Gard's would, apparently, indicate a fold, yet the universal horizontality of the beds elsewhere, together with the glacial evidences, supports the first supposition. No other agency could have accomplished it. Upon the upper stratum of rock at Gard's quarries, which happened to be sufficiently hard to retain them, excellent examples of glacial striæ havebeen preserved. The upper surface, at a fresh exposure, likewise showed itself well smoothed and polished. These striæ bore a direction of about S. 5° W. The Niagara limestone, at Weaver's Station, also shows some faint groovings bearing in about the same course. These, I may now remark, are the only glacial markings upon the surface of the embedded rocks that have been observed in the county. The upper layer of limestone, at Bierley's quarries, is too soft to retain them, had any impressions ever been made, and at Webster's no opportunity was afforded to view a freshly exposed surface. But in the excavation of the public cistern, before spoken of, as, also, in the digging of wells, etc., numbers of very finely striated bowlders have been taken from the lower blue hard-pan or bowlder clay, seemingly to indicate that the same great force which grooved out this rocky basin, was identical with that which ground and polished the bowlders, and transported them where they now are found.

The superficial deposits of Darke county present about the same general character as the Drift elsewhere in this section of the State, consisting of a mass of clay, sand, and gravel, sometimes stratified, lying in regular, separate layers, and at others, jumbled and mixed together in irregular, heterogeneous heaps. The former are indicative of the milder, pains-taking action of water. The latter, of the more violent and reckless agents—glaciers and icebergs—though it must be borne in mind, that the regular, distinct laminations may frequently result from the subsequent action of water upon the confused mass of glacial deposits.

The constituents, origin, and causes of the Drift have been so repeatedly and so exhaustively treated in Vols. I and II of the Reports of the Ohio Geological Survey, that it is not necessary to enter into an extended discussion of them here.

The various phases of the Drift formation are fully and, in a few places, finely shown, but the structure is rendered, I think, somewhat more difficult to unravel, for the reason that the county lies at about the junction of the two grand systems of forces acting from the region of the Lake and that of the Ohio. There appears to be no uniformity in the divisions of the deposits, no two sections showing the same succession of parts. The following section was obtained from the well at the Gas-works, in Greenville:

	FT.	IN.
Sod and yellow clay	0	6
Red clay	1	6
Yellow clay, with pebbles and bowlders	8	0
Yellow sand, stratified	8	0
Hard-pan	1	6
Fine blue clay, very tenacious—stratified	0	8
Blue sand and gravel	21	10
Total depth	42	0

The beds all appeared partially stratified, while the pebbles and bowlders were much water-worn. The thin layer of tenacious blue clay is undoubtedly that derived from melting icebergs, the running streams of which would naturally result in the stratification of the fine material. The surface bowlders consisted chiefly of greenstone, syenite, diorite, etc.; whilst in No. 3, we found many worn bowlders of water-lime and Niagara limestone. One small glacial bowlder was taken up from No. 7. Cyathophylloid corals, and several other of the ordinary Drift fossils, were common.

From numerous other wells, of a greater or less depth, the following typical section might be noted:

	IN.		FT.
Sod or loam	From 6	to	1½
Red clay	" 0	to	4
Yellow clay	" 12	to	15
Yellow sand and gravel	" 6	to	20
Blue sand and gravel	" 8	to	30

		IN.		FT.
Blue clay, with pebbles	From	3	to	18
Fine blue clay—compact	"	0	to	1½
Hard-pan, alternating with blue clay	"	10	to	20
Blue clay	"	3	to	9
Bowlder clay	"	10	to	20
Total	"	41½	to	148½

Average, 95 feet.

From the above section we might be able to separate several eras or divisions of Drift formation, corresponding in general with those described by Dr. Newberry, in Vol. II, in his chapter on Surface Geology, and almost exactly agreeing with those explained in the reports on Clarke and Greene counties, by Prof. Edward Orton.

IV. KAMES.

The feature which, in my mind, most worthily invites our attention in noticing the Drift of this region, are the great sand and gravel hills, denominated "Kames" or "Eskers," which prevail so largely throughout the county; and they are a feature, too, that can be so much more thoroughly studied here than any other, for the reason that they are so easily accessible. The aspect of the country would be far more monotonous did they not figure to the extent they do in its landscape. But, what is of more consequence than serving as a relief, in an æsthetic sense, they constitute the great reservoirs from which the material has been supplied to construct so many fine pikes, intersecting the county everywhere, and of which the people are so proud; and which furnish almost at the very spots where most desired for building and other purposes, quantities of the most excellent sand. Moreover, these kames or gravel knolls afford very pleasant building sites, and, frequently, this is enhanced by one or more inviting springs at their base.

A more especial discussion of these, also, seems proper, as they are not so universal, and, therefore, not so well known as other portions of the Drift. Besides, excepting on the part of Prof. Winchell, comparatively little attention has been paid to this most interesting and important series of superficial deposits.

These kames or gravel hills, which range from thirty to sixty feet in height, are almost universally fashioned after one of two types: the first rounded and cone-like, the other elongated. The latter form is the more common in this country. And it is an important fact to be noted with regard to them that their major axis lies invariably north-west by south-east.

Very little definiteness is apparent in the plan of their distribution, but they are most prevalent in the north-eastern, central, and south-western portion of the county, or along a line passing through the centre of the county parallel to the water-shed. Between Greenville and Richmond, along the Pittsburg, Cincinnati and St. Louis Railroad, they are unusually clustered, and are worked by that company in many points. Sometimes they are single and isolated, and at others lie in groups. If, as we must certainly concede, they have been formed by the action of water, these two facts, namely, their shape and distribution, would rather lead us to suppose their source and cause from the north-west, or at right angles to the direction of the divide.

Moreover, in the relation of the kames to the surrounding soil, there is something very peculiar. It is frequently the case that in the midst of a low, flat, peat bog or black bottom land rise up one, and sometimes several, of these picturesque gravel knolls. We would naturally look for them over a stony, hard-pan region, where the gradation of material is very slight, and where the conditions of both characters of soil seem congenial and similar; but when we meet with them in the contrast mentioned above we are compelled to acknowledge it as something singular and perplexing. But to me it appears this fact in the study of their origin would urge us to regard them as due to local and modern causes, as they evidently must have been formed just where they are, and by causes and at times entirely distinct from those of the surrounding formations.

Here, as elsewhere in western Ohio, they are composed of a mass of sand and gravel, intermingled with a small quantity of yellow clay. The color of the material is, for the most part, yellow, like that of the clay, with occasionally veins and streaks of blue running through it, but frequently from the presence of iron and sulphur it is of a reddish brown color. In most places the sand and gravel are finely assorted and stratified, in the others mingled and unstratified, and almost universally deposited in wedge-like layers, interlocking one with another. The absence of large bowlders, and the roundness and smoothness of the pebbles, at once point to water as a sufficiently potent and probable agent, and the above facts as to their character, stratification, form of layers, plan of stratification, etc., plainly appears to indicate the frequent changing or confliction of small but in many cases forcible currents of water.

The pebbles are mostly of a uniform size, ranging from one-half to two and three inches in diameter, and are always well worn and rounded, very rarely bearing any glacial scratches. Sometimes, however, quite massive bowlders are found imbedded in them. Flint, granite, syenite, greenstone, etc., are the most usual kinds of rock, though many fragments of limestone and shale prevail. From the kind and character of the rock composing these kames, I take the material to be re-wrought material of the glacial drift.

A few of the ordinary fossils were: *Spirifer mucronatus*, *Avicula emacerata* (?), *Rhynchonella capax*, and many cyathophylloid and silicious favositoid corals. The native Niagara and Waterlime Groups also contribute a number of specimens. In most cases the fossils, like the other pebbles, are very much worn, and thereby rendered almost unrecognizable.

Below is a section of one of those isolated kames spoken of, known as "Bunker Hill," situated about a mile and a half south-west from Greenville, near the Pittsburg, Cincinnati and St. Louis Railroad:

	FT.
Red clay	3
Fine yellow sand	4
Unassorted gravel	24 to 30
Hard-pan	3

This example was formerly full fifty feet in height, but has now been pretty much removed.

A very fine section obtained at Hetzler's gravel pit, in Adams township, shows the following series:

	FT.	IN.
Clayey soil	0	4
Yellow clay	1	0
Tough red clay	1	0
Sorted gravel	2	0
Fine sand	0	3
Unassorted gravel	2	0
Fine yellow sand	0	4
Brownish sand—coarser	1	½
Bluish gravel—assorted	2	0
Bluish yellow sand	1	3
Fine bluish sand	4	0
Fine reddish sand.. } Bluish gravel	2	0
	17	8

In this instance there were no bowlders at all, and three-fourths of the pebbles consisted of limestone and blue shale. The layers, too, were exceedingly well stratified, and largely present the interlocking appearance. A dozen different sections might be given, but the two selected here present the greatest variance of any two yet observed, and may be considered as combining the characteristics of all.

In view of the strikingly distinct character of these kames, I think we must conclude that they are comparatively modern, and that they do not, as stated by Dr. Newberry, hold a definite place in the sequence of Drift phenomena.

In accounting for them, two causes seem to be equally conspicuous, viz., currents of water and melting icebergs; and I do not know that they can better be described than in the words of the author quoted above. "It seems," he says, "that in the period of greatest submergence the larger part of the summit of the watershed was under water, and was swept by breakers and shore-waves, by which some of the beds of sand and gravel were formed, which are described under the head of kames; and I have supposed that a considerable portion of the materials composing these kames or eskers was derived from icebergs stranding on the shoals which now form the crest of the divide." At this time sufficient depth of water existed in the passes of the watershed to float icebergs of considerable size. These, as they stranded along the slopes of the divide, or melted in their slow progress southward, discharged their immense cargoes of mud and gravel. When the water level had been somewhat depressed by the slow elevation of the continent, these gaps became, as I have supposed, waste-weirs, through which powerful streams of water continued to flow for a long time. These, constituting the eddies, currents, etc., and the streams from the melting icebergs, have completed the sorting and shaping of he layers.

Bowlders.—Nearly related to the kar es in point of time and origin are the vast quantities of bowlders scattered broadcast over the surface of the county. These are not to be confounded with the true glacial bowlders, which lie more or less deeply imbedded in the Drift, but are superimposed, and owe their origin to *floating* ice. Of the striated or glacial bowlders there appears to be two distinct epochs or systems in the Drift of Darke county, the first being marked by small (rarely ever large), dark-blue bowlders, finely striated and lying very deep, or upon the rocky floor of the Drift, the second lying in the yellow and bluish hard-pans and gravel to within five or eight feet of the surface, and embraced, probably, above a depth of twenty five feet, containing the ordinary Drift rocks, with many coarsely-scratched limestones. The more massive Drift bowlders belong to an entirely different class—that is, as to origin. Lithologically, however, they do not vary perceptibly from the latter of the true glacial rocks above mentioned, being chiefly greenstone, syenite, quartzite, diorites, dolomites, and other metamorphic rocks. They rarely if ever show glacial markings. First we notice them in the north-western part of the county, along the summit of the watershed, where they have been dropped by the stranded icebergs. The watershed at that time formed the southernmost shore of the Lake. Next we find them following the channels of the principal streams, marking out the line of deepest channels, which the icebergs naturally sought in their southern progress, after forcing a passage through the breaks and gaps of the divide. Greenville, Bridge, Mud, and Stillwater Creeks all seem to have afforded such avenues, but especially the first. At Bierley's quarries, however, and in that vicinity, resting just above the Niagara limestone, in probably a foot or two of soil, they exist in a perfect jumble, sometimes two and three huge ones piled up together. Up stream they can be traced as a perfect moraine; below, however, they are few, though for the most part larger. The beds of Niagara rock here must evidently have presented an impassible barrier to the floating icebergs in their passage down the valley of the creek. Similar collections of these large bowlders, though not quite so numerous, immediately overlie the limestone at Weaver's, New Madison, Gard's, and, in fact, all the exposures in this county, showing that there is some truth in the common saying of quarrymen, that where these groups of bowlders are found lying upon the surface of the soil, limestone is likely to be found at a small depth beneath—observing a fact that is frequently true in this region, though not ascending to the cause; the most plausible explanation of which seems to be, that the quarries (from the simple fact of their exposure) are generally the most elevated portions of the underlying rock, and hence stood in the same relation to floating ice that snags and sand-bars do to ships.

An outer belt of these iceberg moraines can easily be traced up the creek from Bierley's quarries, following the left bank, then in less than a quarter of a mile it crosses to the right, until arriving at the farm of H. C. Kerr, where it leaves the creek, pursuing a diagonal course over the land included in the bend of the creek, it again meets it and crosses over, passing south-west of the residence of Josiah Kerr. It then crosses the Greenville and Gettysburg pike, following the north side of the road, until at or near the residence of D. and M. Craig it makes a circuit into the neighboring fields of Messrs. Dun,Kerr, and Greenwalt, and again strikes the creek a little below Knouf's Mill, where the bowlders have been utilized in the construction of a large dam. From here this moraine might be traced almost indefinitely toward the divide or watershed along and about the region of the creek, showing, as indicated that though the former course of the stream differed to a considerable extent locally, its general direction was that of the river valley or basin. This belt of rock just described was formerly, before removed for building purposes, very conspicuous on the commons just east of Greenville.

Another prominent moraine or belt of these large surface bowlders is delineated upon the map of Darke county. It is full three or four hundred yards in width, and is first noticed in the north-western or rather northern part of Van Buren township, just a little south of Bierley's quarries, passing in a south-westerly direction across the northern part of the township, crossing the Dayton and Union Railroad a few miles south of Jaysville, and then passing, with an almost uniform south-eastern bend, I am told, through Twin township, near Ithaca, into Preble county; the same belt continues near Eaton and West Alexandria, in that county. This instead of being, as would at first appear, a separate and distinct belt, is undoubtedly but a continuation of the same line described above,as traceable down the valley of Greenville Creek to Bierley's quarries, and in my mind would plainly show that the great floating icebergs, finding the outcropping limestone at Bierley's a formidable impediment to their further progress in that direction, after disposing of many of their ballasts, swung around and took a southerly course, as indicated by the moraine last described.

Some of the bowlders constituting this belt in Van Buren township measure eight and ten feet in diameter, and one or two probably as much as twelve feet. For a long time the region embraced by this moraine was thought incapable of being cultivated or traversed by roads, but today finds it producing as excellent crops as almost any other portion of the county, and has roads, though exceedingly rough and stony, nevertheless dry and very durable.

Outside of the two prominent belts described above, many bowlders are scattered here and there over the whole surface of the county. These were dropped probably during the more general submergence, when the water was everywhere of sufficient depth to float bodies of almost any size.

Mastodon.—At about the close of the quarternary period, and during the formation of peat alluvium, this region, as well as other portions of the State, was inhabited by the huge mastodon and mammoth. The thickets and marshy banks of the lakelets, which now constitute the peat bogs, seem to have been their most frequent haunts. These truths are attested by the remains which are almost yearly discovered in different parts of the county. These huge animals must likewise have been undisputed lords of the forests, as but few other representatives of a fauna have been found. Dr. G. Miesse, of Greenville, has in his collection an almost perfect skeleton of a mammoth, as well as portions of the remains of a mastodon, both of which were found in the peat deposits of Mud Creek "Prairie." At the Turpen House, Greenville, may be seen a fine tusk of a mastodon, found somewhere in the northern part of the county. But a short time ago a large tooth of a mammoth was picked up in the creek bottom just north of Versailles. Probably portions of fifteen or twenty skeletons of these gigantic beings have been found in as many years.*

V. SOIL AND VEGETATION.

The county owes its soils almost wholly to the Drift, but very little having resulted from the disintegration of the native lime-rock. From the former almost barren deposits of clay, sand, and gravel, by the action of streams, vegetation, and animal life through a long lapse of time have been wrought the present rich and productive soils which so distinctly mark this and the neighboring counties. The fine clays and sands were separated from the hard-pan; rocks were weathered until, by successive frosts and thaws, their mineral constituents disseminated over the surrounding surface; vegetation flourished and decayed; streams overflowed their banks, dissolving and mingling the materials, until there is presented not only a rich but also a tolerably varied soil. There were also embodied in the Drift, together with the vast quantities of metamorphic rocks, a great many pebbles and bowlders of the Niagara and Lower Helderberg groups, which in their decomposition act as excellent fertilizers. But about four kinds are to be noted as characteristic:

First, the clayey or wheat-growing soil. This predominates, and is particularly characteristic of the uplands and higher portions of the county, especially in the region of the watershed. It varies in color from yellow to red and brown. Upon the summit of the divide, from exhaustive weathering and drainage, it is bleached almost white or ashen. Of this the numerous sulphur springs along its base are proof as being supplied by the iron extracted above. This species of soil is for the most part free and porous, but in many places solid and tenacious. When of the former character, it produces copious crops of wheat and other nearly related cereals; when of the latter, it is of great economical value in the manufacture of brick and tile.

The *second* may be termed alluvial or corn-growing soil. This is commonly known as "bottom land," and embraces quite extensive areas in the valleys of Greenville and Stillwater Creeks. In character it may be said to be of a black loamy nature, rendered free and mealy by an average supply of silica. A considerable quantity of decayed vegetable matter likewise add to its fertility. Corn flourishes upon it to a surprising degree.

The *third*, in regard to its importance or extent of distribution, is a kind of dark gray or ashen soil, for which I think the term turf, in a specific sense, might be very properly applied. It is of a very superficial character, and is particularly characteristic of newly-cleared forest lands, and such tracts as are of a low but dry nature. Really it might be classed as a clayey soil, but the long growth of vegetation and toils of insect life have changed its character somewhat, and adapted it for the growth of a different and more varied class of produce. Of these might be enumerated the sweet and Irish potato, pumpkins, squashes, beans, and many of the lesser grains.

The *fourth* kind are the peat deposits, which embrace small patches here and there over the surface of the county. Immediately overlying the Niagara limestone on the land of Mr. Dicky, near Weaver's Station, rest from two to three feet of excellent peat. It is remarkable to see the native rock and rich deposits of decayed vegetable matter in such juxtaposition; and it may not be improper to suggest here that, when this superimposed peat is removed for the purpose of quarrying the stone, it should, by all means, be distributed upon the more exhausted or higher clay lands. While there are yet such extensive forests spread over the county, it would hardly be practicable to use it as fuel. Its proper mission here is that of a fertilizer.

In Mud Creek Prairie, just south-west of Greenville, which was formerly a lake almost or quite to its source in Harrison township, are quite extensive deposits of peat. At Bridge Creek, about one and one-half miles south-east of Greenville, it covers also considerable area. Along the Pittsburgh, Cincinnati and St. Louis Railroad, numerous other places might be cited where it occurs, but this is not necessary. In many places it has been cultivated, and produces some fine corn and tobacco. In Mud Creek Prairie it is employed by Knox & Sater, of Greenville, for the cultivation of willows for wicker-work. This neglect can hardly be regarded otherwise than as an irreparable waste of a rich fertilizer. No fertilizing to speak of has as yet been resorted to in the county, and I concede that there has been no great need of it thus far. However, the productive power of the soil is not infinite. Tillage can not always go on without recuperation. This axiom, I think, the people will be forced to see before another score of harvests pass by.

The productions in 1872 were as follows:

Articles.	Acres.	No. of Bushels.	Average.
Corn	49,437	2,166,965	43.83
Oats	14,532	454,725	31 29
Wheat	41,321	461,173	11.20
Barley	3,246	76,773	22.95
Buckwheat	482	4,753	9.86
Rye	468	8,141	17.39
Potatoes	1,246	87,708	70.31
Sweet potatoes	37	3,030	71.89

The country is well timbered, its flora indicating a very productive soil for grains and fruits. The most common forest trees noticed were:

Oak—Quercus alba (white oak) .... L.
" rubra (red oak) .... L.
" tinctoria (black oak) .... Bart.
" bicolor (swamp white oak) .... Willd.
" macrocarpa (burr oak) .... Willd.
" castanea (chestnut oak) .... Willd.
" palustris (pin oak) .... Du Roi.
Sugar Maple—Acer saccharinum .... Wang.
Swamp Maple—Acer rubrum .... L.
Slippery Elm—Ulmus fulva .... Michx.
White Elm—Ulmus Americana .... Willd.
Beech—Fagus ferruginia .... Aib.
Black Walnut—Juglans nigra .... L.
White Walnut—Juglans cinerea .... L.
Cotton-wood—Populus monilifera .... Aib.
Black Cherry—Prunus serotina .... Ehr.
Shagbark Hickory—Carya alba .... Nutl.
Buckeye—Æsculus glabra .... Willd.
White Ash—Fraxinus Americana .... L.
Sassafras—Sassafras officinale .... Neas.
Sycamore—Platanus occidentalis .... L.
Iron-wood—Ostrya Virginica .... Willd.
Black Willow—Salix nigra .... Marsh.
Thorn—Crataegus coccinea .... L.
Wild Plum—Prunus Americana (rare) .... Marsh.
Trembling Aspen—Populus tremuloides (not common) .... Marsh.
Mulberry—Morus fulva (rare) .... L.
Flowering Dogwood—Cornus florida .... L.

Crab Apple—Pyrus coronaria ....L.
Honey Locust—Gleditschia triacanthos (rare)........................L.
Pawpaw—Asimina triloba...Dunal.
Bass-wood—Tilia Americana ....L.

VI. GEOLOGICAL STRUCTURE.

The geology of Darke county is preëminently the geology of the Drift, but one rock-formation being exposed within its entire borders. This formation belongs to the Upper Series of the Niagara Group, known as the Guelph or Cedarville beds, and is very fully described by Professor Orton in his reports on Clarke and Greene counties. It is supposed to be identical with the Leclaire of Iowa, the Racine of Wisconsin, and the Guelph of Canada, from which it takes its name. Although there are but five exposures, there is no doubt but that these beds compose the entire rock surface. Knowing positively, as we do, of the east, middle, and south-west, from the outcrop of the limestone itself, the other portions of the county are rendered almost equally certain from the fact that the adjoining parts of all the counties, north, east, and south, present precisely the same phase—the same being exposed at Celina and Fort Recovery, Mercer county, at Covington, Miami county, and New Paris, Preble county. It was formerly thought by some members of the Survey, that the Waterlime Group extended into the northern part of the county. This might have been highly probable before the Glacial Epoch, but, being evidently of no great thickness, it must have been removed during that period of erosion.

As remarked before, in speaking of the Surface Features, little can be known of the effect of its contour upon the topography of the surface. One instance, however, was given of an eroded basin immediately beneath the present location of Greenville. The strata where revealed, with but one exception, appear quite horizontal.

The Guelph rocks are most extensively laid bare along Greenville Creek, and at Bierley's, Hershey's, and Roesser's quarries in south-west quarter, section twenty-seven, Adams township. They form the bed of the creek here for a quarter of a mile or more. The quarries are situated in the bottom of the valley or ravine, and are covered with about two feet of dark red clay or loam, mingled with the decomposed lime-rock, and strewn with heaps of large drift bowlders. The banks are twenty or thirty feet in height, and composed of yellow clay and hardpan. The beds of limestone here appear perfectly horizontal, having been deposited (as indicated by the character of the rock) in a quiet and shallow sea, and having witnessed little disturbance and no subsequent upheaval. A section of ten or twelve feet can be observed at the quarries, bearing about the same lithological features as the Guelph beds described from other counties, viz., of a light buff color, porous or spongy, and fragile. The upper portion in particular is so fragile or sandy as to crumble up like chalk, and is composed almost entirely of crinoidal stems (*Caryocrinus ornatus*). No regular planes of stratification appear, the rock breaking into thin, irregular slabs. Lower down, this formation is of a darker yellow color, firm, massive, and contains innumerable fine casts of *crinoidea*.

A second exposure of this formation occurs at the quarries of Dr. I. N. Gard, about a mile and a half southwest of Greenville, south-east quarter, section 33, Greenville township. The beds are worked in two places, known as the "old" and "new" quarries, and lie about fifty yards apart. In appearance the rock does not differ materially from that of Bierley's, but is much harder and totally different in fossils contents, two or three species only being common to both. The upper stratum is especially to be noticed as being of a compact crystalline structure, and also considerably folded. Moreover it shows a perceptible dip toward the south and east.

The section is as follows:

	FT.	IN.
Yellow clay and loam	0	6
Dark red clay, very compact, calcareous and interspersed with many limestone pebbles	2	0
Thick stratum with definite fracture, of dark yellow or bluish cast, compact crystalline; few fossils but well preserved; glacial striæ south 5° west	2	9
Thick, massive, porous, in many places soft and sandy, light buff in color, and containing many fine casts	6	0
Total exposure	11	3

In Wayne township south-west quarter, section 32, just below the mill at Webster, the Guelph beds are again exposed. Here Stillwater has cut down to its old bed, revealing a section on the right of four or five feet. In character it corresponds most nearly with that at Gard's. It is sufficiently hard for building purposes, but is too irregular massive to be practicably worked. However, it is easily accessible and would undoubtedly furnish an excellent quality of lime. The banks of the creek overlying the rock consist of three or four feet of clay, colored dark red from the presence of iron, and partaking much of the calcareousness of the rock. Beneath this deposit several sulphur springs course out upon the surface of the rock into the creek. Some fragments revealed casts of *Pentamerus pergibbosus*, *Favosites Niagarensis*, and one or two species of *Or-*

thoceras, *Pleurotomaria*, and *Syringopora*. The stratum exposed here, I think, is the same as No. 4, at Gard's quarries.

Another exposure on the land of A. Dickey, near Weaver's Station, south-east quarter, section 29, Neave township, shows only the surface of the Niagara limestone, it forming the bed of Mud Creek for 150 yards or more. So near as can be judged, the rocks here, as elsewhere, are horizontal, but differ slightly from the three exposures above in other respects. They are distinctly laminated, breaking out in thin but irregular flags; very sandy in texture, and mostly of the ordinary buff color, but in patches here and there have all the appearance of a red sandstone. The light colored portions, I understand from a very imperfect experiment performed there some years ago, produce a fine white quality of lime, but the other resembling red sandstone becomes very hard when subject to heat. This fact, I think, is attributable to imperfect burning. This rock was employed in the foundation of a mill which stands near by, but it is evidently too soft for building purposes. The utter absence of fossils or traces of any, is to be noted as a very peculiar feature compared with the Guelph beds in other portions of the county.

The only other exposure of the Guelph rocks occurs on the lands of C. C. Walker, near New Madison, north-west quarter, section 24, Harrison township, where it was formerly quarried and burned for lime by C. B. Northrop, but has now been abandoned. A much worn section of six or eight feet is still visible, showing the same general features of this formation as displayed elsewhere.

It is impossible, from the meagre sections afforded, to give the exact measure of the thickness of this formation in Darke county. Prof. Orton gives to this phase of the Niagara rock at Hillsboro, Ohio, twenty feet, and at Springfield, where it probably reaches its maximum, forty-two feet. Twenty or thirty feet, however, might be considered a safe estimate here.

The fossil contents constitute a far more interesting feature of the Guelph beds than any yet described. The life here indicates somewhat different conditions from those shown by the division elsewhere.

First might be noticed the rarity of *Pentamerus oblongus*, but four or five specimens having ever been found. Its place, however, as to abundance and otherwise, is fully supplied by another species of the same genera, *P. pergibbosus*. Lower down in this formation, both at Covington, Miami county, and New Paris, Preble county, the *P. oblongus* constitutes a good part of the rock. All fossils here, it must be remembered, are represented by casts; and though the rock weathers very rapidly, the casts, when newly exposed, are for the most part very beautiful and perfect.

It is remarkable, too, to notice the difference in paleontological conditions between the two principal quarries, Gard's and Bierley's. The former contains a considerable number of genera belonging to five or six classes; the latter many genera and species, but all representatives of one class, viz., crinoidea, which has not a single representative at Gard's quarries. The following is a list representing the grand divisions, Brachiopoda, Gasteropoda, Cephalopoda, Crustacea and Corals, found at Gard's, near Greenville:

Favosites Niagarensis.
" new sp.
Pentamerus pergibbosus.
" Hertzeri.
" oblongus.
" nucleus. (?)
Cyrtoceras dardanum.
Lituites, sp. (?)
Nautilus (?) sp. new.
Cyrtoceras brevicorne.
Platyceras Niagarense.
Calymene Niagarensis.
Dalmania, sp. (?)
Pleurotomaria Halei.
Halysites, sp. (¿)
Trochoceras Desplainense.
Murchisonia. (?)
Rhynchonella neglecta.
Orthoceras annulatum.
Spirifer nobilis.
Meristella Maria.
Rynchonella, sp. (?)
Spirifer radiatus.
Pleurotomaria occidens.
" sp. new.
Atrypa reticularis.
Receptaculites infundibuliformis.
Rynchonella cuneata.
Atrypa nodostriata.
Cladopora reticulata.
Amphicoelia, sp. (?)
Ambonychia acutirostris. (?)
Trochonema fatua.
Straparollus Ohionse. (?)
Orthoceras strix. (?)

The following were found at Bierley's quarries:

Rhodocrinus (?) rectus.
Cyathocrinus pisiformis.
Glyptocrinus armosus.
Rhodocrinus, sp. new.
Apiocystites imago. (?)
Eucalyptocrinus, sp. new.
" conicus. (?)
" coelatus.
" cornutus.
" splendidus.
" crassus.
Stephanocrinus angulatus.
Macrostylocrinus, (?) sp. (?)
Saccocrinus, sp. (?)
Caryocrinus ornatus.
Glyptocrinus nobilis.
Platycrinus prematurus.
Spirifer eudora.
Orthis flabellum.
Holocystites abnormis.
Gomphocystites glans.
Platycrinus præcedeus.
Rhodocrinus rectus.
Saccocrinus ornatus.
Ichthyocrinus, sp. (?)

The character of this rock, as noted in the several sections, plainly indicate its worthlessness for building purposes, or even flagging. Of the twelve feet of exposure, what is not too soft, is too massive. I think, however, that by going down twenty or twenty-five feet at Bierley's quarries, a portion of rock will be found sufficiently hard and well laminated to subserve all the purposes of the ordinary "Covington stone." Whether it would be feasible to work it at such a depth, I am unable to say. Such building material as the Covington stone would be of inestimable value to the county if it could be found at any point above drainage.

The greatest economical value attaches to this division of the Niagara formation for the very fine quality of lime which it produces. The lime, as obtained from these rocks in Darke county, I may say, has no superior within the State. Its extreme whiteness and strength gives it an easy market.

Chemically considered, this rock is a magnesian limestone or typical dolomite. The analysis, as given by Dr. Wormley, Chemist of the Survey, gives to it the remarkable per cent. of carbonate of magnesia, 50.11, a per cent. exceeding that of carbonate of lime. Prof. Orton, however, would make some allowance for this high percentage as being the result of a long-continued presence of carbonated water. But, even at Gard's quarries, the rock shows a percentage of 45.72 carbonate of magnesia. The analysis, in detail, of three specimens, from different quarries in the the county, shows:

	Bierley's quarries.	Gard's quarries.	Northop's quarries.
Carbonate of lime	44.60	51.30	51.70
Carbonate of magnesia	50.11	45.72	45.26
Silica, iron, and alumna	4.60	2.20	2.70
Totals	99.31	99.22	99.66

The specific gravity of specimen No. 1, as determined by Prof. Mendenhall, is 2.452. A table of comparisons as to specific gravities may be found in Vol. II, page 679, and a similar table, as to composition, in Vol. II, page 675.

ECONOMIC GEOLOGY.

A rich and productive soil will always constitute the material wealth of Darke county. Add to this great source of wealth the extensive forests which are spread all over the county, and the inexhaustible supplies of sand and gravel stored up in the innumerable kames. This atter too, I may urge, forms no mean element. Its influence may be seen in the last census, which gives Darke county more miles of good pike than any other county in the State.

The ungainly bowlders everywhere present on the surface, though seemingly an obstruction to good farming, perform many useful functions in the economy of the county. The county being entirely destitute of native building stone, their utility can scarcely be estimated in the construction of foundations and other rough masonry. They can be worked with measurable facility, and can not be excelled for hardness and durability. Mr. Bierley has just constructed a large new "monitor" kiln of them, and he finds them much superior to limestone for that purpos These bowlders are likewise very serviceable for building mill-dams, cellars, abutments, and the like, but above all in their decomposition re-supply the soil with many of the necessary minerals that are constantly being extracted by exhaustive growths of vegetation.

Lime, too, in considerable quantities is produced within the county. In fact, the Guelph limestone here is fit for nothing else but the producduction of lime, and in this it stands without a rival. Bierley & Son are most extensively engaged in the business. Other kilns are owned and operated by Dr. Gard, of Greenville, and by Roesser and Hershey, Adams township. The easy market which this article finds, will undoubtedly induce many others to engage before long.*

The surface clay before spoken of affords excellent facilities for brick and tile manufactories, and a number of them already exist in different parts of the county, a good quality of red brick and tile always being produced. Clay for pottery purposes is not so abundant. An extensive bed of red clay is reported in the northern part of the county, but of what value or quality I am unable to say.

The *water* supply of the county is both good and sufficient, the best quality of well-water being obtained from beneath the sand and gravel deposits upon the surface of the blue clay. This probably includes a range of from 30 to 50 feet of depth. Many excellent springs are scattered over the county. Along the water-shed, however, they are mostly sulphurous, and the well-water of that region is almost unfit for use. In the south-western part of the county, near Weaver's Station, New Madison, and that region of kames, occur many springs which have their origin upon the surface of the magnesian limestone constituting the

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* Under the directions of your local geologist, Mr. Dickey made another experiment with the limestone on his place near Weaver's Station, and the result was as surmised in this report. The lime will compare with the best. He has already begun work on a kiln.

Guelph beds. The water of these springs is consequently charged with carbonate of lime and magnesia extracted from the rock, as well as many other mineral properties derived from the clay. Hence mineral springs are produced, and some of them are as highly charged with mineral matters as the celebrated Cedar Springs, of New Paris, in the adjoining county of Preble.

CHAPTER LXXX.

REPORT ON THE GEOLOGY OF ASHLAND COUNTY.

BY M. C. READ.

LOCATION AND TOPOGRAPHY.

Ashland is a narrow county, having an extreme length, from north to south, of a little over thirty-five miles, and a breadth of fifteen. It is situated on the dividing ridge between the waters of the Lake and the Ohio River, and upon the northern margin of the coal field. The crest of this divide has a north-easterly and south-westerly bearing, lies a little north of the Atlantic and Great Western Railway, and is nearly parallel with its general course. This ridge is deeply divided by a valley now marking the course of a pre-glacial channel, which enters the county from the north a little west of Ruggles Center, following a branch of the Vermillion to Savannah Lake, and thence south-easterly, passing a little to the east of Ashland village, and generally coincident with the valley of Jerome Fork to its junction with the Mohican. North of the dividing ridge the land slopes gently to a broad plain, a few small streams gathering the surface waters and conveying them toward the Lake. On the north side, springs and streams are more abundant, the surface slopes southward, is very irregularly diversified with hills and valleys, and presents many scenes of great beauty.

The highest hills on this divide reach an altitude of six hundred and ninety feet above the Lake, indicating an original table land at this elevation which has since been eroded and diversified by the denuding agencies that excavated the ravines and valleys.

Southward between the Black Fork, Jerome Fork, and Mud Fork, the hills rise to the height of six hundred and fifty feet above the Lake, and now form a succession of ridges trending nearly north and south, with occasional benches on their slopes, showing between them valleys in which the receding waters flowed southward.

South of Loudonville an irregular succession of hills rises to the height of three hundred and ninety-five feet above the railroad at that place, and eight hundred and seven feet above the Lake. These, at their tops, in several places catch the Carboniferous Conglomerate, and on a narrow ridge along the line of Knox county the Lower Coal, connecting the county at this point only with the true Coal Measure rocks.

SURFACE DEPOSITS.

Around the borders of Savannah Lake, and of the valley in which it is situated, are a series of water-washed, sandy ridges, in places filling the valley to unknown depths, and in others working upon finely laminated lacustrine clays, which come near to the surface. Southward from the lake the sand hills become smaller and gradually disappear, and the valley expands into a broad water-plain, bounded by the ordinary drift hills. Savannah Lake, covering a surface, as estimated by Dr. George W. Hill, of Ashland, of about one hundred and sixty acres, and a smaller lake adjacent, of about eighty acres, which has been partly drained, occupy the highest part of this old channel, the present drainage being toward the north, and a low ridge of sand alone preventing draining at the south into the head-waters of Jerome Fork. These, together with several other lakes and swamps in the State similarly situated, illustrate the occurrence of lakes and lakelets with two outlets, and in opposite directions. Both of these are quite deep, the depth of the larger being reported at one hundred feet, and the borders show that the water once stood at a considerably higher level, and that then there was also an outlet at the south. These lakes, draining but a small area of the table land to the east and west, can not receive a large supply of water. Until comparatively hard material is reached, the channels of the outlets are carried deeper, and the lake recedes, until only one channel remains on the side where the descent is most rapid, or the drift-bed is most easily removed. In the meantime, the bottom is being silted up from the wash of the hills, and a growth of vegetation accumulates in the shallow water, until in time the lake becomes a marsh, and this ultimately arable land. In all these old channels which have cut through this table land, separating the waters of the Lake from those of the Ohio River, at the highest point lakelets or marshes, or the clear indications of their former presence, can be seen. The bottom below the vegetable debris is, in some places, bowlder clay; in others, laminated clay. The ridges on each side are usually formed of water-washed sand and gravel, the outlets in each direction passing over the debris of the drift, which has filled, to the depth of from one hundred to two hundred feet, the old channel of drainage now covered with alluvium. On the northern slope this debris, where the alluvium is removed, is largely laminated clay, containing occasionally large, angular, and frequently striated bowlders; southward it is gravel, rolled and water-worn, with ridges and pockets of the unstratified bowlder clay, often disclosed in sinking wells, and occasionally rising in ridges above the water-plain. The water in Savannah Lake is sixty feet above the surface of Jerome Fork at Ashland, and fifty feet below the top of the drift hills in the immediate neighborhood. The summit of the divide, not far from the lake, is one hundred and ten feet above it. The surface in the old channel, one-half mile north, is now on the same level as the water of the lake. On the east side of the lake—partly by the filling up of the channel, partly by the subsidence of the lake—it is fifteen feet above the latter, and is separated from it by a narrow sand ridge.

North of the divide, the surface is covered with Drift, which conceals the geological structure. The soil is a stiff, tenacious clay, with here and there granitic bowlders, more abundant as the crest of the divide is reached, few fragments of rocks, and but little gravel. These broad stretches of level clay land, from the general level and imperfect drainage, have ceased to produce crops of winter wheat, now that the cavities produced by the roots of the original forest have become obliterated, and these channels of underground drainage obstructed. The principal crops are grass, corn, and oats. The forest is greatly diversified—in places almost entirely beech and maple, in others oak; and again, in others, a mixed forest, containing all the trees found in Northern Ohio.

The two small streams which pass diagonally through Orange township, have broad water-plains, and occupy old valleys, filled to an unknown depth with the Drift. The most easterly of these channels extends northward, and connecting with a stream in the east part of Montgomery township, spreads out into a wide, swampy valley, which shows plainly an old pre-glacial channel. North of Orange village the valley of the stream is covered with stratified sand and coarse gravel, all modified Drift, in which the stream is constantly changing its channel, flowing from six to eight feet below the level of the old water-plain. As it encroaches upon the banks it uncovers logs of large size on the level of the stream, which mark the divide between an old fallen forest and a soil-bed, now covered with from six to eight feet of modified Drift. Some twenty to thirty rods from the stream, and near the base of the low hills which border the valley, is a shallow well, which has flowed gas in moderate quantities for a long time, and which has been regarded as an indication of productive oil strata below. There is but little doubt that this gas has its source in the slow decomposition of the vegetable matter of this buried forest. In Ruggles township, the entire surface is covered with Drift, except on the borders and beds of the recent streams where erosion has carried it away. In the broad valley, west of Ruggles Centre, are isolated Drift-hills scattered over the water-plain, which is bordered by ridges of modified Drift.

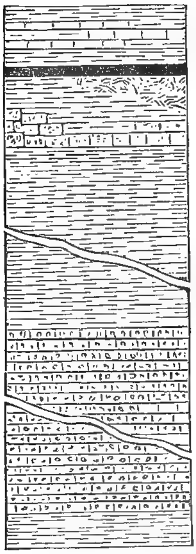
In the south part of the county the valleys are covered with a mixture of alluvium and Drift, and the hills with Drift and the debris of the local rocks. The soil is clay, tempered with sand and gravel, and containing a great abundance of rock fragments, while granite bowlders are very abundant, some of them of several tons weight. The rock fragments preserve the steep cultivated slopes from washing, and cause the rains to penetrate the soil, and accomplish, to a great extent, the work of underdrainage. These hills continue to bear good crops of wheat, as well as of corn, oats, and other crops. The timber is beech, maple, oak, chestnut, hickory, etc., and on the borders of streams, elms and black walnut are occasionally found. In Hanover township the slopes of the hills are ordinarily covered solely with the debris of the local rocks, and the soil is less productive. The alluvium of the valleys renders them fertile, and the greater part of the county has a rich, productive soil, adapted to a mixed and varied husbandry.

In the village of Ashland is a remarkable witness to the immense transporting power of the agencies which brought in the Drift. This is the remains of an enormous bowlder of granite, from which rock has been occasionally quarried for foundation purposes for the last thirty or forty years, and of which there is now enough remaining to load several railroad cars. Its original dimensions exceeded $25 \times 15 \times 12$ feet, and it must have weighed over three hundred and fifty tons. Broken up, it would have sufficed to load a railroad train of thirty-five cars. It is greatly to be regretted that it was not preserved unbroken, as a very interesting memorial of the past.

GEOLOGICAL STRUCTURE.

The geological structure of the county is very simple, and easily understood. With the exception of a narrow ridge of the coal rocks, on the south line of Hanover township, it is a continuation to the east of the upper series of rocks exposed in Richland county, and is made up entirely of the Cuyahoga shales, capped here and there in Hanover township with a thin bed of the Sub-carboniferous Conglomerate. A geological map of the county would have a small spot of brown shading at the south-east corner of Hanover to represent the Coal Measures, two or three small patches of red in the immediate neighborhood to designate the Conglomerate; and all the rest colored yellow to indicate the Waverly.

The following is a section of the rocks disclosed in the south part of Hanover township, where the highest geological formation is formed, and where, it is probable, the ravines reach the lowest rocks exposed in the county:



	FT.
Sandstone and shale.	
Coal	1 to 3
Fire-clay and shales, locally conglomerate (10 ft.)	20
Olive shales	270
Waverly conglomerate	130
Argillaceous shale (exposed)	20

These rocks are all exposed within a short distance of the junction of the Clear Fork with the Mohican, where a well was sunk for oil several years ago. The whole section between the lower coal and the Huron shale, according to this section, supplemented by the log of this well, is as follows:

	FT.
Coal No. 1	1 to 3
Fire-clay shale and conglomerate	20
Olive shales	270
Waverly conglomerate	130
Argillaceous shales	20
Not determined (earth at mouth of well)	5
Sandstone	9
Hard shales	85
"Soap stone"	60
Hard shales	3
Light shales	30
Red "soap stone" (full of gas)	12
Shale, with hard bands	385
Light gray sandstone	14
Sandy shales	176
Gray sand-rock	9
Gray shales	40
Black shale	40
Whole section below coal	1,416
Whole depth of well	976
Interval between lower coal and top of Huron shale	1,376

This section is not entirely reliable, as some of the intervals were given from memory; but the whole depth of the well was asserted to be correct. The depth to which the black shale was penetrated may vary somewhat from forty feet.

In Knox county, where the records of the deep borings were very accurately kept, this interval is 1,473 feet, a difference of ninety-seven feet. All the observations concur in showing that the Waverly rocks increase in thickness in passing southward, and this fact fully explains the difference in these intervals.

It will be observed that the red shale is found at approximately the same horizon as in Knox, but the log of the well is doubtless inaccurate, in making it only ten to twelve feet, while in Knox it is sixty feet.

It is evident that at this place, as in Knox county, upon approaching the coal basin, the material of the Waverly rocks becomes finer and more argillaceous, showing deeper water and weaker currents than existed at the time of its deposition a little to the west and north-west.

As previously stated, the only coal in the county is in a narrow strip along the eastern part of the south line of Hanover township. The hill rises above it about thirty feet, and this patch of Coal Measure rocks extends about two miles into Knox county. A drift has been driven into the hill, and a small quantity of coal taken out and carried to Loudonville. The coal, as far as explored, ranged from one to three feet in thickness, and is of very fair quality, comparing favorably with the best coals of Holmes county. It is Coal No. 1, or the Briar Hill Seam, which no where in this part of the State reaches that high degree of excellence which characterizes it in the counties on the northern margin of the coal-field. Dr. A. J. Scott, of Loudonville, reports that the blacksmiths commend this for their uses, and prefer it to the Nashville coal. Unfortunately, the area covered by it is quite limited, and its thickness variable. It may probably be mined successfully in a small way, but the quantity will not justify the construction of first-class appliances for mining.

Directly below the coal, or separated from it by a thin bed of fire-clay and shale, are found patches of the Sub-carboniferous Conglomerate, which sometimes reaches a thickness of ten feet, and in places is entirely wanting. On high hills, north of Pine Fork, this Conglomerate is largely represented by a silicious iron ore, some of it of great purity, and of the same character as that found in Licking county. These knobs are covered with a dense growth of chestnut, and should be permanently appropriated to the growth of this timber.

The Olive Shales No. 3, of the section, are by no means homogeneous in structure. At all levels they pass into rich, thick layers of quarry rock, some of it quite coarse and approaching the character of a Conglomerate. Occasionally, thin argillaceous strata are observed, and more rarely beds of impure, Fossiliferous limestone.

About one mile north of Loudonville, on the road to Hayesville, a quarry of this rock is opened near the top of the hill, and one hundred and forty-five feet above the valleys in the immediate neighborhood. The hill forms part of a ridge extending nearly north and south with the valleys on each side. The rock is all silicious, of a yellow, olive color, some of the compact layers reaching a thichness of three and four feet. All the strata were originally evenly bedded in horizontal layers. They are now broken up to the center of the hill with lines of irregular fracture, the strata crushed and displaced, showing the result of a force exerted upon each side of the hill, which has crushed the rocks as a ship is sometimes crushed in the polar ice. A few characteristic Waverly shells are to be seen in the upper layers of the quarry. The hills here, and to the north and north-east, have well rounded outlines, with graceful curves, showing that the rock-cores are substantially homogeneous in structure.

The following is a section of that part of these rocks exposed in T. S. Sutherland's quarry, one and a half miles south of Ashland village:

	FT.
Drift clay	10 to 12
Sandy shale, with hard layers at bottom	.. 6
Limestone, with a profusion of shells	1 to 1½
Shaly sandstone	.. 8
Sandstone, in layers of 18 inches to 4 feet, to the bottom of the exposure.	

This quarry is capable of furnishing a large quantity of fine-grained, hard stone, strong and durable, and blue in color, but, like nearly all the rock from this formation, changing to a yellow on exposure to the air. This change is primarily analogous to that observed in the oxydation of the blue to the yellow clay of the drift, and the contrasts of color are about the same in both cases.

The third band of limestone, near the top of the section, is crowded with the ordinary shells of the Sub-carboniferous rocks, and is of interest as pointing to the source of the limestone bowlders frequently found on the margins of the coal fields, and filled with similar shells. Several of these were observed in Summit county, and were easily recognized as differing from the bowlders of the Corniferous limestone, which are still more abundant. No deposit of such rock is known in that county, or directly to the north of it. But wherever denuding agencies have broken up the strata containing such a layer as this, it is easy to see, from its great hardness, that its fragments would long withstand abrasion, and be found in greater or less abundance in the sandy or gravelly debris.

A quarry, one-half mile north-east of Ashland, exposes rock precisely like the stratum below the Fossiliferous limestone indicated in the section above.

Three-fourths of a mile north-east of Mifflin, on a small branch of Black Fork, a quarry shows the following section:

	FT.
Coarse, shaly ferruginous sandstone	4
Coarse, yellow, massive stone	8
Shaly sandstone, with alternate layers of argillaceous shale	25

On the opposite side of the stream, the section is as follows:

	FT.
Coarse, yellow, ferruginous sandstone, thin layers	10
Coarse, yellow layers	4
Thin layers, at bottom, blue, alternating with argillaceous shale	20

Two miles north of Mifflin, the rock is imperfectly stratified, massive in places, and colored red, somewhat like the Mansfield stone. It forms a steep ridge on the east side of Black Fork, the slope being covered with the debris of the ledge, which resembles the debris of the Sub-carboniferous Conglomerate. At the height of forty feet, is a bench, showing the presence of argillaceous shales; and another ridge beyond, rising ninety-five feet above the top of this coarse sandstone, has its slopes covered with the debris of Cuyahoga shales.

Southward from this point, this coarse rock rises to the height of two hundred and fifty feet above Perrysville Station, showing a thickness of one hundred and seventy-five feet, and indicating either a great uplift of the Waverly Conglomerate, or that the ordinary olive shales take, at this place, the form of the Conglomerate. Much of this rock contains a great number of partially formed concretions of white quartz, the blocks which have been weathered, presenting to the eye the appearance of being filled with quartz pebbles. These concretions are all small, have a partially radiated structure, and shade off imperceptibly into the uncrystalized rock. The rock is sometimes broken through them, leaving a mammilary surface on the face of fracture. Their appearance recalls the old controversy in regard to the origin of the quartz pebbles of the Carboniferous Conglomerate, and, at first, seems to favor the hypothesis that they may be formed by the aggregation and crystallization of the quartz during the consolidation of the rock. But these concretions all lack the homogeneous structure, the regular cleanage, and polished and smooth outline which characterizes the transported and water-worn pebbles. This ledge, as is the case with most of the coarse sandstone of this part of the State, contains so much magnetic iron-ore, that the compass cannot be used in its immediate neighborhood.

At George Brubecker's quarry, section 14, Milton township, this rock is found one hundred and twenty five feet above its level in Ashland. It is here a coarse sandstone, partly bedded in thin layers, partly massive, yellow in color, blotched with iron stain, and, in places, passing into a silicious iron ore. The layers are horizontal, the fossils crinoids and fucoids.

At Benjamin Croninger's quarry, section 3, Mifflin township, the Waverly is exposed one hundred and twenty-five feet below the stratum at Brubecker's quarry, and on the level of Ashland village. The section exposed is—

	FT.
Coarse shaly sandstone	18
Massive sandstone	8

This is a fine-grained sandstone, irregularly colored with iron, and containing pockets of soft iron ore and clay. In the ravine below, thin beds of hard, sandy shale alternate with argillaceous shale.

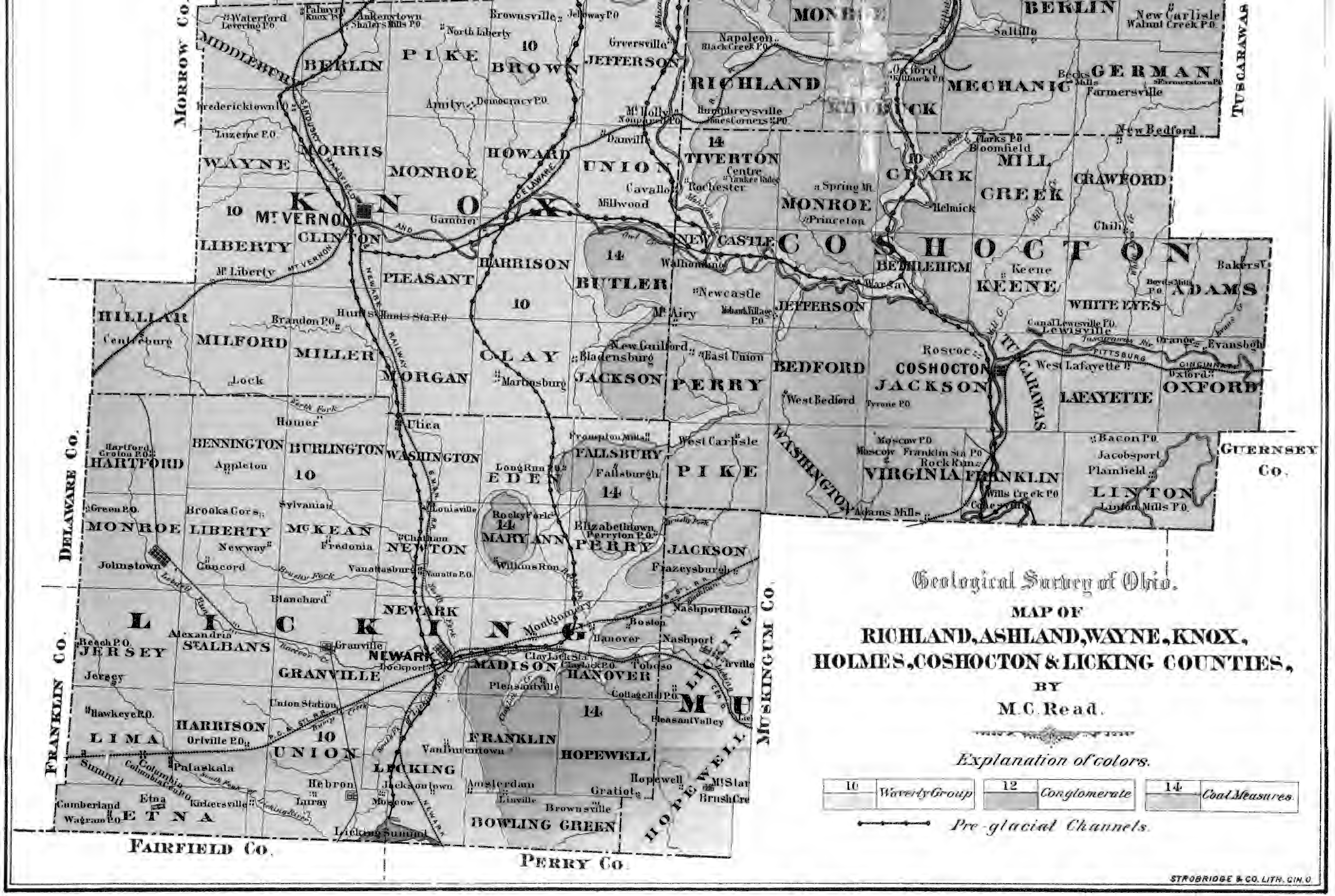
These beds of coarse massive sandstone apparently represent the Waverly Conglomerate of Richland and Knox counties, although generally containing fewer pebbles, and approaching more nearly the characteristics of the Cuyahoga shales of Summit county. In the north part of Hanover township, the rocks on this horizon are in distinct layers, and some of them have an abundance of quartz pebbles.

Below, about twenty feet of soft argillaceous shales are exposed, containing nodules of iron ore, and an abundance of the fragments of crinoids and shells.

The crinoid stems are in small pieces, and uniformly flattened. Of the shells, very few are perfect, the thick portion about the hinge being generally all that is preserved, this retaining the original texture of the shell.

There are many outcrops of this series of rocks in the county not referred to above, but those described are typical, and represent the general character of all, except one in a ravine near the north part of Ruggles township. This is peculiar only on account of the organic remains.

The lower layers of the exposed rock contain very large quantities of the *Spirophyton caudagalli* (Hall), and a form resembling the *S. typum* (Hall). The former is abundant upon the surfaces of the rock layers, and the latter in the interior of the thickest layers. Some of these layers, twelve to twenty inches thick, of rock otherwise homogenous, are filled with the latter, but they shade off so imperceptibly into the other form that it is a question whether they ought to be regarded as distinct. It seems to me probable that the succulent fronds, buried quickly in the homogeneous material which has produced the thicker layers, have resulted in one forming the casts, and that the same fronds abraded, partly decomposed, and retaining only their fibrous structure, have left their casts in the surfaces of the layers, where the deposition of material was arrested, so that the same plant has left apparently two distinct forms of impressions. The thickness of the casts of the spirals in the thick layers, and the amount of carbonaceous matter deposited in the cavities shows that the fronds had considerable thickness. All the casts here observed would also indicate that the plant consisted of a single frond, making a spiral of about one and a half turns, and not the tapering Archimedean screw figured by Prof. Hall in Appendix D. of the Sixteenth Annual Report of the State Cabinet of Natural History of New York. It is possible, however, that these Ashland county forms are distinct from those described by Prof. Hall, and are to be referred to a new species.



Geological Survey of Ohio.
MAP OF
RICHLAND, ASHLAND, WAYNE, KNOX,
HOLMES, COSHOCTON & LICKING COUNTIES,
BY
M. C. Read.
Explanation of colors.
10 Waverly Group
12 Conglomerate
14 Coal Measures.
Pre-glacial Channels.
STROBRIDGE & CO. LITH. CIN. O.
KNOX
COSHOCTON
LICKING
MORROW CO.
DELAWARE CO.
FRANKLIN CO.
FAIRFIELD CO.
PERRY CO.
MUSKINGUM CO.
GUERNSEY CO.
TUSCARAWAS
MIDDLEBURY
BERLIN
PIKE
BROWN
JEFFERSON
RICHLAND
MECHANIC
GERMAN
MORRIS
WAYNE
MONROE
HOWARD
UNION
TIVERTON
CLARK
MILL CREEK
CRAWFORD
MT. VERNON
CLINTON
LIBERTY
HARRISON
BUTLER
PLEASANT
BETHLEHEM
KEENE
WHITE EYES
ADAMS
HILLIAR
MILFORD
MILLER
MORGAN
CLAY
JACKSON
PERRY
BEDFORD
COSHOCTON
TUSCARAWAS
LAFAYETTE
OXFORD
HARTFORD
BENNINGTON
BURLINGTON
WASHINGTON
EDEN
FALLSBURY
PIKE
VIRGINIA
FRANKLIN
LINTON
MONROE
LIBERTY
McKEAN
NEWTON
MARY ANN
JACKSON
NEWARK
JERSEY
ST. ALBANS
GRANVILLE
MADISON
HANOVER
HARRISON
LIMA
UNION
LICKING
FRANKLIN
HOPEWELL
ETNA
BOWLING GREEN
Newark
Granville
Johnstown
Utica
Gambier
Danville
Millwood
Walhonding
Newcastle
Roscoe
Frazeysburgh
Hanover
Nashport
Hebron
Etna
Pataskala


LORAIN CO.
HURON CO.
MEDINA CO.
CRAWFORD CO.
SUMMIT CO.
STARK CO.
RUGGLES
TROY
SULLIVAN
Sullivan
PLYMOUTH
Plymouth
BLOOMING GROVE
BUTLER
CLEAR CREEK
ORANGE
JACKSON
CONGRESS
CANAAN
MILTON
CHIPPEWA
CASS
Shiloh
Lafayette
Rome
Shenandoah
London
Ganges
ASHLAND
Shelby Junc
JACKSON
FRANKLIN
WELLER
MILTON
MONTGOMERY
PERRY
CHESTER
WAYNE
GREEN
BAUGHMAN
Smithville
Orrville
Dalton
SHARON
SANDUSKY
RICHLAND
MANSFIELD
MIFFLIN
VERMILLION
Hayesville
MOHICAN
Jeromeville
PLAIN
WOOSTER
EAST UNION
SUGAR CREEK
West Lebanon
SPRINGFIELD
MADISON
Ontario
Newcastle
Lake Fork
Mohecanville
Millbrook
Moreland
CLINTON
FRANKLIN
SALT CREEK
PAINT
Mount Eaton
Fredericksburg
Salt Creek
Washington
Lucas
MONROE
GREEN
LAKE
Big Prairie
Shreve
WASHINGTON
TROY
Perrysville
Londonville
Lakeville
PRAIRIE
SALT CREEK
PAINT
Mt. Hope
Belleville
Newville
Winchester
WASHINGTON
RIPLEY
Benton
Nashville
Independence
Butler P.O.
HANOVER
KNOX
HARDY
MILLERSBURG
Berlin
WALNUT CREEK
PERRY
JEFFERSON
WORTHINGTON
HOLMES
MONROE
BERLIN
New Carlisle
Walnut Creek P.O.
Waterford
Palmyra
Ankenytown
Brownsville
North Liberty
PIKE
BROWN
JEFFERSON
Greersville
Napoleon
Saltillo
MIDDLEBURY
BERLIN
Oxford
RICHLAND
GERMAN
PITTSBURG FORT WAYNE & CHICAGO
MANSFIELD & NEWARK
A. & G. W. R.

CHAPTER LXXXI.

REPORT ON THE GEOLOGY OF WAYNE COUNTY.

BY M. C. READ.

TOPOGRAPHY.

In its topography Wayne county has in part the characteristics of the coal territory of the State, and in part that of the table land illustrated in the description of Ashland, Richland, and other adjoining counties. A deep pre-glacial channel enters the county from the north, in the western part of Milton township, and extends northward, expanding, as it approaches Orrville, into a broad swamp, the site of an ancient lake. From thence it passes eastward into Stark county, a branch from Milton township trending directly east in the valley now occupied by Chippeway Creek, and another northward through Canaan and Wayne townships, passing east of Wooster, and striking the line of the Cleveland, Mt. Vernon and Columbus Railroad near Apple Creek Another channel from the north enters the county near the east line of Congress township, and constitutes the valley through which the Killbuck flows through the whole extent of the county. A branch bearing north-westward from Wooster is followed substantially by the railroad, until it unites with an ancient channel from Ashland and from Richland, in the valley of the Mohican. These valleys in places expand into broad, alluvial plains, and in others are occupied by marshes, plainly indicating the sites of shallow lakes.

In the central and western parts of the county the surface rises in gently rolling hills between these old channels, in most places covered deeply with clay drift having the same succession and arrangement of material as that described in the reports of the counties to the west.

In the eastern, and especially in the north-eastern and south-eastern parts, the surfaee is hilly and broken, and the erosion of the Coal Measure rocks has left a succession of terrace-like benches, which characterize the hilly regions of the coal-fields of the State.

In protected places the drift clay covering still remains in these hilly regions, and sometimes caps the highest hills. East of Mt. Eaton, an excavation for coal discloses

Yellow drift clay	12 feet.
Blue " "	6 "

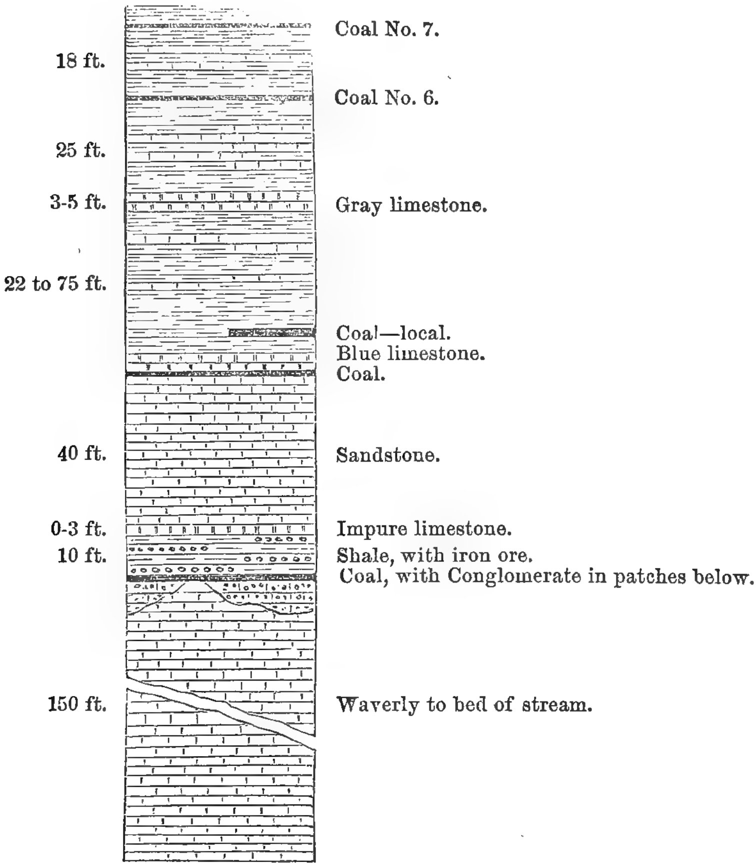
Both members containing striated pebbles of the blue limestone, which is in bed on this horizon, and rounded pebbles of granitic rocks. The surface deposits in the central and western parts of the county are similar to those described in the preceding counties. Between the streams an undulating and billowy surface of yellow clay, with blue clay below, may be seen resting, sometimes directly upon the bed-rock, sometimes with a bed of gravel interposed. On the margins of the streams and old pre-glacial channels are sand and gravel ridges, and in the valleys alluvium, resting upon beds of lacustrine clay, gravel, or bowlder clay, sometimes over one hundred feet in depth.

GEOLOGICAL STRUCTURE.

A small portion of the northern parts of Canaan and Milton townships, the greater part of Chippewa and Baughman, all of Sugar Creek and Paint, the greater part of East Union and Salt Creek, and a small portion of Green, Franklin, and Clinton townships are covered by the coal formation. All the rest of the county is Waverly, as indicated by the shading upon the map. This western margin of the coal rocks is by no means coincident with the western margin of the coal, as the sandstone belonging above the Upper Coal is in places found resting directly upon the Waverly, without coal, coal shale, or fire-clay to mark its horizon. The brown shading indicates, as accurately as could be determined, the territory covered by rocks belonging above the Sub carboniferous Conglomerate, which is here not continuous, and is colored red. Along parts of this western margin heavy beds of Drift mark the geological structure, and the line is located approximately, as the topography and the nearest outcrops of the rocks indicate its position.

A section from Mt. Eaton to the bottom of the valley at Fredericksburgh would expose all the rock strata of the county, from Coal No. 7, at the top, to the Waverly.

The following is such a section:



The interval between the gray and blue limestone in the section varies greatly. At Mt. Eaton it is seventy five feet; on the east line of Salt Creek township, fifty feet; at Kirkendall's, some two miles east of Fredericksburgh, twenty-seven feet; and at Fredericksburgh, on the west side of the valley, twenty-two and one-half feet. Throughout this part of the State, upon approaching the margin of the coal field, its strata are found generally reduced in thickness, bringing the coals nearer together, and showing an approach toward the original western boundary of the field. This was formed by Waverly hills. The same is eminently true of the interval between these two limestones. While for long distances in one direction the interval between them is almost identical, a line at right angles to this will show them approaching in one direction and receding in the other, and generally near the western margin of the field they generally come closer together again.

A large part of the interval between the blue limestone and the Lower Coal, in the section given, is occupied by a sand-rock which appears very conspicuously above the Kirkendall coal. This is often reduced to a thin band, the thickness of the shale being correspondingly increased.

The following sections illustrate these changes:

J. P. Burton's bank, Fairview—

	FT.	IN.
Earth and gravel	13	0
Black shale	40	0
Sandstone	10	0
Black shale	0	3 to 4
Coal	4 to 7	0

On section 26, Chippewa township—

	FT.	IN.
Earth	9	0
Sand rock	56	0
Gray shale	31	0
Black shale	15	0
Coal	4	6

Shaft at Chippewa Mine—

	FT.	IN.
Clay and shale	33	6
Sandstone	30	0
Clay shale	8	0
Iron ore	1	0
Clay shale	11	0
Sandstone	15	0
Gray sandstone	4	0
Shale	2	0
Bony coal	1	6
Good coal	4	0

Drill-hole on Huntz's farm, Chippewa township; shaft since sunk—

	FT.	IN.
Earth	10	6
Quicksand	6	6
Sandstone	3	0
Shale	14	0
Calcareous iron ore	1	0
Black shale	22	6
Coal	5	0

Silver Creek Mining and Railroad Company's property—

	FT.	IN.
Earth	19	0
Gray sandstone	6	0
White sandstone	9	0

	FT.	IN.
Shale	3	0
White sandstone	5	0
Shale	18	6
Coal	4	6

John Adams's farm, one mile southeast from Doylestown—

	FT.	IN.
Earth	14	0
Brown shale	18	0
Coarse white sandstone	22	0
Coal	3	0
Conglomerate	5	0
Coal	5	1
Black shale	0	6
Fire clay	2	0

These sections suffice to show the great want of uniformity in the material directly above the lower coal; the last section, with five feet of Conglomerate wedged between a three-foot coal above and a five-foot coal below, does not indicate a proper Sub-conglomerate coal, or a coal below the true horizon of the Conglomerate. It marks a local subdivision during the deposition of Coal No. 1, after which, the debris of a Conglomerate ridge bordering the marsh, was carried down on to the coal and re-cemented into rock. Similar local deposits of Conglomerate debris are found in the roof of Coal No 1, in Trumbull county. This fact, mentioned in my report on that county in Vol. I, has been quoted by Prof. Lesley, of the Pennsylvania Survey (report of progress, 1875), as evidence that our Coal No. 1 is Sub-conglomerate, and he suggests that the bed of sandstone found above this coal is a combination of the Conglomerate. While it is true, in Ohio, that Coal No. 1 is often, topographically, below the Conglomerate, is bordered by Conglomerate and Waverly rocks, which rise in hills of considerable height along the margin of the old coal swamps, the debris of which is sometimes found in the roof of the coal, it is quite certain that nowhere in the northern or north-western part of our coal-field is this coal geologically below the Conglomerate. It is also certain that the great bulk of this rock is found outside of the productive coal territory. The most of the ravines which penetrate far into the Coal Measures and expose the rocks below the lowest coal, show that this Conglomerate is very thin or wholly wanting. It would be of incalculable benefit to the northern part of the State if this coal could be found under the broad expanse of Conglomerate which covers the most of Geauga and Medina counties and the northern parts of Summit and Portage, but its base is exposed in too many places (where it is always found resting upon our Cuyahoga shales) to leave room for any hope of such a desirable discovery.

We have many newspaper reports of the finding of coal far below this horizon, as in the deep well drilled in Mansfield, where the surface rock is three hundred feet or more below the lowest coal. So in this county in a well sunk for oil near Apple Creek, where the ravines cut through the coal measures, a coal seven feet thick was reported as disclosed seventy feet from the surface. A reliable person, who lived in the place at the time the well was sunk, informed me that he burned the coal, and that there was no possible doubt as to its character and excellent quality.

The investigation was followed up until the fact was learned that the coal was obtained in driving the pipe, which was carried down to a depth of one hundred and twelve feet, and abandoned without striking rock. It was simply the occurrence, by no means unusual, of detached fragments of coal buried in the Drift, and of no significance with reference to the true horizon of any of the coals.

Coal No. 7 I have found only in the top of the hill at Mt. Eaton without cover, where it was formerly mined to a small extent by drifting, and most of it apparently taken out. The hills in other parts of the county are not high enough to catch it.

Coal No. 6 is mined one-half mile east of Mt. Eaton, at George Matthews's bank, where it is two feet three inches thick, roof of black shale one to two feet thick, containing many shells and capped with sandy shale. The coal is of the ordinary type of No. 6, black, lustrous and caking, but containing considerable sulphur. It is from eighteen to twenty feet below No. 7, and its outcrop can be seen on all sides of this hill, and at a few other elevated points in the neighborhood.

It is also present in the hills north of Fredericksburgh, on the north line of the county. The following section, taken here, illustrates the diminished intervals between the coals mentioned above:

	FT.	IN.
Coarse brown sandstone, Mahoning	25	0
Black shale with shells	5	0
Coal No. 6	3	6
Fire-clay	3	0
Black-shale	27	0
Gray limestone	2	0
Coal	2	0
Fire-clay	2	0
Black shale	18	0
Blue limestone	2	0
Coal	2	0
Fire-clay	3	0
Ferruginous shale	6	0

	FT.	IN.
Shell, iron ore	1	0
Black shale (of coal No. 1)	20	0
Waverly, capped with coarse sand rock	145	0

No. 6 is here of good quality, and has been mined for many years. It is about three and one-half feet thick, with roof of black shale containing a profusion of shells.

The interval between this coal and the gray limestone below, is here, by barometer, thirty feet, five feet greater than at Mt. Eaton, and is filled mainly with black shale. The limestone is two and one-half fe t and can be traced eastward to Mt. Eaton, reaching a thickness of four and five feet, and furnishing a good quick-lime. The coal below ranges in thickness from two to three feet, and is reported in places four feet. It is fairly good, containing a rather large amount of ash and often considerable sulphur. It will be mined for local domestic use, and for burning the limestone above it. On Charles Brown's land, about one mile west of Mt. Eaton, it is a fair cannel coal of which about eighteen inches is exposed at the outcrop.

Near the east line of Salt Creek township, Coal No. 3*a* is locally developed, and at the Adam Emig's bank reaches a maximum thickness of nearly five feet. It is a dry coal, semi-cannel of fair quality, and is located a few feet only above the limestone. It is apparently wanting over the greater part of this territory.

Coal No. 3 is somewhat persistent but varies greatly in thickness and character. Near the center of the north part of Salt Creek township a drift has been made into a hill where the coal, at its outcrop, was six feet in thickness, but in a distance of some fifty yards, was reduced to a knife edge according to the testimony of citizens of the vicinity. At Clark's bank, near Fredericksburgh, it is two feet thick. In the south part of Franklin township, an opening has been made in this coal which is of fair quality, and three feet four inches thick, the limestone above having a thickness of five feet.

On Daniel Rehm's land, section eight, Salt Creek township, is the best exposure of this coal I have seen in the county. The following is a section at that place:

	FT.	IN.
Limestone	4 to 6	0
Coal	1	8½
Shale	0	4
Coal	3	5
Shale	0	1
Coal	0	8
Whole thickness of coal	5	9½

The middle bench, of three feet five inches, is a hard, bright, pure coal, nearly dry burning, containing a moderate amount of ash, and but little visible sulphur; the upper bench is rather shaly. This is an unusually good opening of the Blue Limestone coal. The limestone which covers it is ordinarily found at its proper horizon in the hills of all the coal territory south of the Pittsburgh, Fort Wayne, and Chicago Railroad, and is generally of good quality. In most places the coal is too thin to work.

For twenty to twenty-five feet below this seam, traces of Coal No. 2 have been frequently observed, and a few inches of coal have been disclosed at this horizon, in boring for No. 1, but I have no where found promise of its being of any economic value.

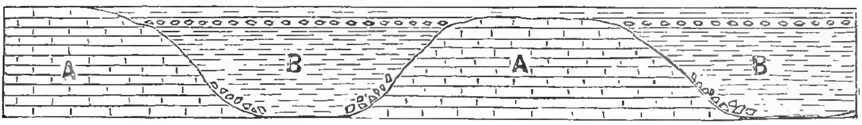
Coal No. 1 is the most valuable mineral deposit of the county. The two mines of the Silver Creek Mining Company had, at the time of my visit, an aggregate daily capacity of five hundred and fifty tons. The coal ranged from four to five feet in one bench, has little sulphur, a small percentage of ash, a large amount of fixed carbon, and is, in all respects, a first-class bituminous coal. Considerable territory in the township is underlaid by it, and the "Blue Chippewa coal" has become well known in northern Ohio and is rated among the best. The result of five borings give an average of four feet three inches of coal.

The sandstone which overlies this seam extends several miles west of Marshallville, and probably to the great valley of erosion, through which flows that branch of Chippewa Creek which has its origin in the swampy region near Orrville. In this western extension of the coal works, only thin coal has yet been found, and, in places, the sand-rock belonging above the coal is to be seen resting directly on the Waverly.

The following section was obtained a little north-west of Marshallville:

	FT.
Coal sandstone	25
Sandy shales, bottom clearly Waverly	50

The line of division is here not well defined, but the coal sandstone evidently rests directly on the Waverly, there being no coal shale or fireclay in the section. The rock at top is in thick, massive layers, becoming thinner at the base of the upper twenty-five feet. Below the layers are thinner beds of finer materials, with many ripple-marks and without fossils, the ravine giving substantially a full exposure to the bottom, where the layers are more evenly bedded and carry a few Waverly fossils. This western extension of the coal-fields has been partially explored by boring, without disclosing workable beds, but it is by no means certain that basins do not exist in which it may yet be found of workable thickness. The abrasion of coal shales in some of the outcrops, the ripple-marked sandstones, and plain channels of erosion formed after the deposition of the coal, are not favorable indications. The cut in the railroad, north of Marshallville, in the sandstone above Coal No. 1, is a very interesting example of erosion. On the same horizon the cut exposes, in succession, the following alternation of shale and sandstone: Sandstone, 161 feet, shale, 493 feet; sandstone, 485 feet, shale, 342 feet; sandstone, 195 feet, shale, 285 feet; sandstone, 480 feet, shale, 487 feet; the shale occupying excavated channels bearing north-west and south-east in the sandstone. The following is a section of part of this cut:



A A, sandstone. B B, shale, with nodules of iron ore near top, and angular debris of sandstone near bottom of cut, on the sandstone slope. The railroad track is at the bottom of the section, the cut not being deep enough to disclose the sandstone below the shale.

Near Fairview Station, east of Orrville, Coal No. 1 has an unusual thickness, and is a typical block coal, equal to the best in the Mahoning Valley. The following is a section of the coal and overlying rocks at J. J. Burton's shaft:

	FT.	IN.
Gravel	13	0
Black shale	40	0
Fine-grained sandstone	10	0
Black shale	0	3 to 4
Coal	5 to 7	0

The coal is in one bench, a dry, open-burning block coal of great excellence. The property embraces one hundred and sixy acres in fee, and three hundred and twenty acres of leased land. Before the depression in coal the mine was producing one hundred and twenty tons per day, which commanded three dollars per ton, delivered on the cars at the mine. This production could be largely increased, but it is not probable that the price of the coal will soon reach the old figures.

At Frank Baker's slope, north of Fairview, the coal varies from three feet to four feet two inches, and is of equally good quality, but the territory containing it, in this direction, is apparently small, and the known coal was, at the time of my visit, nearly exhausted.

About half a mile north of Fairview is another opening in this seam, where it is four feet thick in one bench—an excellent dry-burning coal, with little sulphur. It is a typical block coal, and most of it is mined without blasting. There is in the immediate neighborhood of Fairview quite a large area underlaid by a good furnace coal, which should all be saved for use in the smelting-furnace. Southward to Dalton, explorations have been made to a considerable extent for this coal, with only negative results, but from all the information obtainable, it is decidedly probable that none of the borings were carried to a sufficient depth to thoroughly test the territory, and there is still here a promising field for further explorations, embracing a large part of Sugar Creek and Union townships. The pipes driven near Apple Creek, to a great depth, without striking rock, mark the location of channels of erosion, but these channels have probably not a great width, and, outside of them, all the coal strata will be found in their proper positions. Exploration for Coal No. 1 is expensive and uncertain, but its very great excellence justifies the expenditure where there is any reasonable hope of success.

SUB-CARBONIFEROUS CONGLOMERATE.

The Sub-carboniferous Conglomerate is here quite thin, and its outcrops are not often seen. The western margin of the coal rocks is almost wholly masked by the Drift, so that it can be only approximately located, and on the greater part of this line the presence or absence of the Conglomerate can not be determined. It has here wholly lost the massive character which is seen in Medina and the counties east of it, and approaches in character to the yellow, shaly sandstone below it. Its supposed position is indicated on the map by a red band. It ought not to be regarded as continuous, but as existing in patches of undetermined extent.

WAVERLY.

The strata below the Coal Measures present little of interest to the geologist, and have no especial characteristics distinguishing them from those on the same horizon in the counties to the west and south-west. The upper part of the Waverly, comprising the olive shales of Richland, Knox, and Licking counties, is alone exposed, presenting alternate masses of sandy and argillaceous shales, the sandy shales rarely consolidated into massive layers or affording good building stone.

A little to the north of Wooster, about twenty-five feet of the Waverly is exposed in an open quarry, where the material is all yellow sandrock, most of it fine-grained, and some in layers of from one to four feet and more in thickness. All the layers are so crushed and broken that the rock, so far as exposed, is of comparatively little value. It is probable that the stone will improve in this respect when the quarry is opened further into the hill. A fossiliferous stratum is exposed similar in all respects to one found in the quarries at Ashland, and in Granville, Licking county. Another stratum is filled with quartz pebbles.

There are many outcrops of the Waverly in the central and western parts of the county, where the rock is thin and worthless, and nowhere have I found any good quarry rock in the formation within the limits of the county. The stone used at Wooster is obtained from the Coal Measure sandstone at the East.

CHAPTER LXXXII.

REPORT ON THE GEOLOGY OF HOLMES COUNTY.

BY M. C. READ.

TOPOGRAPHY.

Holmes county is divided into two nearly equal parts by the valley of the Killbuck, an alluvial water-plain, above the buried channel of an ancient river, now filled with from one hundred to two hundred feet of Drift material. On each side of the valley the hills rise gradually to a height of from four hundred to five hundred feet, and then descend as gradually on the east, toward the valley of the Tuscarawas, and rather abruptly on the west to the valley of the Mohican. Innumerable creeks and rivulets emptying into these streams, interlocked in the most irregular manner, cover the face of the county, and uniting into larger streams flow through the narrow, alluvial valleys or deep, rocky gorges, which separate the high hills that compose the greater part of the surface. The same contrast between the members of the ancient and modern river-systems is observed here as in the counties heretofore described. The first flowing in moderately wide valleys on a muddy or gravelly bottom—the gravel composed largely of foreign material—and resting on a thick deposit of Drift, the latter flowing in narrow, rock gorges, generally, with a rocky bottom, and containing, almost exclusively, the debris of the local rocks. The constant succession of hills and ravines exhibits continuous exposures of all the rocks of the Lower Coal Measures, and in no part of the State can their character and relations be more satisfactorily studied.

SOIL.

The soil is generally a light, friable, calcareous loam, in the valleys, rich in vegetable matter, and everywhere well adapted to the growth of wheat. On some of the hills the surface is so thickly covered with rock fragments, the debris of the coal sandstone, as to be entirely unfitted for cultivation, but a dense forest covers these rocky slopes, and the soil was originally everywhere rich. When the growth of the best varieties of timber is properly encouraged, these rock-covered hills are an advantage rather than a disadvantage. They insure a forest reserve for the future, and if the worthless undergrowth, and the poorer varieties of trees are cut out, and the forests protected from the intrusion of cattle, the permanent return from these hills will fully equal in value that from the more inviting lands. On much of the arable land, continuous cultivation has had its usual results in a largely diminished productiveness, but the means of restoring the fertility of the soil are easily obtained in the limestones which crop out in every township, and by a proper use of them, and of clover for soiling, the lands can readily be made to equal or exceed their original productiveness in the great staple of the county.

THE DRIFT.

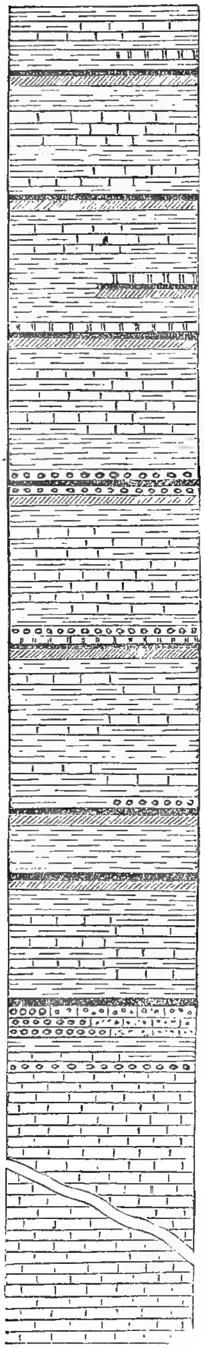
In the central and western parts of the county, evidences of Drift-action are marked and abundant, but no where in the county have I seen any deposits of unstratified bowlder-clay or "till," the typical, unmodified Drift—it is the debris of the Drift that remains. Granite bowlders are scattered over the surface, and along the valley of the Killbuck are high hills of coarse, water-washed gravel, which, in places, is being converted into a hard conglomerate through the action of lime-water, constantly percolating through it. The valley in which the Cleveland, Mount Vernon and Columbus Railroad is located, from Akron, in Summit county, to Millersburgh, and of which the Killbuck Valley forms a part, is distinguished from the country on each side of it by the abundance and coarseness of its Drift-material, indicating that near the close of the Drift-period this was one of the channels by which the waters of the lake-basin, when at a much higher elevation than now, found their way into the valley of the Ohio. Any remains of unstratified Drift, which once covered the county, must be sought for in the material filling the bottom of the Killbuck Valley. A high divide, running irregularly from Berlin through Weinsburgh to Dundee, appears to mark the limit of the Drift-action in the eastern part of the county. On the north, and to almost the top of this ridge, on its northern slope, scattered granite bowlders are to be seen, but I have found none upon its summit, nor to the south-east of it within the limits of the county. This evidence is not conclusive, for the torrents which poured over the divide, carrying away the surface-drift, and washing out the valleys, may have removed, also, those evidences of the Drift. Outside of the Killbuck Valley these bowlders are the only remains of the Drift, and the soil is composed entirely of the debris of the local rocks.

GEOLOGICAL STRUCTURE.

The geological structure of the county is well illustrated by the general section on the opposite page. There is no county in the State where the exposures of the coals and limestone are more numerous, or where they can be traced from hill to hill with more certainty, and the intervals between them measured with greater precision, nor any which better illustrates the want of parallelism in the rock strata, unless it be perhaps the Great Vein Territory of Perry, Athens, and Hocking counties.

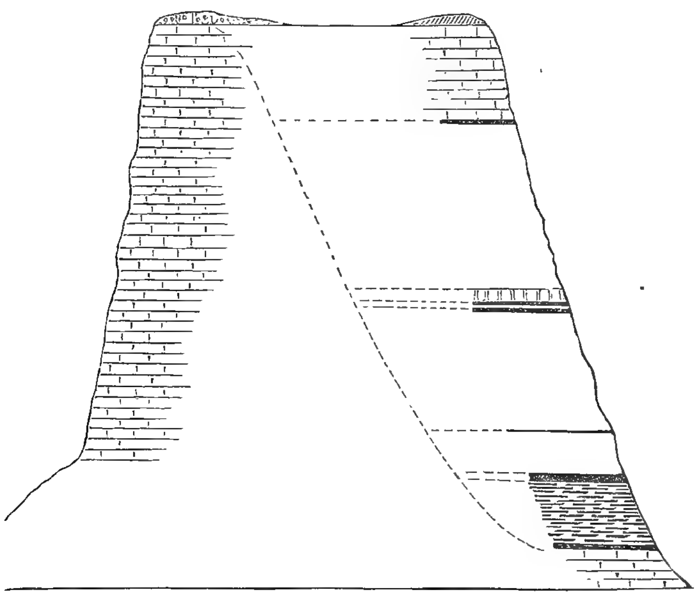
The lowest rocks exposed in the county belong to the Waverly group, the ravines in places cutting down fully two hundred feet into this formation. It covers the greater part of Washington township, and on lot three the Lozier quarries furnish heavy stone of very fair quality, which is shipped for bridge-building and other purposes, to the adjoining counties. From twelve to fifteen feet of this quarry is composed of hard, fine stone, in layers varying from two to four feet, with from six to twelve inches of silicious iron ore at the bottom. The quarry is by barometrical measurement one hundred and seventy feet below the base of the thin deposit of conglomerate which caps the hill above, and the section here, compared with that of the first ravine directly south, illustrates the topography of the county at the commencement of the deposition of the Coal Measure rocks.

GENERAL SECTION OF THE ROCKS IN HOLMES COUNTY.



In the following wood cut A is a section on the north of the road leading from Nashville to Loudonville, from the conglomerate to the bottom of the Lozier quarry. B is a section in the first ravine south of the road and nearly due west of Nashville :

Vertical scale, 1 inch to 72 feet.



		FT.	IN.
1.	Earth.		
2.	Sand-rock	36	0
3.	Coal	2	0
4.	Not exposed	63	0
5.	Blue limestone	4	0
6.	Coal—two benches	3	6
7.	Not exposed	45	0
8.	Coal.		
9.	Not exposed	18	0
10.	Coal—iron ore vein.		
11.	Black shale	27	0
12.	Coal No. 1.		
13.	Waverly.		

We have here a Waverly hill capped with the conglomerate, and rising at least one hundred and ninety-eight feet above the Old Swamp, in which Coal No. 1 was deposited, and certainly five coal seams, and their including rocks, below this conglomerate.

The dotted lines in the section indicate the probable junction of the coal beds with the old Waverly hill, and illustrate facts observed in other localities, where the third, fourth, or fifth coal seam extended northward or westward beyond any of those below it.

The Waverly forms the base of all the hills in Knox and Richland townships; is exposed through the whole length of the valley of Black Creek; in Shimplin's Run, from near the Williams coal, in Monroe township, to its mouth; in the valley of Paint Creek, in Monroe and Prairie townships; in the bluffs forming both banks of the Killbuck, and on all the larger streams emptying into the Killbuck on both sides of it.

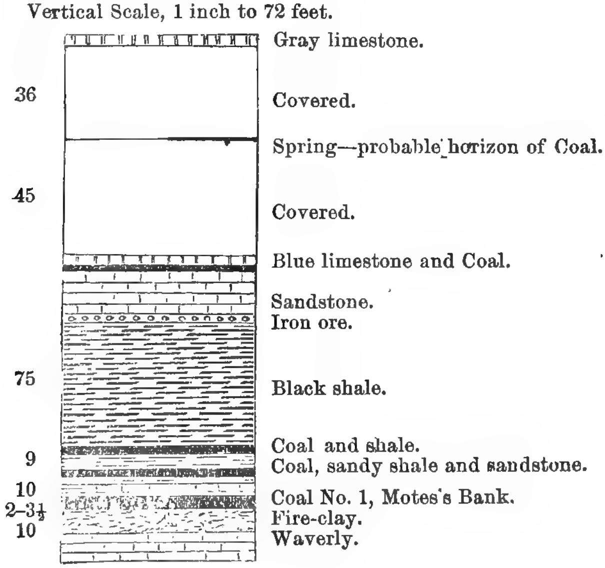
The abundance of building stone covering the surface derived from the Coal Measure sandstone, has prevented any special attention being given to the Waverly. Good stone can probably be obtained from it, should the demand hereafter warrant special exploration.

Near the bottom of a long ravine on Thomas Owens's land, in Knox township, a layer of the Waverly is exposed, which is a true grindstone grit, much like the Berea, and which might be explored with the probability of disclosing material for valuable grindstones. South of Taylor's coal bank, in the Waverly, about ten feet below the base of the Coal Measures, is a deposit of from two to three feet in thickness, of yellow hydrated oxide of iron, which, by burning, assumes all shades from yellow to a deep dark-red, and which will evidently make a good mineral paint. It is exposed by stripping, but an opening into the hill would give a good roof, so that if on trial it proves as valuable as its external appearance indicates, it could be taken out with facility, and in large quantities. It deserves to be carefully and thoroughly tested. Below Motes's bank, in the north-east part of the same township, and in several other places, this horizon carries thin bands of hard, compact, blue carbonate of iron, of good quality. A thin band in the Waverly, on Paint Creek, in Prairie township, is filled with water-worn quartz pebbles similar to those in the Conglomerate, and in other places patches and bands of pebbly Waverly may be seen. The sandstones of the Coal Measures also frequently contain similar pebbles, generally of smaller size and in more moderate quantities, so that care is required to avoid mistaking the true horizon of this pebbly sandstone.

The Conglomerate appears above the Waverly in Prairie township, on both sides of the Killbuck, and on the banks of Paint Creek, reaching a maximum thickness of eighteen feet. It caps the hills above Lozier's quarries, in Washington township, but is here so broken up and covered that its thickness can not be accurately determined. The lithological character of this deposit is here quite peculiar. It contains large quantities of broken, angular fragments of white and yellow chert, with a profusion of fossils identified by Mr. Meek as belonging to the Carboniferous formation. They point to the deposition of a Sub-carboniferous limestone, which has been cut out and removed by the agencies which brought in and deposited the materials of the Conglomerate. Small fragments of precisely similar cherty material I have found at the base of the Conglomerate at Nelson Ledges, in Portage county, and in the same position, mingled with other large, angular, and flat rock fragments, in Boston, Summit county. The form of these fragments, and their occurrence in thin patches of the Conglomerate and at the base of the thick sheet of the north, are quite significant. This Conglomerate seems to be a deposit like the modern Drift, brought in by a force which abraded and pulverized all except the harder materials, and left these in the form of water-worn pebbles. At the base are angular and unworn fragments of the local rocks. It is thickest where the modern Drift is thickest, and at the close of the epoch of its deposition there were eroding torrents which, at the north, removed the mass of the material, leaving only thin patches in protected places. In the larger part of the county it is entirely wanting, being represented in places by a thin layer of coarse sandstone, without pebbles, and often by a hard, compact, fine-grained, white, silicious rock, a few inches thick. This latter is filled with stigmariæ, precisely like that which is often found as the bed-rock of Coal No. 1 in Summit county, while at other places the Coal Measures are to be seen resting directly on the Waverly.

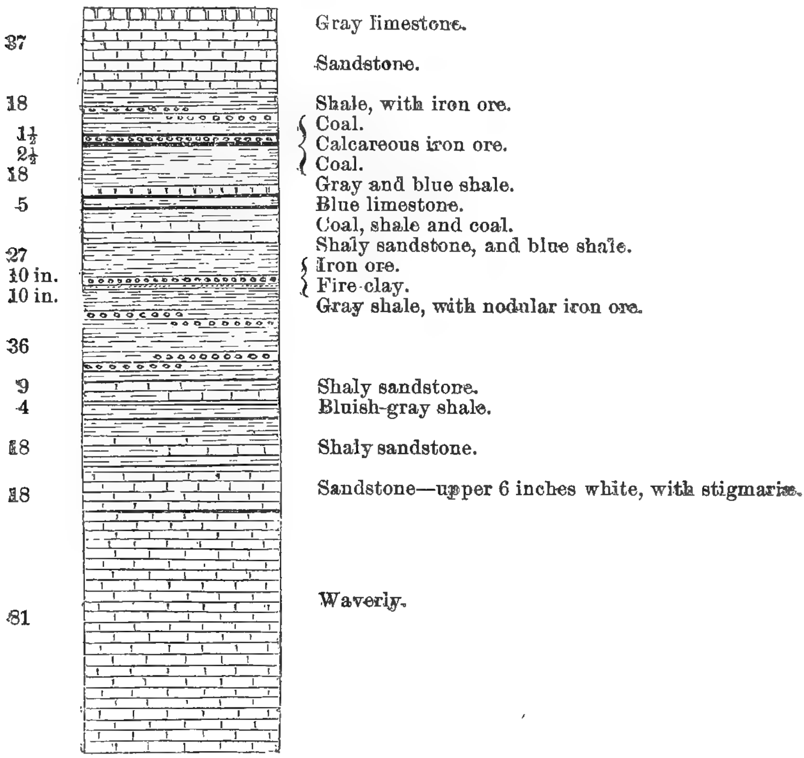
The following sections illustrate the transition from the Coal Measures to the Waverly. The first is a section of the ravine at Motes's bank, Monroe township:

Vertical Scale, 1 inch to 72 feet.



The following is a section from a continuous exposure in a ravine on Mr. Ellison's land, in the south part of Knox, and to the north-west of the last:

Vertical Scale, 1 inch to 72 feet.



In this section the eighteen feet of sandstone represents the Conglomerate, and the top, white layer, filled with stigmariæ, is the horizon and "bottom rock" of Coal No. 1, which is here wanting. At Motes's bank, as illustrated in the first section, the fire-clay of this coal rests directly upon the Waverly.

On Thomas Owens's land, in Knox township, the out-crops of five coals are exposed below the gray limestone, and between the lower coal and the Waverly are twenty-seven feet of blue shale, containing thin bands of shaly sandstone, but no trace of any rock resembling the Conglomerate.

Referring again to the section at Lozier's quarry, if Prof. Lesley's suggestion in regard to the Mahoning Valley, that we should look for the continuance *above* Coal No. 1 of the massive beds of Conglomerate exposed at Parkman and Nelson Ledges, is correct, then we should here look for the Conglomerate above Coal No. 6, and conclude that the Sub-carboniferous Conglomerate and the Mahoning sandstone are the same formation. They are here substantially in the same topographical horizon, but geologically one is above Coal No. 6, the other below No. 1, and the line of division between the Coal Measure rocks and the Waverly. The fact that Waverly and Conglomerate hills bordered the coal-marshes, sufficiently explains the occasional occurrence of Conglomerate in the roof of the lowest coal, composed of the re-deposited debris of the Conglomerate hills. The sandstones above the other coals may also have acquired their quartz-pebbles from the same source.

Coal No. 1.—Above the Waverly, on the Conglomerate, where the latter is found, appears Coal Seam No. 1, or the block coal, ordinarily resting upon a bed of fire-clay, and sometimes separated from the sandstones below by a few feet of shales. It may be seen in many places west of the Killbuck, especially in the territory south of Paint Creek, and north of Black Creek, the most productive coal region in the county. On the east of the Killbuck it has been mined on Mr. Cameron's land, in the south part of Prairie township, where the Conglomerate is directly below it, and the shales, which accompany it, may be identified in the ravine north of the Shepter or Holmes County Company's bank.

At Smith's bank, in the northern part of Monroe township, it reaches a thickness of four feet, is a true block coal, of fine quality, and reasonbly free from sulphur. It inclines to break up into small pieces, is quite rusty, and of rather an uninviting appearance. The blacksmiths do not like it, as they prefer a softer and more melting coal, and as their opinion, where little coal is mined, is potent in determining the reputation of different coals, that from this opening has not had the valuation it deserves.

At Motes's bank, in the north-west part of Monroe township, it is three feet thick, hard, bright, and of good quality, resting upon a compact fire-clay, nine to ten feet thick. Between the coal and the overlying sandstone are two to four inches of highly carbonaceous shale. The sandstone is strong, unbroken, and would readily admit of working-chambers of very large size. On the land of Stephen R. Williams and Washington Williams, near the center of Monroe township, this coal is a little over three feet thick, resting on the fire-clay, and capped with dark, bituminous shale. It is a block coal, of fair quality, but has not been sufficiently opened to determine, accurately, the value of the property. The best exposure is so nearly on the level of a neighboring stream that the water would be troublesome unless an opening is found in a lower part of the valley.

At James Martin's bank, north, and in the same township, it is two feet thick, hard, bright, compact, a semi-block coal, but containing much sulphur. Above it are ten feet of hard, dark, sandy shales. On John and Charles Steel's land, in Hardy township, north of Judge Armor's, it is two feet three inches thick, in three benches, roof massive, bituminous shale, coal semi-bituminous, and with much sulphur. When examined, it had been opened only to the distance of a few feet, and was said to be increasing in thickness, and improving in quality.

At John Carey's, west of the Killbuck, and near Millersburg, it is also two feet three inches thick, in three benches, separated by sulphur-seams, and of no value. The sand-rock rests directly on the coal.

The outcrop of this seam can be seen in the ravine below the Hardy Coal Company's banks; on Barney Carpenter's land, near the east line of Monroe township, and in various other places. Over more than half of the county the deep ravines are below its horizon, and it will doubtless be found in many other places. It gives promise of affording much coal of good quality, and probably some of it equal to the best typical block coal.

The shales above it vary in thickness from a few inches to fifteen feet, and in places are entirely wanting, the sandstone resting directly on the coal. It is probable they were originally deposited of a nearly uniform thickness, and that the agencies which brought in the coarse material of the sandstone have cut down and removed the shale, doubtless carrying away also, in places, the entire body of the coal.

From ten to thirty feet above Coal No. 1 is a local deposit of coal and iron, which I have been able to trace over a large part of the county west of the Killbuck. The best exposures of it are on Locust Lick Run, on Mr. Ellison's land, in the west part of Monroe township; below Mitchart's bank, a little south and west of this; on Carpenter's land, west of the Hardy Coal Company's and Mr. Sanders's banks; in the ravines south and west of the Hardy Coal Company's lower bank; and on Shaffer's land, west of Nashville, in Washington township. It consists of from ten to twelve inches of cannel coal, and about the same thickness of bituminous coal below it, with a band of massive iron ore between the benches. The ore is in places highly bituminous, resembling a compact black band; in other places it is calcareous or argillaceous. It is reported in some localities as four feet thick, but I have seen it reaching a thickness of only eight to ten inches, with scattered patches and nodules of ore above and below it. In some places, one or both benches of coal disappear, and are separated by layers of carbonaceous shale. Occasionally the two benches of coal have a much larger interval between them, as shown in the section at Motes's bank, where the included shale measures nine feet. The want of good iron-making coal in large quantities will probably prevent the mining of this and the other ores of the county for some time, but when a demand arises this horizon will furnish a large amount of valuable ore.

Coal No. 2.—Shales, ordinarily varying from eighteen to twenty or thirty feet in thickness, separate the above from Coal No. 2—the Strawbridge seam—the iron-ore coal, from its local character, not being numbered. In the south part of Knox township these shales are nearly one hundred feet in thickness, exceeding largely their usual development.

This coal rests upon from six to ten feet of white fire-clay, apparently quite pure, and of excellent quality. It is capped with sandy shale, in places passing into a shaly sandstone, which at top frequently becomes massive, and contains nodules of silicious iron ore. At the Strawbridge mine, in the northern part of Killbuck township, now owned by the Hardy Coal Company, this coal is at the outcrop seven feet thick, a hard, compact, semi-cannel or splint coal, reasonably free from sulphur, containing a rather large percentage of ash, but a good domestic and steam coal. The opening is in a narrow gorge, which apparently cuts the centre of the old coal marsh, from whence the coal will doubtless gradually diminish in thickness as the margin is approached. As this coal is ordinarily thin, its remarkable development here suggested the possibility of a slip or fold, causing the coal to double on itself, and thus increase abnormally its thickness. An examination, however, of the rooms and entries shows even, parallel lines of lamination in the coal, and that the unusual thickness is owing to the great depth of the original coal marsh. An unfortunate attempt was made to mine this coal on a large scale, by a company without any experience in coal mining, and just at the commencement of the great depression in the price of coal. Failure, under such circumstances, was inevitable. The work has been abandoned, pillars drawn, and the mine left almost a wreck; while it is evident that there is a large amount of good coal, of workable thickness, in the property. The seam can not be expected to maintain, in the working rooms, the thickness shown at the mouth of the mine. Outcrops on all sides of the hill show comparatively thin coal, and a gradual reduction in thickness is to be anticipated in all directions in the mine.

At Mitchart's bank, in the south part of Knox township, it is four feet thick, apparently of good quality, but, at the time of visiting it, the entry was not pushed far enough into the hill, to determine accurately its character.

The outcrop of this coal may be seen in the ravines near Mr. Glascoe's, in Knox township; on Steel's land, north of Judge Armor's; and on Carpenters's land, in Hardy township; in the ravines, south-east of the Strawbridge mine, in Killbuck township; below Mort's bank, near the north line of Prairie township; and, perhaps, in all the townships in the county. In most places it is strictly a cannel coal. Near New Carlisle, its outcrop is in the bed of Walnut Creek, and throughout the eastern part of the county it is exposed only in the lowest ravines. It is only locally that it is developed to a workable thickness.

Coal No. 3.—The sandy shales and sandstones between the last and Coal No. 3, or the blue limestone seam, are ordinarily from forty to fifty feet thick, but are often much less, and occasionally reach a thickness of from eighty to ninety feet. This coal has a workable thickness in the greater part of the county, and, in places, affords coal of an excellent quality. It is very liable to split up into separate seams, by clay and shale partings, which detract much from its value, and render many openings quite worthless. The blue limestone above it is so persistent, as to constitute one of the best landmarks in studying the geology of the county; but it is occasionally wanting, a highly calcareous shale, containing the characteristic fossils, taking its place, and sometimes it is separated from the coal by several feet of shale. It is often cherty, and, in places, assumes the character of a buhrstone. It is often found in large, cubical blocks, and sometimes with mud seams filling the joints. When this is the case, and it rests directly upon the coal, it makes a troublesome roof, and sometimes one that is quite unmanageable. On Mr. Glascoe's land, in Knox township, a drift was commenced under this limestone, which is there about three and a half feet thick, and is divided into cubes about four feet square. The water percolating through the mud seams, loosens these blocks, and some of them falling, completely blocked the entry. The hazard was so great, that the miners wisely refused to go on with the work, and the attempt to open the mine was abandoned.

One of the best openings of this coal is the Dagger mine, in Knox township. The coal rests upon black shale, is six feet thick, in two benches, separated by a clay seam, five inches thick at the opening, which has gradually thinned down to one inch as the entry is carried into the hill, and will probably thin out entirely. The coal is hard, bright, compact, semi-cannel, containing a rather large percentage of ash and but a small amount of sulphur. It is, unquestionably, a good domestic and steam coal.

At Mitchart's, near the northern part of Knox township, it shows about three feet of coal, separated into nearly three equal benches, by clay seams, each six inches thick; coal of good quality. On Stoker's Hill, south-west of Mitchart's, an outcrop shows coal one foot, fire-clay, six inches, coal, eighteen inches.

On Mr. Ellison's land, in the same township, an outcrop gives—

	FT.	IN.
1. Sandstone	4	0
2. Coal	1	8
3. Black shale	2	0
4. Coal	2	0

On Joseph Blanchard's land, three-fourths of a mile south-east of Napoleon, is an opening, of which the following is a section:

	FT.	IN.
1 Shale	20	0
2. Coal	0	10
3. Fire-clay	0	8
4. Coal	0	8
5. Fire-clay	0	10
6. Coal	1	8
7. Black shale.		

It is evident that such a seam, though containing nearly four feet of coal, will be of little value unless the clay partings thin out. In all of the hills around Napoleon this coal is well developed, but all the exposures found, showed clay or shale partings, rendering the coal of little value for present mining.

Elias Mast's mine, in Hardy township, east of Millersburg, has a firm limestone roof, admitting of chambers fifty to eighty feet wide, timbered only along the railways; coal hard, bright, and of good quality. The following is a section of the coal strata:

1. Limestone	4 ft.
2. Coal	18 to 20 in.
3. Fire-clay	8 in.
4. Coal	2 ft. to 2 ft. 10 in.
5. Black shale	20 in.
6. Cannel coal	1 ft.

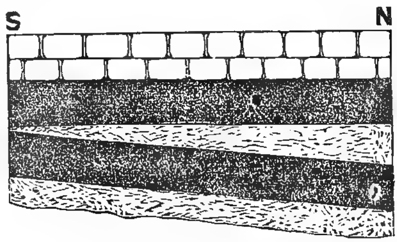
Michael Cullens's bank, in Salt Creek township, gives the following section:

1. Limestone	3 feet.
2. Coal, rotten and soft	2 "
3. Hard gray shale	2 "
4. Coal, good quality	2 "
5. Fire-clay	18 to 20 inches.

An opening in the same hill, a half a mile south, on Leonard Matthews's land, shows limestone two feet, coal four feet, upper half cannel, lower semi-cannel; fire-clay eight to ten inches; compact, drab, calcareous shale, with shells of the blue limestone, one foot. At Henry Harger's saw-mill, in Paint township, the outcrop shows four to five feet of coal, the upper part bituminous, the lower cannel. In Mechanic township this coal is reported from seven to eight feet thick, a true cannel coal. It was exposed by boring and drifting during the excitement incident to the first manufacture of illuminating oil from coal, and the reports of the borings may not be altogether reliable.

In a shallow valley, in this township, several acres of this coal have been burned out, and the roof, which was here a calcareous ferruginous shale, covers the surface, and is found in the banks on each side, presenting the appearance of an uniform blackband ore after it has passed through the fire. The burning of the coal occurred so long ago that the valley has become covered with a mixed forest, the trees of the same size and varieties as over the unburned territory.

In the northern part of Salt Creek township two openings in this coal, something less than half a mile apart, and on the same hill, give the following section:



FT.	IN.		FT.
2	0	Limestone	2
2	0	Coal	2
0	1	Clay	2
2	0	Coal	2
		Clay.	

In which S. represents the southern and N. the northern opening. It is evident that the subsidence which brought in a mud deposit on the surface of the old coal marsh was along an axis in the neighborhood of the first opening at S., where the growth of the coal vegetation was uninterrupted. If the subsidence northward continued at the same increasing rate, in less than five miles the two benches of the limestone coal would be represented by twenty feet of shale, and would be regarded as distinct deposits. Between this limestone and its coal there are in places in the county fifteen feet of shale, while ordinarily the limestone rests directly upon the coal, or is separated from it by only a few inches of shale. The result of many hundreds of barometrical measurements between this and the grey limestone show intervals varying all the way from twenty-two to one hundred and seventeen feet. These facts show conclusively that the successive subsidences were not continental, but occurred along the lines of neutral axes, giving a wedge-shaped form to many of the strata. Indeed, had those subsidences been continental, the lower coal would every where be buried beneath all the other members of the Coal Measure rocks, except where the latter had been carried away by erosion, and the last coal deposited would extend farthest up the slopes of the hills which bordered the coal territory, and would be the first encountered upon approaching the coal field.

The outcrops of this coal are found in every township and upon the slopes of almost every hill, and generally with evidences indicating a remarkable thickness, but few of them have been satisfactorily tested.

Iron Ore.—Just above this horizon are deposits of iron ore extending over most of the county, from which large quantities could be mined should there be a sufficient demand for it. In places the slopes of the hills between this coal and the next above, are covered with the ore; and on John Simmons's land, in Knox township, where these fragments are very abundant, it is reported that a solid deposit of ore eight feet thick was penetrated in sinking a well.

Coal No. 3a.—A sandy shale separates the blue limestone from the coal designated as No. 4 in the preliminary report on this county, but which, from its unimportant character throughout the State, is now designated as No. 3*a*. The interval ranges ordinarily from eighteen to thirty feet; but in Salt Creek township measurements have been made where it is fully seventy feet.

Nowhere in the county have I found this coal of sufficient thickness to be profitably mined, although its outcrops are numerous and its horizon can be accurately determined in nearly all parts of the county. On the Killbuck Coal and Mining Company's property, in Mechanic township, it is associated with iron ore in the overlying shales, and it is possible that further explorations may show that the two minerals can be profitably mined together. The limestone which overlies it in parts of Coshocton county, appears occasionally in the eastern part of Holmes, and care is required not to confound it with the blue limestone below.

Coal No. 4.—The shales and sandstones between the last and Coal No. 4, or the grey limestone seam, range from twenty-five to fifty-five feet in thickness. The material is generally a thin-bedded shaly sandstone of no value, but in places it would furnish fair flagging stone. This coal attains its maximum thickness, in the county, in Salt Creek township, where it is three and a half feet thick, with six feet of limestone resting directly upon it. Very good coal can be obtained from the openings here, but it is in three benches and with many sulphur seams. In other parts of the county it is of a similar character, and generally of less thickness. It is from this coal and the limestone above it, that the farmers of Holmes county are to obtain material for restoring the fertility of their lands and recovering their future productiveness. The coal is usually of sufficient thickness to suffice for burning the limestone which rests upon it, and ranges in thickness from three to six feet. As the coal and limestone can be taken out of the same entry, and both mined with facility, there is no place where quick-lime can be obtained at less expense than here. Properly used, this deposit will add largely to the wealth of the county. This limestone has also been tested as a flux in the smelting furnace, and is well adapted to that purpose.

The Bennington mine, near Nashville, which I refer to this horizon, but which may probably be No. 6, furnishes an excellent coal, much superior to that from any other opening in the gray limestone seam with which I am acquainted. The seam is generally underlaid by a thick deposit of fire-clay of good quality, and which has been successfully used in the manufacture of pottery. That from an opening a little east of Millersburg, makes a very strong, smooth ware, and burns to a bright cherry-red.

Coal No. 5.—From twelve to fifteen feet above No. 4, in a few places in the eastern part of the county, is a black limestone from two to three feet thick, with outcrops of this coal below it, and occasionally its horizon can be seen where the limestone is wanting. None of the outcrops observed gave promise of valuable coal.

Coal No. 6.—At a distance ordinarily ranging from forty to fifty feet above the gray limestone, is found Coal No. 6. The interval is sometimes very much greater, and in a few places not exceeding twenty feet. It is from this seam that the coals of the county are most widely known, and from which a large part of the coal mined in the county will probably be taken for many years to come.

At Mr. Saunders's, and the Hardy Coal Company's upper mine, in Hardy township, this coal has been successfully mined for many years. It is here hard, bright, moderately cementing, is an excellent grate and steam coal, and makes a compact coke. It is in three benches, the middle one containing a much smaller percentage of sulphur than the others, and making a good blacksmith's coal. The peculiar purple color of the ash of the top and middle benches enables one to identify this coal by the debris from the stoves and grates wherever used. At a few place only the ash is light-colored. The seam in this neighborhood, at the Hardy Coal Company's, Mr. Saunders's, Judge Armor's, Johnson's, and Shultz's banks, varies in thickness from four to six feet, and in places reaches a thickness of eight feet, and it is in this vicinity that the most valuable deposits of this coal in the county are found.

At Saunders's and the Hardy Coal Company's mines the roof is shale, containing shells; the bottom is six to ten feet of fire-clay. At Judge Armor's mine the roof is sandstone, bottom fire-clay, with a parting of clay or shale one to six inches thick at two feet from the bottom; lower bench good blacksmith coal. At Johnson's mine, roof shaly sandstone; at bottom ten to twelve inches of compact, calcareous, sulphury iron ore. At Shultz's mine, sandstone roof; bottom, fire-clay. At the Taylor mine (No. 2), Knox township, the coal is thirty-two inches, hard and good; sandstone roof, with a few inches of shale, containing shells. At Sears's mine, Walnut Creek township, the coal is of good quality, three and one-half feet thick; black shale roof, with sandstone above.

In the same township, on Henry Coley's land, an entry of one hundred and thirty feet exposes coal three feet seven inches, still increasing in thickness; coal in one bench of excellent quality; ash white. It was in this neighborhood that a system of book-keeping was observed at one of the mines, which bore eloquent testimony to the economy of the proprietor and the honesty of the patrons. A large amount of freshly mined coal was accumulated at the dump; no one in attendance to wait upon the patrons; a bushel measure and a shovel provided for their use; a blackboard and piece of chalk for book-keeping, the board bearing the following instructions to customers: "Put down the name and the number of bushels." It was evident that the expense of outside superintendence was reduced to a minimum.

At Thompson's bank, Farmersville, a section from above gives black shale, in thick sheets, ten feet; black shale, with a great abundance of shells, eight inches; cannel coal, two inches; bituminous coal, three feet; blue shale, two inches; fire clay at bottom. Coal good; ash white. The cannel coal and the blue shale here apparently represent the upper and lower benches of the Hardy township mines. At an abandoned entry upon the same farm, the sandstone rests upon the coal.

At Berlin village this seam is struck by boring at ninety-five feet from the surface, and is four feet thick. It crops out and is accessible in all the neighboring ravines, and at an opening on Dr. Pomerine's land is three feet thick, and of good quality.

On the Killbuck Coal and Mining Company's property, in Mechanic township, the horizon of this coal is from seventy to eighty feet below the top of the highest hills, but no explorations have been made for it.

On the Holmes county mining property, in the same township, the coal is well opened, of good thickness and quality. The following is a section at this place:

Sandstone.	
Black shale	4 to 5 feet.
Cannel coal	1 foot.
Black shale	6 inches.
Impure sulphury coal	9 feet 10 inches.
Coal, good (sulphur seam at center, 2 inches)	3 feet.
Soft fire-clay, with iron ore	15 to 20 feet.

An excellent entry has been driven into the hill, and extensive preparations made for mining. The entry is two hundred and eighty-five feet above the railroad in the valley below, and bad engineering to overcome this rise, together with poor management, involved the company in serious embarrassments before any large amount of coal was taken out, so that the most of the money invested in the enterprise was lost. The debris at the mouth of the mine discredits the coal with the very large amount of sulphur shown in it, but from an examination of the face of the coal, it is evident that with proper care it can be sent to the market with no large amount of this impurity.

Coal No. 7.—The sandstone above Coal No. 6 is generally massive, and reaches a thickness varying from thirty to ninety feet. It constitutes one of the most prominent features of the geology of the county, freqently forming precipitous bluffs, with clean rock exposures, and in places its debris, in large masses, so covers the slopes of the hills as to entirely unfit them for cultivation. Large blocks of this sandstone are found in most of the valleys of recent erosion, and from these detached pieces the greater part of the rock quarried in the county for bridge and building stone has been obtained. It marks accurately the horizon of Coal No. 6 below it, and of No. 7 above, except that in places it has apparently cut away, removing the lower of these coals.

No. 7 is generally an excellent coal, containing a small percentage of ash and little sulphur. At Taylor's Bank, in Knox township, it is from four to six feet thick, with a shale roof and fine clay below. No better coal than this is found in the county, but it is so near the surface that it is soft, rusty, and uninviting in appearance, and the area covered by it is not large. On Mr. E. Glascoe's land it is so near the surface as to be quite worthless, and throughout most of the county it is either wanting, or so near the tops of the hills, as to be of little value. Its outcrop may be traced in the hills in the neighborhood of the Taylor and of the Holmes County Company's Mine, in Mechanic township, and in all the high hills in the neighborhood of Saltillo. Under Berlin village it is shown to be three feet thick, and so far from the surface that it may be profitably mined. The sandstone below it rests upon No. 6, and is thirty feet thick.

On the hill west of Millersburg a patch of limestone may be seen near the horizon of this coal, which probably represents the buff limestone of No. 7, in the central and eastern parts of the State. The sandstone above this is the highest rock found in place in the county.

IRON ORE AND FIRE CLAYS.

Incidental mention has been made of these minerals in the previous pages of this report. The fire-clays observed are all plastic, of a thickness ranging from four to ten feet or more, and are found under nearly all the exposures of the coal. They are of good quality, and practically inexhaustible.

Very little drifting or digging, has been made anywhere to develop the character of the ore deposits. Accidental exposures are numerous, and in some places very large quantities are found on the slopes and in the ravines. The following table of analyses of specimens taken from the surface in localities giving the best promise of a large supply, will indicate their character:

Number.	1.	2.	3.	4.	5.	6.	7.
Specific gravity	3.692	3.428	3.298	3.296	3.371	3.692	2.796
Water	1.89	....	....	8.37*	16.28*	6.12	11.70
Silicious matter	18.80	22.72	18.84	33.68	4.30	13.28	26.64
Carbonate of iron	36.96	47.48	55.36	32.29	20 59	52.07	....
Sesquioxide of iron	23.13	15.18	13.53	18.44	53.54	25.40	56.75
Oxide of manganese	1.50	0.80	1.25	1.50	1.80	0.40	1.40
Alumina	....	2.00	0.90	1.00	0.30	0.10	1.40
Phosphate of lime	7.97	6.55	1.53	0.32	trace.	0.06	1.46
Carbonate of lime	7.46	2 16	2.72	1.30	1.78	1.19	....
Carbonate of magnesia	2.12	1.74	5.14	1.59	1.36	0.64	0.75
Sulphur	trace.	0.07	0.14	0.79	trace.	....	....
Totals	99.83	99.33	99.41	99.63	99.95	99.26	100.1
Metallic iron	34.03	34.00	36.19	28.50	47.42	42.91	39.73
Phosphoric acid	3.645	3.005	0.702	0.15	trace.	0.03	0.67

* Water and organic matter.

No. 1. Under Motes' coal, Knox township.
No. 2. " " Waverly.
No. 2. Under Coal No. 2, Hardy township.
No. 3. " Knox "
No. 4. Over Coal No. 3, Knox township, Simmons's.
No. 5. " " Ellison.
No. 6. Iron ore seam, Washington township.

Of these, Nos. 1 and 2 contain so much phosphoric acid as to probably render them worthless. The others have only a very small amount of sulphur or phosphorus, and have so large a percentage of iron as to render them valuable ores. Those of Knox township especially give promise of great excellence, and if, on exploration, the reported eight-foot deposit is found to have half that thickness, it will prove the most valuable mineral deposit in the county.

Edward R. Taylor, a chemist of Cleveland, Ohio, furnishes the following analysis of an iron ore from the surface near Johnville, Washington township:

Protocarbonate of iron	88.77
Phosphoric acid	.16
Sulphuric acid	.04
Gangue	9.12
Metallic iron	42.49

The following is a table of the analyses of the coals of this county, made by Professor Wormley:

Number.	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.
Specific gravity	1.395	1.369	1.328	1.345	1.335	1.312	1.269	1.282	1.394	1.292	1.428
Moisture	2.75	5.10	2.75	2.30	4.30	3.85	7.30	4.20	1.65	3.90	3.20
Ash	9.65	4.20	8.05	10.66	15.40	12.00	3.40	7.00	16.35	5.65	17.10
Volat. com. mat'r	43.75	39.00	42.95	29.30	45.70	40.15	34.90	32.20	37.35	40.50	22.40
Fixed carbon	43.85	41.70	46.25	57.80	34.10	44.00	54.40	56.60	44.65	49.95	56.30
Total	100.	100.	100.	100.	100.	100.	100.	100.	100.	100.	100.
Sulphur	6.19	2.26	4.85	4.42	1.62	1.83	2.19	3.34	1.70	1.55	0.54
Gas per lb. in feet	----	3.40	----	2.87	2.67	2.32	3.20	3.32	2.31	2.95	2.24

No. 1. Sanders' Coal, No. 6, lowest bench.
No. 2. Sanders' Coal, No. 6, middle bench.
No. 3. Sanders' Coal, No. 6, lowest bench.
No. 4. Bennington Coal.
No. 5. Smith's Bank, No. 1, upper bench.
No. 6. Smith's Bank, No. 1, lower bench.
No. 7. Taylor's Coal, No. 7.
No. 8. Mast's Bank, No. 3, bottom coal.
No. 9. Strawbridge Coal, No. 2.
No. 10. Gloscoe's Cannel, No. 3.
No. 11. Daggers' Mine, No. 3, lower bench.

It will be noted that the average percentage of ash is here greater than in most of the other productive coal regions of the State, and that in a few instances the amount of sulphur is large. It is probable that no large amount of iron-making coal, to be used either raw or coked, can be obtained from this county, but it is capable of producing a very large amount of fuel, valuable for all ordinary uses.

LEAD.

Almost every county has its local traditions of lead mines formerly worked by the Indians; and the testimony is often as positive as second-hand testimony can be, pointing to a definite location from which the Indian hunters obtained their supply of this metal. Such a location is definitely pointed out in Mechanic township, and old markings upon the forest trees are claimed to be signs made by the Indians to indicate the precise location of the deposits. These traditional rumors obtained more credence here, from the fact that the valley indicated is filled with the buried Ferruginous Shale mentioned on a preceding page, which shows plainly the action of fire; and, as no other explanation was suggested, this cinder-like material was assumed to be the result of fires kindled for the purpose of smelting the lead-ores. The Indians were no architects, and erected nothing deserving the name of buildings, either for residences or store-houses; and it is probable that all these traditions have their origin in the fact that they were compelled to ensure safety of all their surplus supplies by burying them in the earth. Such deposits of lead, known only to a few, and visited by stealth, would readily give rise to the traditions of lead-mining. This cinder-like material is plainly the result of the burning-out, locally, of a coal seam; and the Coal Measure rocks which are here alone exposed, show no evidences of lead in any quantity whatever. A little lead and zinc are occasionally found in the Waverly, but the quantity is exceedingly small, and it may be regarded as quite certain that there are no valuable deposits of either of these minerals in the county.

DIP OF THE COAL MEASURES.

It has been previously claimed, that there is a substantially uniform dip in the Coal Measure rocks, in a north-eastern direction, and that this is so even and regular that, having determined its rate and direction, a topographical survey will enable one to locate any member of the series in any other part of the field. All the results of my explorations tend to show that this claim is unfounded—that while it may be, and often is, true of particular localities, and over limited areas, the fact is, that the rate and direction of this dip are constantly varying, and that in places the dip is in the opposite direction from what it would be if this claim were well founded.

Barometrical observations, repeated many times at the same stations, enable me to give the entire dip of the rocks in this county, and to the east, as accurately, probably, as it can be determined by this instrument. Coal No. 1 (Motes' bank), in the south-east corner of Knox, is, in this manner, found to be 207 feet above Millersburg; one and a half miles east, at Jas. Williams' bank, 211 feet, rising a few feet in that distance. In a ravine north of Judge Armour's, west line of Hardy township, and about four miles east of last, it is 146 feet, the dip east being about eighteen feet to the mile. At John Cary's bank, near Millersburg, and two miles further east, it is seventy-six feet—dip east, forty feet to the mile.

Commencing on the western slope of the hills west of Saltillo, the Blue Limestone is 220 feet above Millersburg. At its first outcrop, descending from Saltillo to the east, it is 229 feet, having risen nine feet. On the slope between Dowdy's Run and Farmersville, it is 218 feet, having sunk eleven feet. On the slope east of Farmersville, it is 184 feet, and further east, in the lowest valley, 137 feet, having sunk eighty-one feet. From this place to a point east of Shanesville, it gradually rises to 156 feet; amount of rise, fourteen feet. It then steadily dips to the east, and at its first disappearance west of the Tuscarawas, is seventeen feet above Millersburg, the dip from the point of observation, east of Shanesville, being seventy-nine feet. All the observations here, show a dip towards these deeper valleys, indicating an intimate connection between the present topography and the undulations of the Coal Measure rocks. Observations taken at remote points, will eliminate these undulations, and show a dip to the south-east, at a rate which will represent the excess of the dip in that direction over the reverse dip, and not the rate of dip at any particular place. From facts stated above, it will also be evident that the dip of the different strata will not be the same, nor always in the same direction. When a wedge-shaped formation occupies the interval between two coals or limestones, the dip of the two can not be the same. It follows that the identity of two coals, in distant parts of the field, can be established with certainty only by laboriously tracing the outcrops throughout the whole field. The system of numbering, and the determination of the members of the series which are substantially persistent, will afford great aid in this determination; but there are so many local, intrusive coals, and so great variation, both in the character and thickness of the material filling the intervals, that a section in one place will only approximately represent a section in another; so that a careful and painstaking study of all the members of the series, is required in every township, to enable the explorer to reach accurate results.

CHAPTER LXXXIII.

REPORT ON THE GEOLOGY OF COSHOCTON COUNTY.

BY J. T. HODGE.*

GENERAL FEATURES.

Coshocton county lies wholly in the great bituminous coal field, reaching close to its western margin. Its surface is, in appearance, very rough and hilly; yet, there are no ridges, and rarely any point of considerable elevation above the general summit-level. This level, which is that of the great plateau of Eastern Ohio, and the neighboring country farther east, varies little from 1,100 to 1,200 feet above the sea. By the excavation of the valleys below it, the surface has been carved into hills, the slopes of which descend to the general depth of 350 to 400 feet. That the surface of the great plateau once stood considerably higher, is rendered probable by the occasional occurrence of a mound of hard strata, standing like a monument above the general level. A very conspicuous one of this kind, rising about eighty feet higher than the summit of the highlands about it, and composed, apparently, of beds of Conglomerate (loose pieces of which cover its top and steep sides), is seen near Coshocton county, in Tuscarawas, opposite Port Washington. Another, of similar appearance, is seen in the north-east part of Coshocton county, just north of the road between Chili and Bakersville.

As the highlands of the county appear to have once been considerably higher than now, so the bottoms of the valleys were obviously once much deeper than at present; for (as already explained of other portions of the State, in the first Annual Report) below the surface of the valleys are frequently accumulations of sand, clays, and gravels, reaching to the

* The survey of Coshocton county, was made by Prof. Hodge, in 1872, and the MS. of his report was sent from Marquette, Michigan, where he had gone to escape hay-asthma, just previous to his starting to return on the steamer Coburn, which foundered in Lake Huron, with the loss of all on board. (See notice of Prof. H., in vol. I, part 1, p. 12, note.) The report has recently been revised, and brought up to date, by Mr. M. C. Read.

depth of more than one hundred, and sometimes to nearly two hundred feet. The gravel beds of the rivers, made up of pebbles of sienitic, porphyritic, basaltic, and other more ancient rocks than are found in Ohio, and the same class of bowlders in the sand-hills and terraces bordering the streams, point to the currents of the Drift period as the agents of this denudation; while the great width of the valleys, which is sometimes four to five miles, bear witness to the long time these currents must have been in action to have produced such astounding results. Sometimes, indeed, it appears that a broad valley, once formed, has been blocked up and deserted, while another, as extensive, has been excavated in a new direction, and is followed by the river of the present day.

In Coshocton county, such an ancient valley is seen to the south of West Lafayette, extending from the Tuscarawas Valley south south-east to the valley of Wills Creek. When far enough from the Tuscarawas Valley not to be confounded with this, it is seen, in places, to be full three miles wide, varying from this to one mile. It is a valley of Diluvium, somewhat sandy, with hills of sand from thirty to forty feet high, the beds of which are sometimes seen exposed to this extent in the cuttings of present streams. Hills of the stratified rocks of the Coal Measures project into it from its sides, as irregular-shaped peninsulas, or stand in its midst as islands. A remarkable single hill, of this character, is seen directly north from West Lafayette, on the edge of the Tuscarawas River, opposite the mouth of White Eyes Creek. This ancient valley is known as White Eyes Plains. It is nearly all under cultivation; and from the elevated points that overlook it, especially where it blends with the broad valley of the Tuscarawas, it affords views singularly beautiful and picturesque. Toward the south, the White Eyes Plains are lost in the valley of Wills Creek. By these two valleys, and that of the Tuscarawas, the larger part of the townships of Tuscarawas, Lafayette, Franklin, and Linton are encircled and isolated.

Opposite this valley, and north of the Tuscarawas, a similar valley, but of much smaller dimensions, extends north-westwardly through the south-west part of Keene township, and toward the Killbuck, in the center of Bethlehem township. Possibly it may be found, on further examination, that this was an ancient valley of the Killbuck.

GEOLCGICAL STRUCTURE.

Beside the Diluvium in the valleys of the streams, no other geological formation is found in Coshocton County, except the Carboniferous; and of this the range is limited to the lower half of the Coal Measure (comprising a thickness of some 350 feet), and the upper portion of the Waverly group—the lowest subdivision of the Carboniferous. The Lower Carboniferous limestone, which belongs above the Waverly, appears to be wanting; and the Conglomerate, which, in places, forms the floor of the Coal Measures in massive beds, often several hundred feet thick, was seen in place at only one locality, and there in a small layer not more than two or three feet thick. The almost total absence of any fragments of it, where one would look for them, near the base of the Coal Measures, indicates that this stratum is, also, generally wanting. The bottom of the Coal Measures is marked by its lowest great bed of sandstone, commonly about a hundred feet thick; and, in places directly under this, the lowest coal bed is seen, sometimes, of workable thickness, and sometimes pinched and insignificant, and separated from the well marked Waverly shales by only a few feet of clayey strata.

These beds are all so nearly horizontal, that the dip is imperceptible at any locality. It is detected only by tracing them for several miles in the direction of the dip, which is toward the south-east, or in the opposite direction as they rise. Owing to this general inclination of the strata, the Sub-carboniferous group is only seen in the northern and western townships of the county; and in these, only in the deep valleys, where the Waverly shales form the lowest portion of the marginal hills, and rise in them, sometimes, to the height of over 200 feet; as on the east side of the Mohican River, and on the upper part of the Walhonding. The top of the group comes down to the level of the canal, near the junction of the Killbuck and Walhonding, a little over twelve miles in a straight line from the Mohican River. The canal, in this distance, has descended, by nine locks, so that the total fall of the strata is over 270 feet, and may, perhaps, be 320 feet in the twelve miles; as on the south side of the Walhonding, toward the town of Newcastle, the top of the Waverly is about 250 feet above the level of the canal.*

The brown and olive-colored shales, and light-colored sandstones of the Waverly, are seen in most of the branches of the Walhonding River, and in all the runs in Tiverton township that discharge into the Mohican River. In the bottoms of these, the group is exposed within a mile, or a little more, to the town of Tiverton, toward the south. From Warsaw, it is traced up Beaver Run into Monroe township; but, the valley rising faster than the strata, it is lost to view above Princeton. On the other side of the Walhonding, the group passes under the valley of Simmons's Creek,

* Later observations show that Coshocton is near the bottom of a synclinal trough, the dip, south-east from Tiverton to Coshocton, being about 500 feet; while at Bridgeville, fifteen miles farther on the line south-east, the strata have risen 135 feet from the bottom of the basin.

within about a mile of its mouth; and the same is true of Mohawk creek, the next branch above. It stretches up the valley of the Killbuck into Holmes county; and near the mill in the great bend of this stream, in Clark township, it forms cliffs of shales and sandstones, forty to fifty feet high, in which the peculiar fossils of the group are found in great profusion. It forms here, altogether, probably 100 feet of the lower portion of the hills. Doughty's Fork, a branch of the Killbuck, also runs in the Waverly shales, as they were found with their fossils in the bottom, two miles south-west from Bloomfield. Over the line, in Holmes county, near the north-east corner of Tiverton township, the Waverly is exposed in the valley of Wolf Run.

This group of the Carboniferous formation contains little of economical importance. It affords no coal nor iron-ore. Some of its beds of sandstone may prove of value, especially for flagging-stones. The Coal Measures are very deficient in these; and the want of such stones is already felt at Coshocton and the other principal towns situated in this formation. The brown and olive-colored shales produce, by their decomposition, soils of great fertility, as is seen everywhere through the bottoms where they occur. Probably no more productive corn-fields, for their extent, are to be found in the State, than those in the Waverly soils of the Western townships of Coshocton county.

Small quantities of galena are not unfrequently met with in the Waverly, and they have led to the conviction that this metal might be found in abundance in this and the adjoining counties. There are, however, no facts yet known that justify this belief. The lead of the Waverly forms no connected veins or beds, but is found replacing fossil shells, or, in isolated crystals, scattered in small number through the rock. Hence, while the reports of the existence of lead in Coshocton county, are "founded on fact," there is not the slightest probability that it will be ever discovered in sufficient quantity to pay for working.

That portion of the Coal Measures found in Coshocton county, comprises, altogether, the seven or eight coal beds in the lower half of the series; but only a small number of these occur of workable dimensions in the same vicinity, and it is not often that more than one bed has been opened and mined in the same hill or neighborhood. The relative position of these coal beds, and of the accompanying strata, may be best understood by reference to the section, which exhibits the general manner of their arrangement in this county. Every farm in the county, that lies above the Waverly strata, contains one or more of these coal beds beneath its surface; and those localities that contain the uppermost beds, also contain all the lower ones. But while each coal bed can almost always be found and recognized in its proper place in the column, it does not follow that it should always maintain the same character, even approximately. On the contrary, it is not unusual for it to change in the course of a few miles—sometimes even in the same hill—from a workable bed of several feet, to a worthless seam of a few inches in thickness. Hence, there is no safety in figuring up an aggregate of so many feet of workable beds, in any locality, until these beds have there been actually opened and proved. The indications afforded by borings, are generally of very uncertain character, as respects the thickness of the coal beds and the quality of the coal. It is, without doubt, often the case that the beds of black shale passed through are called coal, and when one occurs as the roof of a coal bed, it serves to add so much to the thickness of the latter. By remarking, in the description of the townships, how rare it is for two workable beds to be found in the same locality, and how seldom any bed at all is worked below the sixth bed of the series, it can hardly be safe to estimate the total average distribution of the workable coal in the county, at much more than the thickness of this one bed; and this, taking into consideration the probability that some of the lower beds will yet be worked below the level of the valleys, where their range is unbroken. It is to be hoped that the lowest bed of all, about which very little is now known, may be found as productive and valuable as it is in the counties to the north, in which event the estimate given above would prove too low. The sixth bed is a very remarkable one, for the regularity it maintains, not only through this county, but over several others—even to the Pennsylvania line, and into that State. It here varies but little from four feet in thickness, and is everywhere depended upon as the most valuable bed of the lower Coal Measures. Throughout its great extent, even into Holmes county, and to the Ohio River, at Steubenville, it may be recognized by the peculiar purplish-ash. The heaps of it seen by the farm houses, show to the passer-by, almost always without fail, whether it is this coal, or some other bed that supplies the neighborhood.

Of all the strata, the limestones are the most persistent, and serve as the best guides for identifying the coal beds that accompany them.

There are two bands of these, in particular, that are most useful in this respect. Both are fossiliferous, often abounding in crinoids and shells. The upper one, called the Gray limestone, is found varying in thickness from one foot, or less, up to six feet ten inches. It lies immediately on the coal bed known as No. 4. The lower one, called the Blue limestone, has about the same range of thickness as the gray, and is sometimes only twenty feet below this.

In some localities in the county, two other beds of limestone make their appearance: one, dark-gray, or black, above the "Gray limestone" and Coal No. 6; the other, a local bed, between the "Blue" or "Zoar," and the "Gray" or "Putnam Hill limestone." In one place—Alexander Hanlon's farm, Mill Creek township—these lower limestone beds seem to run together, forming a nearly continuous mass, twenty feet in thickness. Usually, the persistent limestone strata—the "Blue and the "Gray"—are fifty to eighty feet apart. A coal seam (No. 3) generally lies immediately under this limestone, also, but is rarely of any value; and the same may be said of the bed above it (No. 3*a*), and also of the next below it (No. 2), both of which seem to be wanting in this county. The limestones in the western and central parts of the county are frequently accompanied by large quantities of the hard, flinty rock, known as chert. There is often a great display of it, in loose pieces, in the roads above and below the outcrops of these calcareous strata; but natural exposures of it in place, are very rare. In several instances, the limestone beds are seen intermixed with chert, and it is also noticed that chert sometimes takes the place entirely of the limestone.

A few other limestone beds have occasionally been noticed at a higher position than the gray limestone, and one also between that and the blue, but they are of rare occurrence, and have only a local interest, except in their relation to limestone beds in similar part of the series in other counties.

The sandstone beds are sometimes developed to the thickness of 70 to 100 feet of massive layers. They are very apt, however, to pass into their bedded sheets, and again into shales. Rarely do they become even slightly calcareous, and no instance was observed of their passing into limestone. The most persistent of the sandstone beds, so far as it could be traced before it disappears under the overlying strata, is the great bed at the base of the Coal Measures. The bed over Coal No. 6 is also very uniform.

No iron ore, in any encouraging quantity, has been met with in the county. It is seen scattered in kidney-shaped pieces among the shales, but never concentrated sufficiently to justify drifting for it. There may be one exception to this on the farms of James Boyd and W. Hanlon, in Keene township, near Lewisville, where a slight exploration, made at our suggestion, has developed, just below Coal bed No. 6 (or it may be the one above it) ferruginous layers resembling the blackband ore, mixed with kidney ore, said to be six feet thick. Kidney ore of good quality is also found between Linton and Jacobsport, in the south-east part of Linton township.

The gravel beds of the rivers may be mentioned as among the useful mineral products. At Coshocton they furnish an excellent material for covering the streets of the town, or the clean pebbles might serve well for concrete work.

Indian Mounds.—Two Indian mounds were met with in the county, which are worthy of notice, and which have never been explored. One is on the east bank of the Tuscarawas River, about three miles below Coshocton. It is of conical form, about twenty-five feet high, and of about eighty feet diameter at base. Its sides are covered with trees. The common road down the river passes close by it. The other one is in the river bottom, just above the village of Walhonding, a conspicuous conical elevation in the meadow near the road. Evidences of the ancient mining of chert for the manufacture of arrow-points, etc., are also abundant.

LOCAL GEOLOGY.

In describing the localities visited, it will be convenient to take them up in the order of the townships, beginning at the north-west, and attention will be directed chiefly to the coal beds as of principal importance.

Tiverton.—The highest range of the Coal Measures in this township is but little above the gray limestone. Its outcrop is seen on the high plateau in the neighborhood of the town of Tiverton, and that of the blue limestone about forty feet lower down. The "blossom" of a coal bed is occasionally seen in the road to the north of the town, in one instance, about a mile north from Tiverton, five feet below a bed of "black marble," a black, compact limestone, which has been found in the same relative position at a few other localities in the county. This rock appears as if it would take a good polish, and be serviceable for ornamental purposes. It is known that there are coal beds in the northern part of the township, but none of them have been opened except at Phillips's, in the north-west corner, which place was not visited. The bed is reported to be small, and it is undoubtedly of little importance or the coal would be in some demand. At Tiverton Centre, coal is supplied for the use of the blacksmith from Coshocton, twenty-one miles distant, and is hauled in wagons, costing at the bank $1.80 per ton, and $5 for hauling. Longsinger's reported bank, about four miles east from Tiverton Centre, is a narrow seam of cannel coal of no importance. It is probable none of the beds above No. 1 are worth working, or there would have been some development made. No. 1 might be looked for to advantage at the base of the great sandstone bed, and between that and the Waverly shales, for about 200 feet above the Mohican River. This coal bed is opened, and appears well so far as it could be examined at McFarland's, on the south edge of Monroe township, south-east from Princeton. It is very variable in thickness, often being cut out by the sandstone that always overlies it. In Mahoning county it is known as the Brier Hill coal, and is regarded as the most valuable bed in the State for blast furnaces. It should be looked for in the deep runs below Tiverton Centre, and on the slope of the steep hill down to the Mohican.

Monroe.—The coal seams of this township have been developed but little more than those of Tiverton. There is here the same range of the Coal Measures, with the addition of one higher coal bed, the outcrop of which may be recognized close to the town of Spring Mountain, which is on as high land as any in this township. The gray limestone is seen about sixty feet lower down, half a mile to the south. The only coal mines opened in the township of which we have any knowledge, are Cooper's two mines, north-west from Spring Mountain, and McFarland's, on the south line of the township. Our examinations of these, as of most of the other coal beds in the county, were made under very unfavorable circumstances. As they are worked only in the winter season, the localities are commonly found with difficulty, and when found the drifts are flooded with water, so that they cannot be entered, and no one is about to give any information. The coal extracted is usually all carried away, not enough being left behind to give one any knowledge of its quality. For this reason it has been impossible to furnish specimens of the coals for analysis or the cabinet.

Cooper's bed was found in this condition. The coal seam appears to be four feet thick. It is overlaid by a confused mixture of fire-clay, shale, and limestone, the last close to the roof, and supposed to be the gray limestone. Over these strata, which are sometimes more than ten feet thick, are massive sandstone rocks, much tumbled, the bed of which is not less than twenty feet thick. The coal has been mined to some extent for use of the farmers around.

McFarland's coal mine, as already mentioned, is in the lowest bed of the series, No. 1. It appears to be three feet thick, and is overlaid by slaty sandstone, of which eight feet are visible. The coal seems to be partly cannel. In the run, about fifteen feet below the opening, are the Waverly shales, recognizable by their fossils.

Clark.—The principal coal mines of this township are in the south-east part, near the line of Bethlehem, on the farms of Thomas Elliott, John Moore, and J. Shannon, all in Coal No. 6. Jas. C. Endsley's coal bank, in Bethlehem, belongs to the same group, and is the most important one, having been worked eighteen years, and supplying a large part of the two townships with coal. It is forty feet above the gray limestone, under which is said to be a coal bed two feet thick; and it is about ninety feet below another coal seam eighteen feet thick, struck near Mr. Endsley's house, over which the hill still rises some seventy or eighty feet. The bed worked is three feet nine inches thick, less a seam it contains of six inches of pyritous fire-clay. The roof is black shale, of which five feet are exposed. The coal is in good repute for domestic uses, but does not answer for blacksmiths. It is said to be the only coal bank opened in Bethlehem township. The following analysis of Endsley's coal has been made by Dr. Wormley:

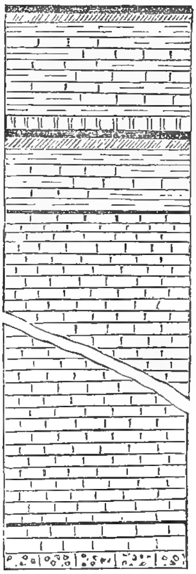
Specific gravity	1.268
Moisture	3.20
Ash	2.60
Volatile matter	37.50
Fixed carbon	56.70
	100.
Sulphur	2.33
" left in coke	0.69
" forming of coke	1.17
Fixed gas in feet per pound	3.40
Ash	gray.
Coke	compact.

Thomas Elliott's coal-bed, just over the line in Clark township, is probably a continuation of Endsley's. It is two feet ten inches thick under a black shale roof, the shales abounding in fossil shells, but too fragile for preservation. The coal appears to be too pyritous to be of much value. The other beds we did not succeed in finding. On the high lands, north-east from the mill at the great bend of the Killbuck, we heard, after having left this part of the township, of a coal-bed being worked, which, from its elevation, we suppose to be No. 6. These northern townships seem to be the most hilly and uncultivated in the county. They lie along the heads of many of the branches of the Tuscarawas, and the general course of the streams is not far from the dip of the strata. The greater elevation of the plateau in this region accounts for the occurrence of the higher coal-beds in the summits. Though unusually hilly and rough, the surface exhibits few outcrops of the coals and limestones for long distances. From the bend of the Killbuck, north-east, toward Bloomfield, the road ascends three hundred and fifty feet in the first mile. The first coal outcrop observed is about two miles south-west from Bloomfield, just after crossing the small branch of the Killbuck, running on the Waverly shales. This must be the outcrop of Coal No. 1. Descending toward Bloomfield, on the other side of the summit, the gray limestone is met with at one hundred and seventy feet higher elevation by barometer, with large coal outcrop immediately under it. Forty feet below this is another outcrop of coal, and about seventy-five feet below this, a third, and a sandstone bed beneath this, with no appearance of the Waverly to the bottom of the valley in which Bloomfield is situated. This group must, however, be very near the surface at this place. None of the outcrops, noticed above, appear to have been followed up to ascertain the character and thickness of the coals. This neighborhood is supplied with coal from beds in the adjacent township of Mill Creek.

Recent explorations disclose the fact that in Bethlehem and Clark township, near the line separating them, Coal No. 7 is in places four feet thick, and of good quality. At Mr. Durr's bank, it has this thick vein, is an open, burning, white ash coal, containing little visible sulphur, and gives better promise of being a good iron-making coal than any other examined in the county. A coal was disclosed in a well near Mr. Glover's residence, without cover, showing eighteen inches of the bottom bench, which may be No. 7, or perhaps No. *7a*. On the east half of the south-east quarter of section 23, Clark township, an outcrop of Coal No. 6 is thirty-seven inches in thickness, with a heavy body of shale above it. Other outcrops in the neighborhood are reported to show three feet nine inches of coal. At the opening examined, the coal increased in thickness as the drift was carried into the hill. The coal is hard and black, with a brilliant, resinous luster, containing a large percentage of fixed carbon, and is evidently of excellent quality. At the Imley Bank, on section 25, Bethlehem township, the coal at an outcrop measures forty-three inches, and is reported to reach a thickness of four and one half feet in some of the rooms worked. It is, by the barometer, twenty-five feet below the coal on section 23, Clark township, and about one-half a mile distant. This coal in Bethlehem township, I am inclined to regard as below No. 6, and as that which is disclosed a little farther north, capped with the black limestone. The coal is of superior quality, and there is quite a large territory underlain by it. Coke made from it, in a smothered fire, in the open air, has been analyzed by Mr. E. R. Taylor, who reports the following composition:

Ash	5.02
Carbon by ignition	94.16
Sulphur	.82

At the place of these openings, all the rocks of the Coal Measures are in their positions, and the horizons of seven coals and two limestones can be determined. About one mile north, on Mr. Glover's land, in Clark township, the following section was obtained:



FT.	IN.	
		Coal No. 6, 100 feet from top of hill.
30	0	Shaly sandstone.
3	0	Black limestone.
2	6	Coal.
20	0	Sandy shale. Coal streak at base.
280	0	Unevenly bedded, massive, coarse sandstone, with streak of coal near base.
		Conglomerate.

This section shows that after the deposit of the lower coals there was an upheaval of 280 feet, and a channel plowed by the water to the base of the Coal Measures. The thin conglomerate in this neighborhood is cherty, and from one of these fragments of cherts I have obtained a fair sized crystal of galena, the best specimen of lead ore I have ever seen obtained from Ohio rocks.

Mill Creek.—Low's coal bank, in the north-west corner of this township, one mile east from Bloomfield, lies directly under the gray limestone, a seam of fire-clay, seven inches thick separating the limestone from the upper layer of coal. This upper layer is bright coal five inches thick, under it cannel coal seven inches, and under this two feet five inches of good, bright coal. In the next hill west is Evans' coal bank, at thirty feet higher elevation. This has been opened, but not worked much, and was in no condition to enter. The bed is said to be three feet thick, the coal to be of good quality. It has a good cover of sandstone, making the summit of the hill.

Through the western part of Mill Creek, by the "grade road," exposures of strata that can be recognized are very rare; and no openings of coal are met with. Near the south line of the township the blue limestone is seen at several places along the road, sometimes with the "blossom" of coal beneath it. Chert in considerable quantity is often associated with it. At one place the blue limestone appears to be seven or eight feet thick. Immediately over it is a large bed of chert, and about forty feet higher up the blossom of coal, but no appearance of the gray limestone.

In the south-east corner of Mill Creek, and in the adjoining lands in the three townships of Keene, White Eyes, and Crawford, are several coal banks, all in Coal No. 6, which is recognized, both by its position (about one hundred feet above the grey limestone) and by its peculiar purplish ash. The outcrop of other coal beds is seen at several places on these lands, but the only bed worked is No. 6. The coal is mined only in the winter season, and chiefly on the farms of A. Overholts, in Mill Creek; of Thos. Davis, adjoining this, in Keene; of Scott, Funk, Boyd, and Miller, in White Eyes; and of Boyd, Graham, and Swigert, in Crawford. The bed where it was accessible was found varying from two feet ten inches, at Davis's and at Overholts's, to four feet three inches thick at Scott's; but the openings being all deserted, nothing could be determined as to the quality of the coal. Some pyrites is seen, one seam of it an inch thick near the floor, but the quantity is small. As this group of mines supplies the demand of a large portion of the four townships, the coal is, without doubt, the best the country affords. It is, moreover, obtained exclusively from the bed well known to be the most important one in the county. The summit level in this vicinity is about one hundred feet above the plane of the coal bed; and immediately over the coal is a heavy bed of slaty sandstone, apparently not under thirty-five feet thick. On Alexander Hanlon's farm, half a mile north-west from Overholts's, and also on Oliver Crawford's, nearly a mile farther north, are seen a number of exposures of coal and limestone beds, which, taken together, give sections not readily explained in connection with the barometrical elevations obtained, and which were verified in part by repeating in going and returning. Coal No. 6 is opened on the south side of the hill, on Mr. Hanlon's farm, about one hundred and twenty feet below its summit. A bed of limestone, about one foot six inches thick, shows itself sixty-five feet above the coal bed. To the south about one-quarter of a mile, and two hundred feet below the coal bed, is the top of a great bed of gray limestone, which, followed by successive steps down the bed of a run, presents a thickness of about twenty-five feet, as leveled with the hand-level. This may be somewhat exaggerated, as there is a strong dip to the south, and the exposure is down the run in this direction for nearly two hundred and fifty feet. Under the upper layers is seen some coal smut, and under the whole is a bed of coal, said to be two feet thick.

The strata for twenty feet below are hidden, and then succeeds a bed of massive sandstone, from thirty to forty feet thick. On Crawford's land, nearly a mile to the north, two coal outcrops are seen in two neighboring runs. One is of a coal bed about thirteen inches thick, directly under gray limestone, apparently only two inches thick, and one hundred and ten feet below the level of coal No. 6. In the other run, at twenty feet lower level, is a bed of coal three feet thick, of which the upper portion is cannel, and the lower partly cannel, and partly bright coal. No limestone is exposed near the coal. It would appear that these two coal outcrops are continuations of the beds on the south side of the hill, though they are ninety feet higher, and nothing is seen of the great mass of limestone that there lies between them. The coals are probably the representatives of Nos. 3 and 4, and the limestones that overlie these have here run together. The unusual high elevation of Coal No. 6, on the south side of the hill, may be a barometrical error. The dip, which is certainly very great here, would account for a part, at least, of the discrepancy in the height of the coal above the two outcrops of limestone on the opposite sides of the hill.

ANALYSIS OF CRAWFORD'S COAL.

Moisture	2.80
Ash	19.50
Volatile matter	28.20
Fixed carbon	49.50
	100.00
Sulphur	5.57
Fixed gas, per cubic feet per pound	2.19

Crawford.—Beside the coal banks on the edge of Mill Creek township, there appear to be none worked in Crawford. The outcrop of coal was observed on the north line of the township, near New Bedford, but over all the rough country from thence to Chili, through the centre of the township, no one appears to have given any attention to obtaining coal elsewhere than from the locality in the south-west corner, already described. It is probable that No. 6 disappears to the north, rising faster than the surface of the country in this direction, and the lower beds have not been found worth working. Wood has not yet become expensive as fuel, and the demand for coal is not sufficient to render it an object to search for it.

Newcastle.—The northern half of this township is in the Waverly, excepting only the upper part of the hills in the north-east quarter. The highest lands near the town of Newcastle, on the south side of the Walhonding, are about four hundred and twenty feet above the bottoms of this river, *i. e.* seven hundred and eighty above Lake Erie. The highest and only coal bed worked in the township is No. 4, under the gray limestone, and from seventy to eighty feet below the highest elevations. Coal No. 1 is seen on descending the steep hill from Newcastle to the Walhonding, in a bed only eighteen inches thick, beneath the great sandstone bed at the base of the Coal Measures, which is here about thirty feet thick. Kidney ore, with a little shale from six inches to a foot thick, separate the coal from the sandstone. For fifty feet over the sandstone the strata are concealed, excepting that the smut of a very small coal seam is observed below the diggings for fire-clay, at the top of this interval. Over the fire-clay, which is three feet to four feet thick, is coal (seen here only in the outcrop), and over the coal a fossiliferous gray limestone, two feet thick, overlaid with blue chert. The fire-clay is dug for the supply of Butler's pottery, at Newcastle. There is also another small pottery there owned by Mr. Lewis.

Though the gray limestone is met with almost every where near the summit of the township, the openings of the coal-bed it covers are not very numerous. One of these is James Smith's, half a mile north-east from Newcastle. The limestone is here several feet thick, and forms the roof of the coal. This is two and a half feet thick, and much mixed with small seams of shale and pyrites. Though the coal is of inferior quality, it finds a sale for local uses, at ten cents a bushel.

At Calvin Stott's, one and one-half miles south-east from Newcastle, the coal is found two and one-half feet thick, under six feet of the gray limestone. It is here of better quality, compact and bright, with not so much sulphur.

This bed may be opened in numerous places, and is the best the township affords; yet the next higher bed may perhaps be found near the line of Jefferson, on the road to Jericho.

The following section, from summit of hills at Newcastle to the mouth of Owl Creek, will show the general geological structure of this portion of the county:

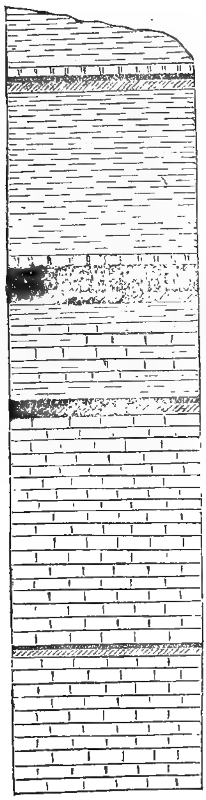
1.	Interval covered	45 feet.
2.	Blue chert	1 "
3.	Gray, rotten limestone	2 "
4.	Blue chert	$1\frac{1}{8}$ "
5.	Coal No. 3	$2\frac{1}{2}$ "
6.	Fire-clay worked for pottery	4 "
7.	Slope covered	85 "
8.	Sandstone	30 "
9.	Iron ore	6 to 18 in.
10.	Coal No. 1	$1\frac{1}{2}$ feet.
11.	Waverly shales	225 "

The cherty limestone over the upper coal is traceable several miles along the banks of Owl Creek into Knox county. It abounds in fossils, which include nearly all the species found in the famous locality on Flint Ridge, near Newark. The lithological character of the rock is the same, a blue, earthy, sometimes cherty limestone, weathering light brown. The horizon of the two localities is doubtless the same. The base of the section is three hundred feet above Lake Erie.

Jefferson.—The north half of this township is in strata probably too low for any of the workable coal-beds except No. 1, which may be looked for with good prospect of success, as it is worked just over the line in Monroe, as already described. On the south side of the township, Coal No. 3 *a* has been opened upon several farms, and being found of large size and of cannel character, rich in oil, large preparations were made to work it for the supply of oil distilleries, when the great developments of the petroleum wells put a stop to the business. On the farm of John Taylor (west side of Simmons' Creek) the bed is opened about fifty feet below the top of the hill. It is about five feet thick, sound cannel coal, with a little pyrites scattered through it. The coal abounds with impressions of coal-plants, and in the shaly blocks from the roof are remarkably fine specimens of *Stigmariæ* with lateral rootlets. On the other side of the same hill (to the west) is Lyman's opening in the same bed. The roof is here exposed, and consists, next the coal, of blue limestone six inches, over this, chert eighteen inches, and limestone at top, making in all over three feet. The coal-bed is full six feet thick. Sharpless' mine, across the valley, in Bedford township, belongs to this group. The gray limestone is found scattered near the top of the hill above Lyman's opening, but the coal-bed under it is not opened. Its outcrop is observed in the road toward Newcastle, overlaid by a thick bed of shale. Chert is very abundant, associated with both the limestone beds, and also at higher levels than the gray limestone. Descending the hill toward the Little Mohawk, the gray limestone is seen not far below the summit, about four feet thick, with coal-smut below, and shale-beds containing kidney ore above it. The coal-bed is opened on the farm of James Moore, Sen., close by this outcrop, and was worked for oil, the coal yielding forty gallons to the ton. The bed is seven feet thick, the lower five feet cannel and the upper two feet bright coal, overlaid by gray limestone and chert. On the opposite side of the road the same bed was worked by Wm. Gibbons. The descent from this point to the bridge over the Little Mohawk at Jericho, about a quarter of a mile to the west, is one hundred and eighty feet by barometer. This should reach into the Waverly shales. There are no exposures of any strata to be seen. The hill to the west rises nearly or quite three hundred feet above the Little Mohawk, beyond the township line, in Newcastle, and the next coal bed above the gray limestone probably carried in, an outcrop being seen, supposed to belong to this bed.

SECTION BETWEEN SIMMONS'S RUN AND JERICHO, JEFFERSON TOWNSHIP, COSHOCTON COUNTY.

FT. Vertical scale, 1 inch to 52 ft.



ANALYSIS OF MR. TAYLOR'S COAL.

Specific gravity	1.418
Moisture	1.35
Ash	19.70
Volatile combustible matter	36.35
Fixed carbon	42.60
	100.00
Sulphur	1.89

Fixed gas per cu. ft. per lb. 3.42.

Bethlehem.—This township is very largely in the Waverly and the lower, undeveloped Coal Measures. The only coal bed known to be opened in the township, is that of James C. Endsley, close to the line of Clark, and already noticed in the account of that township. It is probable that Coal Bed No. 14, may be found of good size and character in the extreme south-west corner, as it is worked in the north-west corner of Jackson.

Keene.—The eastern half of Keene township has several openings of Coal No. 6, which appears to be the only bed now worked. That of Thos. Davis, in the north-east corner, has been referred to in the account of the coal beds of Mill Creek. In the southern part of the township, James Boyd has worked the same bed to considerable extent, by three openings on his farm, about one and a half miles north from Lewisville. The bed lies about 150 feet above the level of the canal at Lewisville, and 100 feet below the summit of the hill. The canal is about on the same level as the railroad at Coshocton. Fifty feet above this, is an outcrop of the gray limestone, near Lewisville. In one of the openings, the coal is found three feet nine inches thick, with a parting seam of either fire-clay or pyrites, three inches thick, nine inches above the floor. In another, on the west side of the same hill, the bed is four feet thick, including four inches of fire-clay, eight inches above the bottom. The overlying strata are slaty sandstones, thirty feet thick. The coal appears to be of excellent quality, is of brilliant, jet-black color, and is mostly free from sulphur. It is not in demand by the blacksmiths, probably from not melting well to make a hollow fire; but is sold wholly for domestic uses.

On the adjoining farm of W. Hanlon, another coal bed was opened some time ago, sixty feet higher up, and is said to be over three feet thick. It is not worked. Since our examinations here, the discovery before referred to, has been made of the ferruginous layers resembling the black-band ore, accompanied with kidney ore, a few feet under this bed, or the one below.* Other coal openings in this township, are

* The iron ore referred to on Mr. Hanlon's farm, is reported by Mr. James Boyd to be from three to six feet in thickness, regularly stratified. An analysis, by Dr. Wormley, reveals the following composition:

Specific gravity	3.100
Water and organic matter	4.90
Silicious matter	15.08
Iron sesquioxide	13.86
Iron carbonate	51.88
Manganese	2.80
Alumina	0.50
Lime phosphate	1.11
Lime carbonate	4.53
Magnesia carbonate	4.46
Sulphur	0.35
	99.47
Metallic iron	34.74
Phosphoric acid	0.51

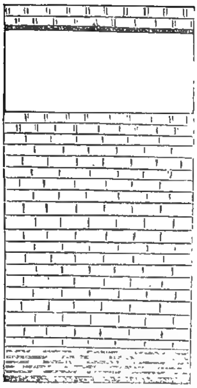
reported in the south-east corner, and, also, about two miles east from Keene Center, on the land of A. Boyd. These two are supposed to be in Coal Bed No. 6. Keene Center, though on very high ground, does not, apparently, quite reach up to the plane of Coal No. 6; and no openings are made in the lower beds. To the north of the town, the strata are well exposed by the side of the road, from the top of the hill down into the valley of Mill Creek, presenting the following section: Near the top, at the town, slaty sandstone; shales, mostly olive-colored, forty feet; limestone (gray?), coal-smut, and fire-clay, underlaid by olive shales, sixty feet; several layers of kidney iron-ore, ten feet above the bottom of the shales; coal outcrop under the shales; five feet under this to top of great bed of chert, associated with blue limestone and coal outcrop beneath. A large bed of massive sandstone, supposed to be that at the base of the Coal Measures, lies not far below the blue limestone, its upper layers about twenty feet below the top of the chert and blue limestone This group of about 150 feet, affords little promise of any workable bed of coal; and some portions of it occupy the greater part of the township

White Eyes.—The only coal openings visited in this township, are those in the north-west corner, noticed with the coal beds of Mill Creek. The developments there have had the effect of discouraging other enterprises of the kind, especially as the demand for coal is so limited In the north-east part of the township, along the road from Chili toward Bakersville, the lands lie near the plane of the two limestone beds, with no promise of workable coal; and none is reported by the farmers, in answer to our inquiries.

Adams.—Throughout the north part of Adams, the coal bed most worked is No. 4, under the gray limestone. It is a bed of inferior character, both as regards the amount and quality of the coal it affords. It is commonly known as the "double bed" from a seam of fire-clay, about a foot thick, in the middle of the bed It has been worked half a mile west from Bakersville, where the whole bed was four feet thick, the upper part mixed with cannel coal. About twenty feet above the gray limestone, which covers the coal bed, is a bed of black limestone, of slaty structure, perhaps two feet thick. It contains fossil shells, but in poor condition. This bed corresponds, in position with the "black marble" found in the western part of the county. Near the western side of the township, the double coal bed is worked on the farms of Powell, of Fillibaum, and of others in the neighborhood, and further east on Zinkon's. At this place, the next upper bed (No. 6) is also opened ninety to one hundred feet higher up, and too close to the top of the hill to be worked to advantage. It is a little over three feet thick, contains no slate seams and but little sulphur. On Vance's farm, lying next south from Zinkon's, the same bed is again opened near the top of the hill, and has, so far, been worked by stripping. It appears to be about three feet thick, of sound cubical coal, very black, the upper portion sulphurous. It is overlaid by black shale, two feet nine inches; sandstone, one foot three inches; and over this, shaly sandstone, a thick bed, to the top of the hill. The lower part of the bed, and the strata below, are hidden. In a run near by, at about fifty feet lower elevation, is a bed of chert and "black marble," some of the latter of compact structure, and some of it shelly; and thirty-five to forty feet below this, is the outcrop of the gray limestone, and Coal No. 4 (not opened), the strata between being mostly slaty sandstones. There are numerous other coal openings to the south-east of Vance's, as Pinkerton's, March's, and Miller's, on the west side of Evans Creek, all in No. 6 coal bed; and Addie's, on the east side, supposed to be in the same; and that of W. Davis, also on the high lands to the north-west of Orange, and near the township line of Oxford.

Perry.—The strata here, as in Newcastle, are of the lower part of the Coal Measures; and, frequently, over the surface of the hills, the gray and blue limestones are recognized, accompanied with chert. They are seen in the neighborhood of East Union; but no openings of the coal beds usually associated with these, are met with; and it is probable these beds are of little or no value in this township. A little to the south-east of the center of the township, near the foot of a long hill, and below a great bed of massive sandstone, is Crawford's coal-bank, in bed No. 1. The bed is from two and a half to three feet thick, with a black shale roof. The coal is of excellent quality, mostly in sound blocks, very free from sulphur, and of "open burning" character. Some of it is of slaty cannel structure, with mineral charcoal intermixed. This is the only really good display of this lowest coal bed met with in the county; and it is an encouragement for hoping that a seam that has proved so valuable as this has in other counties, may be found at many other localities in this, of good character. Its low position gives it an extensive range; but there is always uncertainty about its continuing far without being encroached upon and disturbed by the sandstone bed above it. Its occurrence here indicates that of the Waverly group in the bottoms of the runs in this township.

SECTION AT EAST UNION, PERRY TOWNSHIP.



The following is the composition of Crawford's coal, as determined by Dr. Wormley.

Specific gravity	1.277
Moisture	4.40
Ash	5.65
Volatile matter	33.40
Fixed carbon	56.35
	100.00
Sulphur	1.83
Sulphur left in coke	0.41
Sulphur forming of coke	0.66
Fixed gas per pound c. f.	2.36
Ash	fawn-color.
Coke	compact.

Bedford.—The occurrence of cannel coal in a large bed under the blue limestone on Sharpler's farm, on the north line of the township, has been noticed in describing the coal openings in Jefferson. In the north-west part of Bedford, at the coal openings of John Little and Jos. Freese, a greater number of coal beds are seen in one section than at any other locality in the county. At the base of the hill, in the road, and under a bed of massive sandstone not less than thirty feet thick, is the blossom of coal supposed to be No. 1. Fifty feet above this is John Little's coal bank under a bed of blue shale, the lower layers of which are calcareous, and no doubt represent the blue limestone. The coal bed (No. 3) is of workable size, but nothing more could be ascertained of its character, the opening being flooded with water. In the run close by, and seventy feet above the base, is Jos. Freese's coal opening under massive sandstone, of which twelve feet are exposed.

The following is a section near Joseph Freese's mine, north of West Bedford, Bedford township:

	FT.	IN.
Soil and drift.		
Buff limestone.		
Sandstone and shale partly covered	100	0
Coal outcrop		
Shale	30	0
Gray limestone	5	0
Coal No. 4	2	4
Shaly sandstone	30	0
Coal, J. Freese's (No 3*a*?)	3	11
Blue calcareous shale	20	0
Coal outcrop (No. 3)		
Space partly covered, mostly sandstone	80	0
Coal No. 1 (?)		

Freese's coal is a compound seam, consisting of,

Bituminous coal	18 inches.
Cannel coal	10 "
Fire clay	3 to 4 inches.
Bituminous coal	15 inches.
Black shale	

At one hundred feet elevation the gray limestone appears in the run overlying a coal seam twenty-eight inches thick, not opened, and at one hundred and thirty feet is the outcrop of another coal bed of cannel character, the thickness not known. Over this coal is a heavy bed of massive sandstone, and above this to the top of the hill, about one hundred feet more, no more exposures are seen. But in the forks of the road near by, and some twenty to thirty feet higher elevation than the uppermost coal bed in the section, is an outcrop of hard, compact limestone, abounding in fossil shells, the stratum probably not over two feet thick. It is remarkable, at this place, what a change the coals Nos. 3 and 4 have undergone from their much larger dimensions in Jefferson, only about three miles distant. No. 3*a* also assumes here a workable character, not observed any where else in the county.

No other coal openings are seen between this place and the village of West Bedford. The village stands some fifty feet above the gray limestone, which is seen a little to the north; and the range of the strata is from the summit down into the bottoms about two hundred and forty feet. About forty feet lower than the gray limestone is a large outcrop of coal in the road, which is probably No. 3*a*, the blue limestone being met thirty feet lower in a large exposure of massive blocks. At the lowest point in the road, about one-half mile east from West Bedford, where the road forks, one branch going to Warsaw and the other to Roscoe, is the lower great sandstone bed of the coal measures, about one hundred and ninety feet below the gray limestone. Two miles east from West Bedford is Sproule's coal bank, three feet thick, the coal very sulphury, no cannel in it. Johnson's mine, half a mile further east, and Marshall's still farther in this direction, exhibit the same characters. The bed is evidently the same at the three places, and is supposed to be No. 4, though the gray limestone is not seen near it. No good coal is found in the central and southern part of the township, and the blacksmiths depend upon coal brought from Parks opening in No. 6, in the northeast corner of Washington township. The same bed could no doubt be found in the south part of Bedford, as near the school house, not a mile south from Sproule's mine, the following outcrops are observed from the blue limestone up. The gray limestone fifty feet higher, four feet thick; coal outcrop (No. 6), eighty feet up. Above the school house: coal outcrop, one hundred and twenty-five feet up; top of the hill, one hundred and eighty feet above the blue limestone, reddish brown sandstone.

Section on Sproule's farm, east of West Bedford, Bedford township.

	FT.
Soil and drift.	
Gray limestone.	
Coal, Sproule's land	3
Fire-clay.	
Shales and sandstones, mostly covered	80
Blue limestone	8
Cannel coal	2
Fire-clay.	
Space mostly covered, sandstone below	100
Coal No. 1.	

Jackson.—In the northwest corner of this township, coal No. 4 is worked on the farm of Abm. Haines, near the summit of the hills. The bed is four feet thick, and the coal appears to be of good quality; has no cannel seams. Its roof is shale, three inches thick, and over this is the gray limestone, six feet ten inches thick. From the bottom of this limestone it is twenty four feet to the blue limestone exposed in the run below, mixed with chert, and overlying a cannel coal bed, the thickness of which is not known. As both these coal beds attain large dimensions on the other side of Simmons Creek, in Jefferson and Bedford townships, they may be expected to occur in other places in the northwest part of Jackson, also, of workable size; but the only locality in Jackson where either is opened is in the extreme corner of the township. Toward Roscoe, over the high lands to the south of the Walhonding River, the summits are far above the plane of these beds, and between four and one-half and five and one-half miles from Roscoe, the outcrops of two coal beds are observed, one of which is supposed to be No. 6, and the other the next bed above. In a run near the road in this vicinity, an imperfect section was obtained, showing the blue limestone at bottom three feet thick, and thirty feet above it the bottom of a bed of massive sandstone full fifty feet thick, with signs of coal six feet below it, with shale between the coal and sandstone. Near the summit, about seventy feet above the top of the sandstone, is the outcrop of the uppermost bed. On the next road to the south of this, a mile and a half west from Roscoe, the upper part of the great sandstone bed below coal No. 6, forms the pavement of the road, and beneath is a cave formed by the overhanging rock and extending entirely across under the road. The bottom of the sandstone is fifty-five feet below the road, and down the run fifteen feet lower is a fine exposure of the gray limestone two or three feet thick, with an inferior kind of cannel coal under it. A blue limestone crops out still further down the run, only about twenty feet under the gray limestone—shales and slaty sandstones occupying the intermediate space. The hills in this part of the township are quite high enough to catch No. 6 coal, and also the next bed in many localities. But No. 6 is the only bed known in the township as of much importance. It is opened at a number of places to the south of Roscoe, as at Dougherty's, Oder's, Jacob Housers, etc. The bed is from three to four feet thick, the coal is in good repute, and that from Oder's bank is hauled to Moscow, in Virginia township, for blacksmiths' use. But the most important mines in the township are in the southeast part, near the line of Virginia, especially those worked on adjoining tracts, belonging respectively to the Coalport Coal Company, and the Summit Coal Company, both under the management of Mr. Jos. Alexander. The locality is a mile and a half from the canal, with which it is connected by a horse track railroad. The coal bed is three feet ten inches thick, with a seam of shale one to two inches thick, fifteen inches above the floor. The mines have been in operation fifteen years. They now employ about twenty men, and the coal, which is of good quality and in good demand, finds a market in the central part of the State, being transported west by the canal. The roof of the bed is blue shale, and in the shale beds above and below the coal, kidney ore is found, which Mr. Alexander supposes will prove sufficiently abundant to work. He finds the dip to be southeast sixteen and one-half feet in a mile.

Prosser's coal mine is three miles south from Coshocton, and half a mile west from the canal. The bed is close upon four feet thick; contains no visible sulphur but what can be easily sorted out. The upper part is harder coal than the lower, and separated from it by a small seam of fireclay, eighteen inches above the floor. It has been worked for three years.

past. The coal is shipped by canal, and finds a market westward, and to the north-west as far as Sandusky. The following is the succession of strata observed in the run below the coal bed: Seventy-five feet below, is the bottom of a large bed of massive sandstone, not less than thirty feet thick, some layers of it conglomeritic; under it, shale beds (bluish) about twenty feet thick, with balls and layers of iron-ore; at ninety-five feet below the coal, is fire-clay, and, under this, blue shale and kidney ore; at 105 feet, black chert, five feet thick; and 15 feet below this, black shale and cannel coal, not distinctly divided—altogether, about four feet thick. The lowest of these strata represent the blue limestone, and Coal No. 3; and the black chert is the representative of a limestone which is locally found over the next coal above.

The following are the analyses of the coal from the mines above mentioned, No. 1 being from the mines of the Coalport Coal Company; No. 2, Prosser's upper bench; No. 3, Prosser's lower bench:

	1.	2.	3.
Specific gravity	1.357	1.253	1.296
Moisture	3.60	4.30	3 70
Ash	6 20	1.40	2.20
Volatile combustible matter	37 20	38.00	36.10
Fixed carbon	53 00	56.30	58.00
	100.00	100.00	100.00
Sulphur	3.31	1 61	2.77
Sulphur left in coke	2.08	0 38	0.90
Sulphur forming of coke	3 51	0 65	1.47
Fixed gas, per pound	3.08 c.f.	3.65 c.f.	3.42 c f.
Ash	gray.	yellow.	fawn.
Coke	compact.	compact.	compact.

Tuscarawas.—The lowest strata in this township, are those near the blue limestone. It lies near the level of the railroad, and of the canal near the aqueduct to the north of Coshocton. Where the highway crosses Mill creek, in the north-east part of the township, the following section of 165 feet may be observed: At top of the hill, massive sandstone, extending down about 100 feet; 125 feet below the top of this sandstone, gray limestone, four feet thick, with much chert intermixed and overlying a coal bed, the thickness of which is not known, only about fifteen inches seen in the outcrop; thence down to the level of the bridge over Mill Creek (165 feet below the top of the sandstone), is a bed of shales, about thirty-five feet thick. The blue limestone was not seen in place, but a loose piece of it was found below the level of the bridge and of the road. These strata produce no workable coal beds. The mines to the south and east of Coshocton, are altogether in Coal No. 6. Those of the Home Mining Company, a mile south-east from the town, supply a large part of the coal there consumed. They are situated on the west side of the high hill, near together, and are worked by means of twelve separate entrances. The bed is about 150 feet above the level of the railroad, and the coal is run down to the town by a gravity track, the cars being hauled back by mules. The thickness of the bed is three feet eight inches; the coal is very free from sulphur, bright, hard, and compact, and breaks with clear and brilliant smooth faces; is better adapted for steam and domestic purposes, than for blacksmiths' use, not having the melting and coking quality to the extent they require; still, it is in demand for this purpose, and is, in fact, the best this part of the country affords. It is transported by railroad to Newark and Columbus, and is said to be as good for railroad use as any coals obtained there. It is worked by large chambers, the roof being strong. A thin seam of shale divides the bed into two benches, and the upper bench supplies the best coal. It is overlaid by gray shales and sandstones; and 115 feet above it is the outcrop of another coal bed (No. 7), not opened, overlaid with limestone and some iron-ore—the position in which to look for the black-band iron-ore. The gray limestone is about sixty-five feet below Coal No. 6.

Of the Coshocton Mining Company, Colonel Stanhope is manager. About 40,000 bushels are mined per month. The analysis of this coal is as follows:

Specific gravity	1.303
Water	3.80
Ash	1.90
Volatile matter	37.10
Fixed carbon	57.20
	100.00
Sulphur	1.75
Sulphur left in coke	0.11
Sulphur forming percentage of coke	0.18
Fixed gas, per pound, c. f.	3.42
Ash	gray.
Coke	compact.

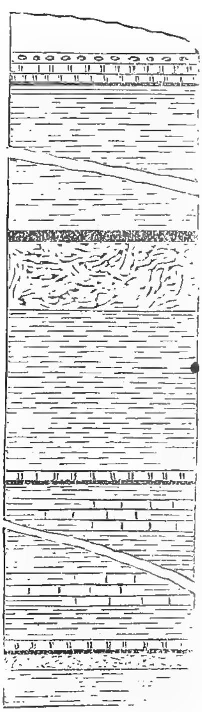
This analysis indicates a superior coal, specially adapted for coking, from its cementing character and extraordinary loss of sulphur in coking. The seam contains, here, as generally, a slate parting, which can only be removed by some care in mining.

In the hill north-east from the last described locality, toward the coal mines worked on that side, and discharged on the railroad, the following section is obtained, from Coal No. 6 down:

		FT.
1.	Coal No. 6.	
2.	Fire clay.	
3.	Sandstone	30
4.	Black marble	6
5.	Gray shale	10
6.	Gray limestone	3
7.	Coal outcrop.	
8.	Fire-clay.	
9.	Blue shale	60
10.	Blue limestone	7
11.	Cannel coal, thin and poor.	
12.	Fire-clay.	
13.	Shale to railroad, three miles from Coshocton	30

In the central part of the township, the summit level is, for the most part, high above the plane of No. 6 Coal—the tops of the hills full 200 feet higher. Indications of the black band ore were looked for in these higher strata; but none were met with that can be considered encouraging. No. 7 Coal must occur considerably below the general summit level; but the only bed worked appears to be No. 6.

SECTION SOUTH-EAST OF COSHOCTON VILLAGE, TUSCARAWAS TOWNSHIP.
Vertical scale, 1 inch to 52 feet.



FT.	IN.	
		Nodular calcareous iron-ore. Gray limestone. Coal outcrop (No. 7)
115	0	Gray shale and sandy shale.
3	8	Coal No. 6 (Home Company's).
20	0	Fire-clay.
45	0	Gray shale.
3	0	Gray limestone. Coal outcrop.
80	0	Shaly sandstone, and shale. Railroad at Coshocton.
3	0	Blue limestone. Coal outcrop.
5	0	Fire-clay.
15	0	Shale.
		Low water in river.

Lafayette.—The greater part of this township is alluvial bottom land. Its interests are exclusively agricultural, and we encountered no coal openings in the township. The higher parts of it, however, must contain what appears to be the only important bed of this region, viz., No. 6. The ancient valley, or river bed, extending through it from north-west to south-east, has already been noticed.

Oxford.—A considerable part of this township, also, is bottom land, in the broad valley of the Tuscarawas. Coal beds, however, are worked in the north-west corner of the township, which were not visited. They are probably on the same bed (No. 6) as the workings in Adams, not far to the north, and those on the same side of the river, and as near to it at Newcomerstown, over the line in Tuscarawas county. The valley of Wills Creek, on the south edge of the township, is on the level of the blue limestone, and a small seam of cannel coal is seen directly under it in this vicinity; and under the gray limestone, twenty-five feet higher up in the same run, is a coal bed not well exposed, the upper part of which is cannel. Coal No. 6 must be in the hills in the south-east part of the township, but no openings of it were seen.

From Coshocton to the east line of the county, the dip has not continued in an easterly direction, but appears to be reversed. At Coshocton, Coal No. 6, at the Home Company's mine, is about 148 feet above the railroad, which is there 138 feet above Lake Erie; and at New Comerstown, the same bed is 130 feet above the railroad, which is there 163 feet above the Lake, making the bed seven feet higher at Newcomerstown. The direction is about due east. The effect of this flattening of the dip, is to keep the same series of strata near the surface, and give a monotonous character to the geology. There appears to be no southern dip, either, in the south-east part of the county, judging from the barometrical elevations of the Tuscarawas and Wills Creek valleys.

Pike.—This township is altogether near the bottom of the Coal Measures. The gray limestone is seen very frequently in the high grounds, accompanied by its coal bed, No. 4; and as we see no evidence of the coal being worked, it is probably of little importance. At West Carlisle, the sandstone just under the gray limestone, contains numerous specimens of what are probably fucoidal stems, in a variety of unusual forms, some bearing a curious resemblance to the fossil saurian foot-prints. On the west side of the village, is a large outcrop of slaty cannel coal, probably belonging to the gray limestone, but of no value. No particular change is observed in the strata from this point to the south-west part of the township, where the land soon descends down to the Waverly.

No considerable deposit of iron-ore was found in place in Pike township, but a number of nodules of ore, of fine quality, were noticed in the valleys of the streams, doubtless washed from the hills in the vicinity. The excellence and abundance of this ore render it highly probable that the important deposits of Jackson township, Muskingum county, extend northward into Coshocton. Below are given the analyses of two specimens from the valley of Brushy Fork, in Pike township. No. 1 consists of a nodule of carbonate, changing exteriorly to limonite; No. 2, a similar nodule, being converted by surface oxidation into anhydrous sesquioxide. A similar difference has been frequently noticed among the Coal Measure iron-ores, but no explanation has, as yet, been given:

	1.	2.
Specific gravity	4.043	3.863
Water	3.88	6.04
Silicious matter	13.16	14.44
Iron sesquioxide	26.50	32.25
Iron carbonate	50.01	42.36
Manganese	2.20	0.70
Alumina	1.00	0.00
Lime carbonate	1.32	1.55
Lime phosphate	1.17	0.95
Magnesia carbonate	0.29	0.90
Sulphur	trace.	trace.
	99.53	99.19
Metallic iron	42.69	43 03
Phosphoric acid	0.51	0.44

Washington.—The only coal mine of importance seen in this township, is Parks's, in the north-east corner. The bed is No. 6, three and a half to four feet thick, the coal of superior quality, very brilliant, of waxy lustre, giving a brownish-red powder, and purplish ash. It is a good coking coal, melting easily. The pyritous seams it contains, are small and easily sorted out. The coal finds a ready sale over a considerable region around. The bed lies high up near the top of the hill, but probably may be found in many other places in the eastern part of the township.

The following is a section of the strata associated with Parks's coal:

		FT.
1.	Slope covered	100
2.	Coal No. 6 (Parks's)	3 to 4
3.	Fire-clay.	
4.	Sandstone	80
5.	Gray limestone	4
6.	Coal No. 4	1
7.	Gray shale	30
8.	Blue shale	20
9.	Blue limestone.	
10.	Coal outcrop, No. 3.	

The following is an analysis of Parks's coal:

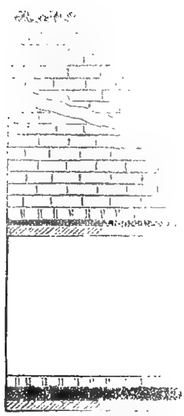
Specific gravity	1.296
Moisture	3.80
Ash	2.90
Volatile combustible matter	38.80
Fixed carbon	54.50
	100.00
Sulphur	1.12
Sulphur left in coke	0.82
Sulphur forming percentage of coke	1.42
Fixed gas, per pound	3.16 c. f.
Ash	gray.
Coke	compact.

Virginia.—Coal No. 6 is pretty generally worked throughout the north and east parts of this township—in the north-west part, by Joshua Cornell, half a mile north from Moscow. The bed is here about three and a half feet thick, the coal in sound blocks, with very little waste of fine coal, and very little sulphur. When burned, it shows the purple-colored ash peculiar to this bed. This, as well as Parks's coal, is in good demand through the neighborhood, and as far to the north west as West Bedford. From Moscow, east to Franklin, there are numerous openings worked in this coal bed, and thence south nearly to the canal and the railroad. At Michael Zimmer's, two miles north-west from the canal, the bed is about ninety feet thick below the top of the hill, and overlying a bed of sandstone ninety feet, under which is the gray limestone. The roof of the coal is black shale. The coal bed is four feet thick, the coal very hard, black, compact, highly bituminous, melting easily, and of excellent quality altogether. What sulphur is found, is in heavy lumps, and easily separated. A small seam of shale runs through the bed, a foot above the bottom. The elevation of this bed above the canal is about 170 feet.

Two miles south from this, and near the south line of the towbship, is the mine of James Scott, in coal bed No. 3, under the blue limestone. The locality is near the canal, and not far above its level. The coal bed is four feet thick, divided into two benches by fire-clay parting, the upper bench from six to twelve inches thick. The mine was opened in 1833, and has produced a large amount of semi-cannel coal, of good quality. The roof of the bed is a black, calcareous shale, two feet thick, abounding in fossil shells. The blue limestone resting upon this, is from four to five feet thick. The gray limestone is seen about forty feet higher up the hill, and under it a bed of slaty cannel coal, fifteen inches thick.

Section of Hills near Scott's Coal Mine, Virginia Township.

Vertical scale, 1 inch to 72 feet.



FT.	IN.	
90	0	Slope covered.
4	0	Coal No. 6—Zimmer's.
		Fire-clay.
90	0	Sandstone.
4	0	Gray limestone.
1	6	Coal No. 4—poor.
		Fire-clay.
40	0	Covered.
		Blue limestone.
3	0	Coal No. 3—Scott's.
4	0	Fire-clay.

Franklin.—The western half of this township is chiefly bottom land along the valley of the Tuscarawas. The eastern half rises, for the most part, above the plane of Coal No. 6, which bed is worked near both the northern and the southern line of the township. On the north line, by the mouth of Rock Run, three miles below Coshocton, is the mine of Mr. Keith, 110 feet above the railroad, with which it is connected by a tram-road. The old mine is near the railroad, but the new opening is half a mile from it. The work here is well laid out for a large business. The coal-bed is four feet thick; the coal in cubical blocks, very black and brilliant, with frequent flakes of charcoal scattered through it, and the coal is here 110 feet above the railroad, and the railroad 125 feet above Lake Erie, which proves the coal to be fifty-one feet lower than at the mines of the Coshocton Coal Company, three miles east of Coshocton.

Section at Keith's Mine, Rock Run.

1.	Black shale.	
2.	Coal No. 6, Keith's	4 to 6 feet.
3.	Fire-clay	3 to 6 "
4.	Massive sandstone	75 "
5.	Spring and probable horizon of coal seam.	
6.	Shaly sandstone	30 "
7.	Black shale and covered space	40 "
8.	Blue limestone	3 "
9.	Covered to river	10 "

The following are analyses of the Rock Run coals. 1, Keith's new mine; 2, Muskingum Valley Coal Company, top bend; 3, Muskingum Valley Coal Company, bottom bend:

	1.	2.	3.
Specific gravity	1.339	1.264	1.322
Moisture	4.00	4.80	2.15
Volatile combustible matter	36.20	36.50	39.25
Fixed carbon	54.70	56.80	49.80
Ash	5.10	1.90	8.80
	100.00	100.00	....
Sulphur	2.69	1.74	2.73
Sulphur left in coke	0.80	0.65	....
Sulphur forming percentage of coke	1.34	1.10	....
Fixed gas, per pound, cubic feet	3.23	3.42	3.35
Ash	gray.	gray.	gray.
Coke	compact.	compact.	compact.

Near the southern line is John B. Hershman's coal bank, one mile above the bend of Will's Creek, on the east side and ninety feet above its level. The bed is four and one-half to five feet thick and yields very sound and black coal of apparently excellent quality. Near the bottom is a thin seam of sulphury shale, which can be easily separated. It has a thin roof of shale, and over this is sandstone. Below the coal is sandstone thirty feet thick, and under this a large bed of shale.

Linton.—This is the next east from Franklin, and the south-eastern township of the county. Except in the wide bottoms of Will's Creek, the greater part of the surface is above the plane of Coal No. 6. The road from Coshocton comes down to it near the north-west corner of the township, six miles from Coshocton, where an old opening is seen by the run, to the right-hand side of the road. At the school-house, near by, and below the level of the coal, is a display of iron ore in oxydized blocks, that might be supposed to indicate a considerable quantity, but these outcrops are little to be depended upon.

The road continues to descend toward the east, following the valley of the run, and in the bed of this, two miles before reaching Jacobsport, the blue limestone is seen well exposed over three feet thick. At Jacobsport, over the bridge across Will's Creek, the same rock lies ten or fifteen feet above the creek, in a bed measuring four feet ten inches thick. Great blocks of it, of rectangular shape, and weighing many tons, have fallen down and lie by the side of the creek. The rock abounds in fossil shells, which, however, are obtained with difficulty. A little seam of slaty cannel coal, four inches thick, adheres closely to the underside of these blocks. The underlying strata down to the creek are shales, with nodules of kidney ore. A gray limestone is twenty-five feet above the blue, and under it is a coal outcrop. A mile south from the bridge, toward Linton, is an opening in No. 6 Coal, and others also, are seen along the road. At Linton, we found the same bed on the land of Mr. Heslip, where it presents its usual features. At this place another coal-bed is found fifteen feet below No. 6, and has been worked to some extent, but it appears to be of little value. The shales in this neighborhood contain balls of iron ore of good quality, sufficient in quantity to inspire hopes of their being of value, but little dependence, however, can be placed upon them. They are seen in the road a mile or more north-west from Linton, and specimens were preserved. Deposits of bog iron also are said to occur in the bottom of the creek.

This locality is interesting from the discovery of bones of mastodons, found in the bank of the creek, and in the alluvial bottoms. One of these bones was found a few years ago in excavating the bank for the mill-dam at Linton. One large joint, supposed to be a cervical vertebra, with a cavity through it as large as a man's arm, was taken out, and more bones were thought to be behind it. Search can be made for these whenever the water is drawn down at the dam, at Jacobsport. This backs the water up eight feet, which is all the rise for fourteen miles by the creek. Another discovery was made a mile below Linton, at the mouth of White Eyes Creek, of a large and sound tooth, which now belongs to Mr. W. K. Johnson, of Coshocton.

A third discovery was made forty-eight years ago, two and one-half miles above Linton, near Bridgeville, in Guernsey county, on the farm now owned by Mr. George Gay Mitchell. His father, at that time, in digging a well on the terrace, fifty feet above the creek bottom, found at the depth of forty-two feet, some large bones in a bed of blue mud. Only two of these were taken out, one described by Mr. Mitchell to be a hip bone, and the other as a shin bone, weighing eight pounds. The well was then abandoned, and the rest of the skeleton is supposed to be still there.

I append analyses of two varieties of the buff limestone overlying Coal No. 7.

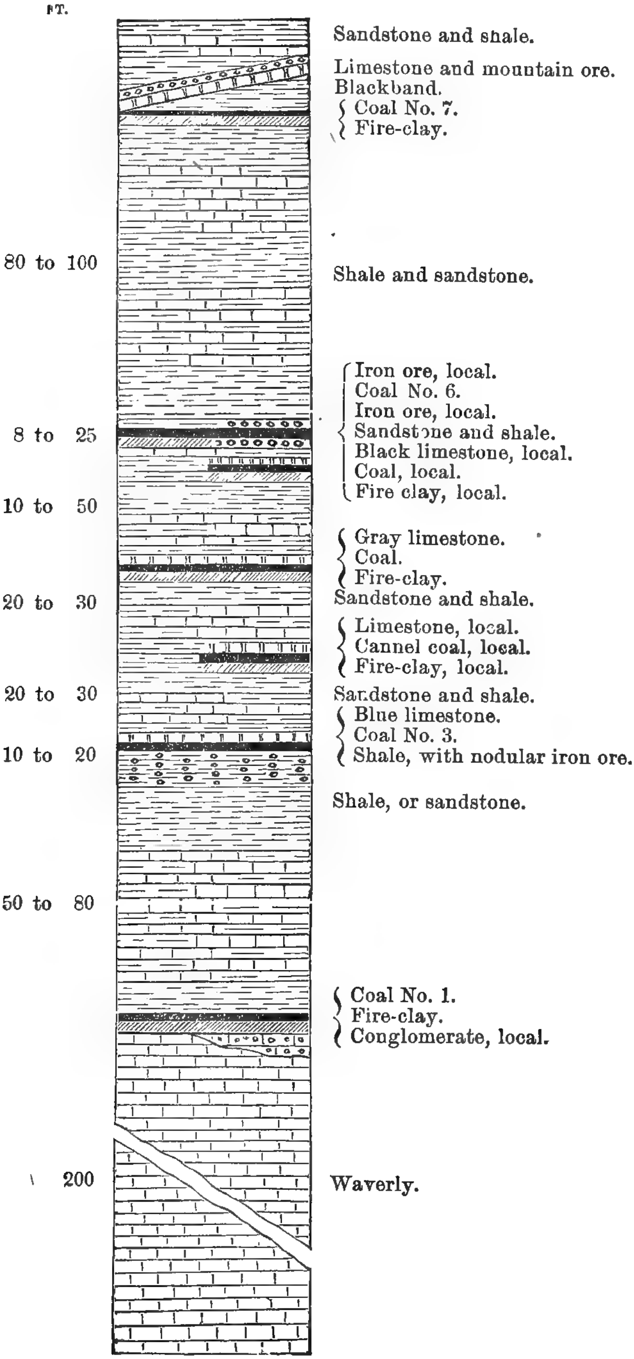
Silicious matter	7.80	12.30
Alumina and iron	3.20	12.60
Carbonate of lime	87.00	73.00
Carbonate of magnesia	1.51	1.66
	99.51	99.56

This limestone occupies the horizon, and is doubtless the equivalent of that, which, when highly charged with iron, is in Tuscarawas county called the "mountain ore." The notable amount of iron it contains will perhaps make it valuable as a flux where too lean to be considered an ore.

This report will be concluded with a general section of the rocks of the county. An examination will show that the different strata vary greatly in thickness and character. The local limestones tend to mislead the explorer, and it is possible that some of the distances given between the blue and gray limestones, are too small, as the local cannel coal limestone may in some instances have been mistaken for the blue. The lower four limestones are locally cherty, and in places constitute flint ridges. The one above the cannel coal is sometimes separated from its coal by shales, and sometimes changes to a black limestone, and may be mistaken for the one directly below Coal No. 6. The coal below it is often bituminous, and sometimes wanting. The black limestone, in places, approaches very near to Coal No. 6, and becomes a drab limestone much like that below Coal No. 6, in Columbiana county.

General Section of the Rocks in Coshocton County.

Vertical scale, one inch to fifty-two feet.



CHAPTER LXXXIV.

REPORT ON THE GEOLOGY OF FRANKLIN COUNTY.

BY EDWARD ORTON.

I. SITUATION AND TOPOGRAPHY.

Franklin county is bounded on the north by Delaware county, on the east by Licking and Fairfield, on the south by Pickaway, and on the west by Madison. Union county touches it also on one corner, furnishing a very small portion of the northern and western boundary. Its position in the State is very nearly central. A nearer approximation to an exactly central location, could have been secured by combining portions of Delaware and Franklin counties in one county.

Its topography is very much more varied than that of any of the counties that lie along the same parallel to the west of it, the valleys of the Scioto and its tributaries constituting the chief features. This first named valley divides the county into two main divisions, the eastern division having the larger area. Its course, from the northern border to the center of the county, is south-easterly; from this last named point to the line of Pickaway county, its direction is very nearly south. Several of the principal tributaries of the Scioto do not enter it within the limits of the county, but they run in north and south valleys approximately parallel to the main valley, until they pass the southern boundary.

The north and south direction of the tributary valleys, as well as of the main valley, is a characteristic of the county, especially of the northern half. It is well shown by a section taken from west to east along the southern line of Sharon township. Beginning on the west side of the county, with the well-marked valley of Big Darby Creek, we find a dividing ridge, about eight miles in breadth, from which we descend into the Scioto Valley. A second stretch of table land, about five miles wide, carries us to the Olentangy Valley. The intervening high ground between this and Alum Creek Valley, is not far from seven miles in width, while not more than three miles separate the Alum Creek Valley from the Big Walnut Valley. About four miles intervene between the deep furrow worn by Big Walnut, and the scarcely less conspicuous one of Rocky Fork; and the interval between the last named valley and Black Lick, is of the same extent. Another extension of table land, of three miles in breadth, carries us to the east line of the county. This east and west section shows, in other words, seven conspicuous notches or depressions, every valley, in fact, of any note, in the northern half of the county, being shown in it.

A similar section, taken in the southern half of the county, on the north line of Hamilton and Madison townships, would agree very well in its main features with the first section. It would show the valleys of Big Darby, of Darby Big Run, Scioto Big Run, of the Scioto River, of Alum Creek, Walnut Creek, and Black Lick.

The highest land of the county is found on its northern and western borders. The several water-sheds between the valleys named above, in Plain, Blendon, Sharon, and Perry townships, hold land about 925 feet above tide-water. The summits, on the western side of the county, rise, perhaps, a few feet higher; but it is not known that any land in the county exceeds 950 feet in elevation. The lowest land is, of course, found in the Scioto Valley, on the southern line of the county.

The elevations of a number of points in the county, are here appended, being compiled from various railroad and other surveys that have been carried through the county:

	FT.
Columbus—Union Depot, above tide-water	740
" Water-table of Ohio Agricultural and Mechanical College	763
" Low water of Scioto, about	700
Groveport	835
Winchester	769
Georgesville	807
Worthington Station	910
Westerville Station (C. C. C. & I. R. R.)	926
Westerville—depot in village	905
County line, on C. C. C. & I. R. R.	930

In these elevations, the level of Lake Erie is assumed to be 570 feet above the sea, in accordance with the most recent determinations; but it is to be added that the results given above are not minutely accurate. They are drawn from various railroad surveys, which do not, themselves, exactly agree as to the elevation of their common point—Columbus. The limit of error will not, however, exceed five, or, at most, ten feet.

The Scioto Valley, which has already been named as giving rise to the most conspicuous topographical features of the county, consists of two well marked portions. From the north line of the county, almost to the city limits of Columbus, the river has worked out its channel in heavy beds of Devonian limestone. In the vicinity of Dublin, the vertical wall is between forty and fifty feet in height, and the real depth of the excavated valley is not less than 125 feet. The most picturesque scenery of the county, is shown in the gorges of the Scioto and its larger tributaries in this region. But, through all this part of its extent, the valley is very narrow, the bottom lands being of comparatively small extent, and often being entirely wanting. As the river approaches Columbus, its eastward course carries it beyond the outcrop of the limestones into the softer beds of the Huron shale, and from this point on, the character of the valley is very different. It is no longer confined to the river channel, nor even to the broad bottom lands that border it, but widely eroded regions, now filled with heavy and irregular deposits of Drift, attest the former presence of the river at points several miles removed from its present limits. In Hamilton and Jackson townships, especially, the boundaries of the valley are quite indistinct, the second bottoms often merging imperceptibly into uplands somewhat more elevated, but not separated from them by any obvious line of demarkation. For several miles, on either side, the altitude is but little greater than that of the valley proper. In Hamilton township, indeed, and also in Madison, very extensive erosion of the bedded rocks must have taken place.

The valley of the Whetstone, or Olentangy River, also constitutes a very prominent feature of the northern half of the county. It enters the county west of the middle point of its northern boundary, and flows almost due south, until it enters the Scioto at Columbus. Throughout all of this district, it has been excavated in the easily eroded shales of the Huron system. It furnishes, by comparison with the Scioto Valley, at points due west of it, a striking example of the disparity with which different geological formations resist wear and waste. The levels run in the construction of the Worthington and Dublin turnpike, show that low water in the Olentangy, west of Worthington, is sixteen feet lower than low water in the Scioto at Dublin. The Scioto exceeds the Olentangy several times in volume, and, other things being equal, its valley should be much deeper. It is also to be noted that the disparity would be still more striking, if the actual depths of the valleys were taken into the account. The Olentangy runs upon Drift beds, the shales having been cut out to an unknown, but probably considerable depth, while the Scioto, at the points named, has a rocky floor. The contrast between the valleys, in width, is equally marked. As already stated, the Scioto Valley, in the northern half of the county, is but a narrow gorge, walled with vertical cliffs. Its bottom lands are of small extent, and often there is no interval whatever. The valley of the Olentangy, on the other hand, often attains a width of two miles, and is seldom less than half a mile. Its broad plains constitute decidedly the best farming lands in the northern half of the county.

The erosion has been especially extensive near the junction of the two rivers. For three miles, at least, north of the mouth of the Olentangy, the rocks between the rivers have been cut away to such a depth that no trace of them is now visible, even in the deepest wells that are dug. The Drift deposits that take their place, do not rise to the same altitude that the surrounding uplands attain, and thus the whole of the country, from North Columbus westward to the Scioto, belongs in the category of lowlands.

Alum Creek and Big Walnut Valleys are wrought in the Huron shale, and have all the characteristics of valleys worn in this formation. Their bottom lands are wide enough for rivers, and the water-sheds between them and adjacent streams, are not as high as those that are found to the westward. The tributaries of Big Walnut, that enter from the east, in many instances reach to the overlying Waverly group. Black Lick and Rocky Fork, in particular, disclose quite heavy sections of the Waverly in their banks, and valuable quarries have been opened at several points.

The valley of Big Darby constitutes the western boundary of the county, for a number of miles, and then, directed to the eastward, forms a deep and broad furrow across Pleasant township. As the highest lands of the county are to be found on either side, the valley is made more striking by the steep descent by which it is reached.

II. GEOLOGICAL SCALE.

Franklin county has an extended geological scale; much more so than we are prepared to expect from its flat-lying surface. In this respect, it is surpassed by but four counties in the State, and is equalled by a scarcely larger number. Highland, Adams, and Pike counties, to the southward, have a somewhat wider range, the two first named extending from the Lower Silurian to the Sub-carboniferous formation inclusive, and the ast, from the Upper Silurian to the Coal Measures; but none of them contains a greater number of geological elements, after all, than Franklin county, for the Devonian limestones of central and northern Ohio, are excluded from this region by the overlap of the Huron shales upon the Helderberg and Niagara rocks. (See Report of Progress for 1870, p. 307.) For the same reason, the scale of Ross county, although beginning and ending with that of Franklin county, comprises one less formation than it.

Marion county, to the northward, has a greater range, by a single formation—the Niagara limestone occupying a small corner in the northwestern part of the county, while the Waverly sandstone appears upon the eastern boundary.

Pickaway county, to the south, and Delaware, to the north, exactly agree with Franklin, in both the range and composition of their geological columns. The following formations, named in descending order, are found in Franklin county:

4. Waverly group.
3. Huron shale.
2. Corniferous limestone.
1. Lower Helberberg limestone, or waterlime.

These formations represent three main divisions of geological time, as is shown in the appended diagram:

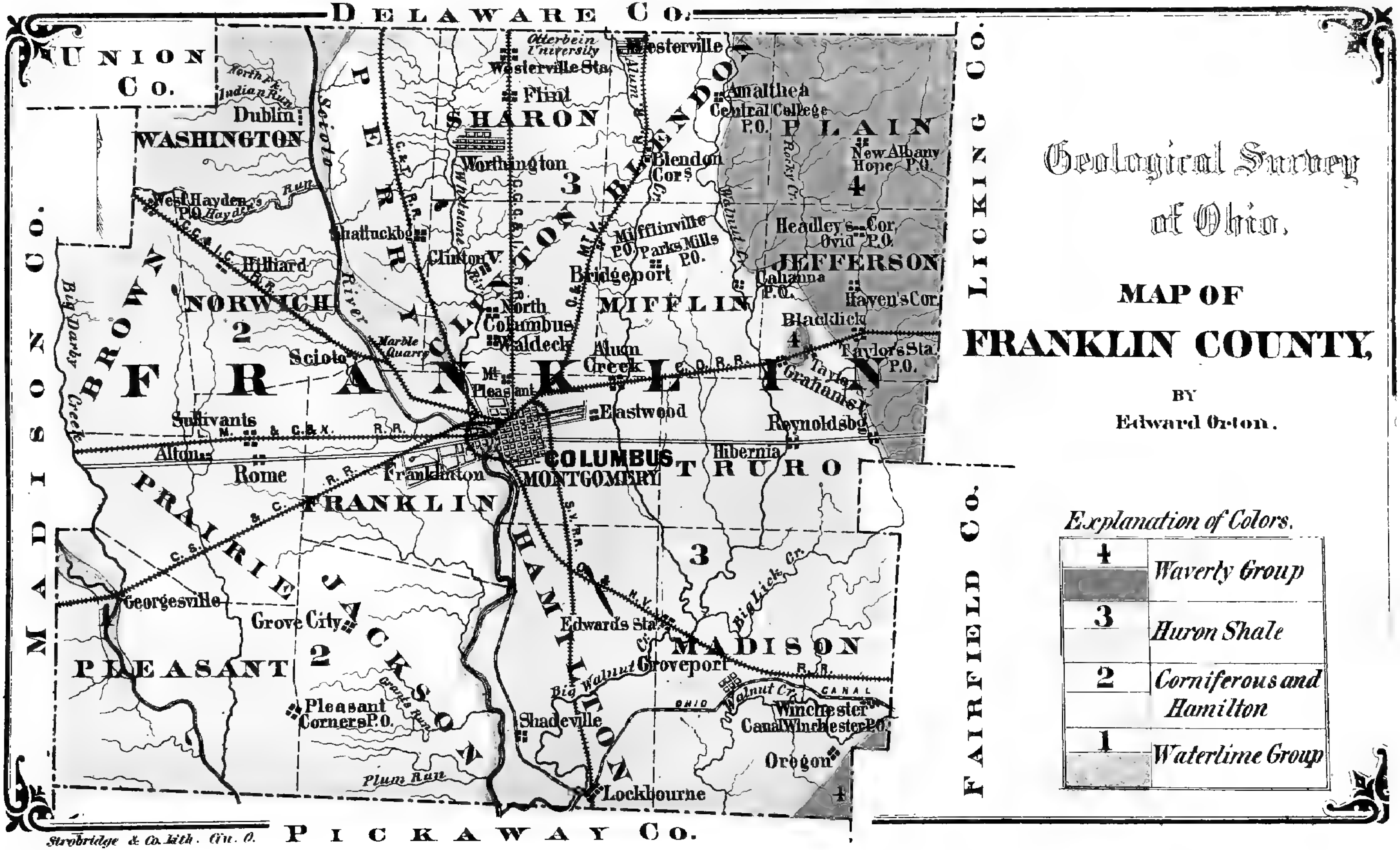
Carboniferous Age—Waverly group { Cleveland shale. / Waverly sandstone. / Waverly shales.

Devonian Age { Huron shales. / Corniferous limestone.

Upper Silurian Age—Waterlime group.

These elements will now be briefly described, commencing with the lowest:

1. The Lower Helderberg limestone, or waterlime, is a late-found, but important, member of the geological series of Ohio. Its presence in the State was first recognized at the beginning of the present Geological Survey; but as the structure of the State has been more accurately determined, it has been found to occupy a larger area than any other limestone. It makes, however, but a very small contribution to the surface of Franklin county, its outcrops being limited to a few points on Little Darby and Big Darby creeks, on the extreme western border. The valleys of both these streams now lie in this formation, for several miles above and below Georgesville; but, on account of the heavy drift deposits that occur here, the rock is seen but at a few points. The best exposure is found in the bed and bank of Big Darby, one mile below Georgesville, and in the sections formed by small tributaries of the stream in the same vicinity. It is also seen in the banks of the Little Darby, one mile above Georgesville. The last named exposure is a continuation of the outcrop below West Jefferson, in Madison county. As both of the localities named contain the same elements, the description of one will answer for both.


Geological Survey of Ohio,
MAP OF
FRANKLIN COUNTY,
BY
Edward Orton.
Explanation of Colors.
4 Waverly Group
3 Huron Shale
2 Corniferous and Hamilton
1 Waterlime Group
DELAWARE CO.
UNION CO.
LICKING CO.
MADISON CO.
FAIRFIELD CO.
PICKAWAY CO.
FRANKLIN
WASHINGTON
NORWICH
BROWN
PERRY
SHARON
CLINTON
BLENDON
PLAIN
JEFFERSON
MIFFLIN
TRURO
MONTGOMERY
FRANKLIN
PRAIRIE
JACKSON
PLEASANT
HAMILTON
MADISON
COLUMBUS
Westerville
Otterbein University
Westerville Sta.
Flint
Worthington
Dublin
West Hayden P.O.
Hilliard
Shattuckbg
Clinton V.
North Columbus
Waldeck
Mt. Pleasant
Scioto
Marble Quarry
Sullivants
Alton
Rome
Franklinton
Eastwood
Alum Creek
Bridgeport
Mifflinville P.O.
Parks Mills P.O.
Blendon Cors
Amalthea
Central College P.O.
New Albany
Hope P.O.
Headley's Cor.
Ovid P.O.
Calianna P.O.
Haven's Cor.
Blacklick
Taylor's Sta. P.O.
Taylor
Grahamsy
Reynoldsbg
Hibernia
Georgesville
Grove City
Pleasant Corners P.O.
Edwards Sta.
Groveport
Shadeville
Winchester
Canal Winchester P.O.
Oregon
Lockbourne
Scioto River
Big Darby Creek
Alum Cr.
Walnut Cr.
Rocky Cr.
Big Walnut Cr.
Big Lick Cr.
Plum Run
Grants Run
Hayden's Run
North Fk. Indian Run
Whetstone River
Ohio Canal
C. C. C. & I. R.R.
C. & M. V. R.R.
C. O. R.R.
S. V. R.R.
C. S. & C. R.R.
Strobridge & Co. lith. Cin. O.

About fifteen feet of this formation are shown at the point first mentioned, viz., in the bank of Big Darby below Georgesville. It is immediately overlain by the heavy and easily recognized ledges of the Corniferous limestone. This point, then, possesses the interest that always attaches to a well marked boundary in a geological series. In fact, the junction of two great divisions of geological time is found here, the Helderberg limestone belonging, as will be remembered, to the Upper Silurian system, while the Corniferous is a Devonian formation. As this is the only point in all this portion of the State where the line of junction between these limestones is distinctly shown, it will be well to note with care the facts that are here met.

The Lower Helderberg limestone as found here presents the same general appearances that its outcrops, both to the north and south, exhibit. The greater portion of it is a very thin-bedded, buff-colored, magnesian limestone, which could be confidently identified at once by any one acquainted with the formation as shown either in Highland county or in the islands of Lake Erie. It contains also, here as well elsewhere, so notable a quantity of bituminous matter that it can be recognized by the odor of a freshly broken surface almost as readily as by its appearance; unless carefully examined, the limestone will be pronounced non-fossiliferous, for there are considerable portions in which no traces of life remain. Occasional layers are found, however, that contain indistinct casts of the characteristic fossil, *Leperditia alta*, of two or three small brachiopods and of a small number of corals.

Another phase that the formation here exhibits may be styled the *concretionary phase*, masses rudely spheroidal in shape and which show in section something of a concentric structure, varying from six inches to two or three feet in diameter, are met with, especially in the lower part of the limestone that is here exposed. The smaller masses are in appearance not unlike sponges of the *Stromatopora* group, but there is no good reason to believe that any of them are of organic origin. These concretions seem entirely destitute of fossils. Some of the beds towards the upper portion of the series are distinctly brecciated, i. e. composed of angular fragments that have been re-cemented by the infiltration of water holding carbonate of lime in solution. This same peculiarity of structure is reported in rocks of this formation in the northern part of the State.

These seams of clay are sometimes found in the uppermost beds of the section, a fact not elsewhere reported in the Lower Helderberg rocks of the State. A question may be entertained as to whether the clay occurs in seams or in pockets. If the latter term is the proper one, it might be believed that the clay is the result of the decomposition of the overlying Corniferous limestone, and not a product of original deposition. Such accumulations are very common along the outcrops of limestone formations, and notably, in the seams and crevices of the State quarries, but whenever they have this origin, they betray it by the silicious fragments of rock or fossils that they enclose. The clay here referred to is very fine-grained and homogeneous, is either white or red in color and contains no recognizable foreign fragments. It may, therefore, be taken to mark a change in the character of the seas in which the underlying limestone had so long been forming, and it may be added that other indications, derived from their chemical analysis, point in the same direction.

Their composition is shown in the following analyses, made for the Survey by Professor Wormley, number 1, being the red variety and number 2, the white variety just named. Both samples were taken from the bank of Big Darby on the John Phillips farm, one mile below Georgesville:

	1.	2.
Silicic acid	48.11	35.30
Alumina	35.30	9.50
Sesquioxide of Iron	6.70	Trace
Lime	.60	00
Magnesia	.83	23.03
Soda and Potash	1.27	.75
Water	7.65	32.35
	100.46	100.93

The dissimilarity in composition is so great as to forbid their reference to a common origin and especially to the weathering of the adjacent limestone.

It has already been remarked that this limestone is magnesian in character. The composition of some of its phases is shown in the following analyses. It may be added that the concretionary masses give promise of making a hydraulic cement. At least they do not readily burn into lime:

	1.	2.	3.	4.
Insoluble matter	1.10	.80	.20	.40
Carbonate of Lime	64.20	55.20	47.20	55.00
Carbonate of Magnesia	34.44	43.58	41.82	44.10
	99.74	99.58	99.32	99.50

All of the samples were taken from the Roberts farm, on the banks of Little Darby and just above the county line.

The only economical use to which the very limited exposures of the Helderberg series in the county can be turned is to the production of a good quality of lime. The preceding table shows that we find in them the typical magnesian limestone which is so much esteemed as a source of lime in all the districts to the south and west in the State. Several of these analyses are almost identical in character with those of the limestones of Greenfield and Leesburg, in Highland county, which belong to the same formation, and they do not differ essentially from those phases of the Niagara formation that are turned to most account for the same purpose, viz., the Springfield, Cedarville and Yellow Springs limestone. It will presently be seen that the county possesses an unlimited supply of lime of a very different character, viz., the hot and quick setting lime derived from true carbonate of lime, from which the existing demand is principally met, but it is clearly an advantage to have the magnesian carbonates at hand as well as the true carbonates of lime. Good natural facilities can be found for producing large quantities of lime, both above and below Georgesville.

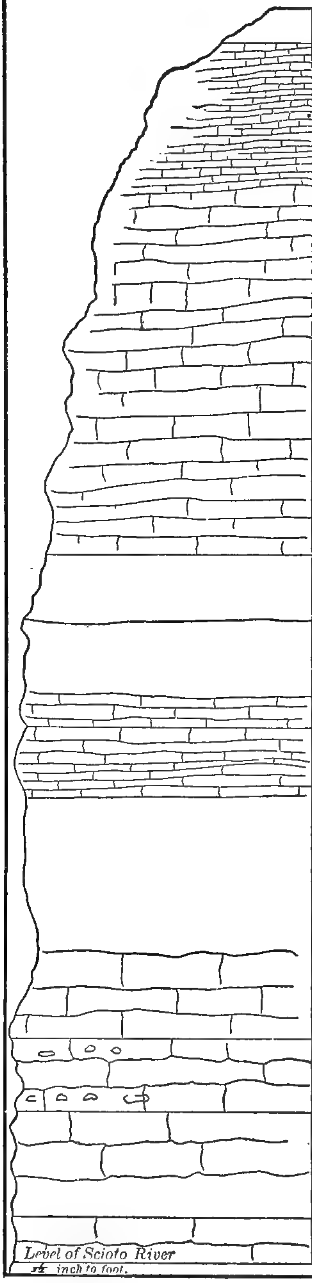
The courses of the Helderberg limestone are too thin and uneven to be valued for building purposes, especially in the presence of the heavy bed of the Corniferous formation that overlies them.

III. CORNIFEROUS LIMESTONE.

1. *Stratigraphical relations.*—The Corniferous limestone holds a very different place in the geology of the county from the foregoing. It covers a much wider area, is a much thicker formation, has very numerous exposures, yields building stone and lime of great value, and is worked very extensively for both purposes. When to this it is added that it is one of the most remarkable store-houses of ancient life in our whole series of rock formations, it will be seen that it possesses every element of geological interest.

As has been already implied, the whole thickness of the formation appears in Franklin county, but there is no one section that contains every element. The nearest approach to a complete section is found in the east bank of the Scioto, from Dublin northwards to the county line. A few feet are here wanting both at the top and at the bottom of the series. The Waterlime, or Lower Helderberg, is found in the bed of the river, a little to the northward, and it is probably safe to say that a descent of ten feet at several points within the district named, would carry us to the lower boundary of the Corniferous; while its upper limit, viz., the

SECTION OF CORNIFEROUS LIMESTONE NEAR CORBIN'S MILL, PERRY TOWNSHIP.



	feet
HURON SHALE.	
Courses 6 in. *Ferris's Quarry. "Delaware Stone."* *"Blue Limestone." Siliceous.* *Bone bed.*	32,
Shaly Limestone *not distinctly seen.* *Lower portion like section below.*	11,
Thin. *Highly fossiliferous.* *"Delhi Stone."* *"White Limestone".* *Building Stone.*	19,
Courses 6 to 8 in. *Flinty nodules rich in fossils in 2 layers.*	5,
Cutting Stone.	8
Buff Magnesian Limestone 3½ feet. *Works easily, known as Sandstone.*	
Cutting Stone.	

Huron shale, occurs on the same side of the river, and but a little ways back, in various exposures, for eight miles to the southward. The actual thickness of the sections found here is about seventy-five feet.

A section found in this neighborhood, at Corbin's Mills and on the adjacent land of Joseph Ferris, can be taken as a fair representative of the series here. It is shown in the annexed wood cut. Beginning at the water's edge, a heavy course of cutting stone is first seen. Its thickness sometimes rises to two and one-half feet. This is overlain by eight feet of buff colored magnesian limestone, which lies in quite heavy but rather uneven beds. These courses have a maximum thickness of three and one-half feet, and an average thickness of two and one-half feet. They are raised in blocks sufficiently large to make them valuable as a cutting stone. They are easily wrought, especially when first quarried, and on this account have acquired the local names of "freestone" and "sandstone."

These courses are followed by five feet of thinner bedded rock, the thickness of the layers ranging between four and eight inches. Two of these layers, one near the bottom and the other near the top of the section, hold flint concretions. These occur in irregular nodules, chalk white on the outside, and often of the same color throughout their substance. They are very rich in the fossils of the formation, and these are here found in a remarkable state of preservation. Univalve shells of the genera *Murchisonia*, *Loxonema*, *Pleurotomaria* are especially abundant and perfect. Very fine casts of the brachiopod *Meristella nasuta*, Conrad, occur here also. Several of the type fossils of the formation were described from specimens found in the flint of this geological horizon.

The flinty layers in the section are overlain by nineteen feet of light colored beds, commonly called "white limestone." These beds are crowded with fossils, of which brachiopod shells are the most numerous. The beds are thin, seldom exceeding six inches, and not very even. They furnish at the best "building stone" as distinguished from "cutting stone," but the most valuable application that can be made of them is in lime burning. They yield a very strong and very white lime.

The nineteen feet shown in the quarry above the mill, together with the lower portion of the next division marked in the cut, constitute the Delhi beds of Prof. Winchell. *This next division, eleven feet in thickness, is not homogeneous, as has been already intimated. It is not clearly shown at this point, but the uppermost five or six feet are made up of shaly layers, not adapted either for building stone or lime burning. Their upper boundary is made distinct by a remarkable layer called the bone bed, which will be described in detail on a subsequent page.

* See Report on Delaware county, Vol. II Geology, page 297.

The bone bed is the boundary between two very distinct divisions of this series of limestone—viz., the Delhi and Delaware beds of Professor Winchell. The latter division is locally known as the "blue limestone," to distinguish it from the underlying courses. It differs from these courses in color, in style of bedding, in chemical constitution and in fossil contents. The color of the stone is uniformly blue. In bedding it is very even and regular. It contains a notable proportion of silica and alumina in its composition, which militates against its durability as a building stone. It would otherwise answer an admirable purpose for this use, the thickness of the layers, which average six inches, the regularity and the color all recommending it above any other limestone of the vicinity. Some beds are found that can resist the weather, and these come to be valued highly.

The fossils of the Delaware beds are at this point chiefly fish remains. Teeth, plates, jaws, and other bones are not infrequently met with throughout twenty-five feet of this series. The uppermost seven or eight feet consist of very thin and shaly beds, which contain flint in large quantity. They are, as a rule, without fossils of any sort. The Delaware beds of this immediate section are thirty-two feet in thickness. Their upper boundary is as distinct as their lower, consisting of the blue shales that make the base of the great system of Devonian shales that succeed this, the last of the Paleozoic limestones of Ohio.

All but one, the lowermost, of the elements of the Corniferous limestone of the county are shown in this interesting section. Before treating of other sections in detail, it will be well to establish the divisions of the formation which it is proposed to recognize here. Two well marked divisions have already come to view in the section just described, viz., the blue limestone, thirty-two feet in thickness, which is, from its occurrence at Delaware, and the extensive use made of it at that point, well named the *Delaware limestone;* and secondly, the white and buff limestones which occupy forty-five feet of the scale below the Delaware beds. Though the several portions of this last named section differ from each other considerably in color, bedding and composition, the differences found are not marked and constant enough to demand recognition, and the whole of this section will be designated the *Columbus limestone.* This name was first given to it by Dr. Newberry, in Vol. I, Geological Survey of Ohio, page 143. It is in all respects a suitable name, marking a central and well known locality where the formation is most largely displayed and worked. The Columbus limestone will be held to include all of the beds intervening between the waterlime group of Upper Silurian age, and the bone bed to which reference has already been made. The Delaware limestone completes the series so far as it is shown in Franklin county, holding everything between the bone bed and the blue shales which constitute the base of the Huron shale.

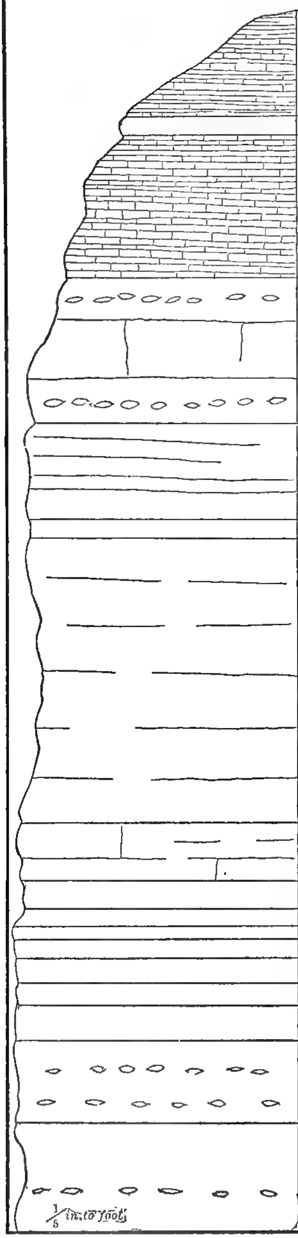
The Hamilton group, a very important member of the Devonian system, is due in this interval, and there is no reason whatever to doubt that some of these upper beds, perhaps a considerable portion, were formed in that period—but no one has yet been able to point out the line of division, stratigraphical or paleontological, in this series, that separates the Hamilton from the Corniferous. In northern Ohio, Dr. Newberry finds a series of shales interposed between the Sandusky (Delaware) limestone and the Huron shale, which contains so strong a preponderance of true Hamilton fossils as to deserve to be called by this name. The apparent stratigraphical equivalent of these Hamilton shales, is the bed of blue shales designated by Prof. Winchell the *Olentangy Shales*, to which reference has already been made in preceding pages, as lying at the base of the Huron shale. In this county, however, it has proved non-fossiliferous wherever examined. There are, indeed, but very limited exposures of it.

Two additional sections of the Columbus limestone will now be described, somewhat in detail. They are found in the two belts of quarries that have been most extensively worked, both for building stone and lime, viz.: the quarries on the east bank of the Scioto, three miles above Columbus, near the railroad bridge of the Piqua (P. C. & St. L.) Road, and known originally as the Medary quarries, but latterly as the Smith and Price quarries, and the "State quarries," located due west of the city, on the further bank of the Scioto River. From these quarries, the stone of which the Capitol is constructed, was derived, the State having purchased the lands which they occupy, and still retaining the ownership.

The Smith and Price section will be first considered. The annexed wood cut represents it. The total thickness of the beds shown in the quarries is thirty-three feet. It does not reach as low an horizon as the section already described, and it includes only the bottom layers of the Delaware beds.

The lowest bed reached here is a three-feet course—quite flinty in composition. It is not raised in large blocks, and the flint prevents it from being easily worked. There is, therefore, no sufficient reason for working it, and it is generally undisturbed, except when drainage or track-laying reaches it. The same can be said of the "two-foot course" that overlies it. This course has a double layer of flint nodules, and probably belongs to the same horizon with the flint nodules of the first section. The layers that immediately succeed this, constitute the most valuable stone of the quarry.

SECTION OF CORNIFEROUS LIMESTONE AT SMITH & PRICE'S (MEDARY) QUARRIES.



	ft	in
Shaly Limestone — *Delaware Beds.*	3	
Bone bed.		6
Blue rock. Tough. Thin Courses.	4,	
Smooth rock. Best for lime. Over 90 per cent Carbonate of lime. Breaks Easily. Two Flint Courses.	4,	
Building Stone. Courses 8 in and less.	2	6"
"Sheepskin." Cutting.		5"
Rough rock. Building Stone. Good for heavy work.	8,	
Building Stone.	1,	7"
"Upper Hackletooth." Seldom cut.		8"
"Lower Hackletooth." Cutting Stone.		5 to 6"
Shell, belongs with above.		
Curb Stone.		6"
Best Cutting Stone of quarry Blue.		8"
		7"
"Big Stone" Blue and drab. Cutting Stone 225 feet Blocks.		11"
Flinty layers.	2,	
Flinty.	3,	

First comes an eleven-inch course, some portions of which are blue in color, though the prevailing color is drab. It is raised in larger blocks than any other course in the quarry. Two hundred square feet are easily obtained in a single block. It is known in the quarry, on this account, as the "*big stone.*" For platforms and other like uses, it is especially valuable.

The "big stone" is followed by a seven-inch course, which sometimes yields cutting stone, but not regularly. This is followed by an eight-inch course, quite blue in color, that is, on the whole, durability, size, color, freedom from flint being considered, the most valuable course of the quarry. It is covered by a six-inch course that serves a good purpose as a curb-stone. This is followed in turn by the lower and upper "*hackle-tooth*" courses, the former a six-inch course, and the latter an eight-inch course. These beds get their name from a sort of suture-like interlocking of their apposed faces. They are quite persistent throughout the district in which quarries are wrought, and serve as guides to the identification of the several sections. The lower course is most valued for cutting, chiefly because of the absence of flint from its substance.

Next in order comes a nineteen-inch course that cannot be raised in blocks large enough to make it a cutting stone. It goes in with the section that lies above it, for all heavy work for which the quarries have to provide. The section which we have now reached is called the "*rough rock.*" It is put down in the scale as eight feet in thickness, but it is oftener four and one-half feet than eight feet. The rough rock is covered by one of the most persistent layers of the quarries. It is called by the quarrymen the "*sheep-skin*" course. It is four to eight inches in thickness; is raised in good sized blocks, and is largely wrought as a cutting stone. The steps of the State House are, to a large extent, derived from this layer. It is crowded with fossils, and these are brought out very distinctly by the wear of the stone. A well-known univalve shell, the *Euomphalus De Cewi*, Billings, belongs in this horizon, and is very often seen on the slabs that belong to this course. Cyathophylloid corals also crowd the surface frequently.

Another series of building stones—in courses eight inches thick or less, making an aggregate of two and one-half feet—overlies the sheep-skin course, and this in turn covered by what is called the "*smooth rock,*" which includes about four feet in thickness. There are two flint courses in this interval that can be followed through the whole belt of quarries. They are easily separated from the rock in which they are bedded. The latter breaks very easily, and yields the best lime of the formation. It averages over ninety per cent. of carbonate of lime, and frequently rises to ninety-five per cent. It is the nearest approach to a pure carbonate of lime that is burned, in the large way, in the State. The lime of New Carlisle, Clarke county, has a somewhat higher percentage, but it does not enter the general market. For all purposes, where a strong and hot lime is desired, this particular layer would meet every requirement. It is called the "*smooth rock*," as has been already stated. This name is well applied to it, on account of the planed surface that the upper face of the rock presents. It could very easily be mistaken for a glacial-planed surface; indeed, it would seem to have been acted on by some force precisely of this character. Fossils that belong in its substance have been cut down just as they have been worn in the surface beds, by agencies of the recent Drift period. No explanation of this unusual phenomenon is offered. Modern researches indicate that ice periods must have prevailed at wide intervals throughout geological time; but no instance is known to be recorded in which the planing and polishing of ancient glaciers, or icebergs, are preserved in rocks of such high antiquity as this Devonian limestone.

The smooth rock is overlain by four feet of what is called by the quarrymen, the "*blue rock*". It lies in very thin courses, and is valueless for building stone, and of little worth for lime.

The course that covers it is the most interesting stratum, not only of the section now under consideration, but of the whole Corniferous formation of Ohio as well. It is one of the most remarkable layers, indeed, in the entire series of American Paleozoic deposits. Reference has already been made to it under the name of the *bone bed*. The name describes the stratum. It is six inches in thickness, and is literally made up hrough considerable portions of its extent, of the teeth, and plates, and bones of fishes. These remains are in excellent preservation. The teeth retain the polish and structure of life, but in color they have been uniformly changed to light brown; the plates and bones are usually black or brownish black. The surfaces of the plates frequently retain the dermal tubercles, or other ornamentation, with perfect distinctness. The teeth belong mainly to one genus, viz.: *Onychodus*, and it is not certain that the forms, shown so abundantly at this horizon, differs specifically from those described from other beds. The crest of teeth in the end of the jaw, which is characteristic of this genus, is sometimes, though rarely, found here, the teeth occurring usually detached, but a large number of them being entire. Other fossils are found to a limited extent in the bone bed, the most abundant and conspicuous being an *Athyris*, which closely resembles *A. vittata*, Hall, from the same general horizon at Louisville, Kentucky.

The description now given applies to the stratum, as shown in the quarry, under discussion. The stratum extends through the formation, wherever shown in Franklin county, but it is only in a limited area, even in this quarry, that it presents all of these points of interest. Elsewhere scarcely a single square foot can be found which does not contain some fragment of a tooth or plate; but here these elements make up the substance of the bed. Several chemical analyses have been made up of this layer. Two, executed at the Ohio Agricultural and Mechanical College, by Mr. C. C. Howard, gave the following results:

No. 1.

Triple phosphate of lime	16.80
Carbonate of lime	73.24
Carbonate of magnesia	4.97
Oxide of iron	2.46
Silicious matter	2.14
	99.61

No. 2.

Triple phosphate of lime	18.32

These specimens are exceptionally rich in phosphate of lime, and can not be taken to represent fairly the composition of the whole bed to which they belong.

An analysis is reported to have been made by Prof. H. B. Cornwall, of Princeton, New Jersey, which indicated as much as five per cent. of phosphate of lime for the body of the rock. If continuous deposits should hereafter be discovered, that would average as well as many samples now found, they could be turned to economical advantage for fertilizers.

The bone bed can be traced from the State quarries, the southernmost point at which its horizon is exposed, to the north line of the county, being easily recognizable in every section in which its presence is due.

The identification of most of these exposures was first made by Mr. W. Farrar, a student of geology in the Ohio Agricultural and Mechanical College.

The discussion of its origin and history will be reserved for a subsequent page in the report.

It will be remembered that the bone bed makes the boundary between the Delaware and the Columbus divisions of the Corniferous limestone. Immediately above it, in Smith and Price's quarries, three feet of very thin bedded, shaly limestones are found. The same formation can be traced along the water-courses that descend to the river here, until twenty feet, at least, is added to the quarry section. The Delaware beds here have but little in common with the same division on the northern line of the county. The layers are seldom an inch thick, except when black flint courses, three or four inches thick, come in to supplement the shales. They are almost destitute of fossils; but three shells have ever been recognized in this series at this point. One of them is a shell of universal occurrence, and that existed as a species through vaster periods of duration than any other known form, viz.: *Strophomena rhomboidalis*, Wahl. It begins in Lower Silurian time and continues until the close of the Carboniferous age; thus spanning the whole vast cycle of Paleozoic time. It is but half grown, as found in the shales, having nothing of the robustness belonging to the form in the beds below. A second shell sometimes, though rarely, found in these beds is *Spirifera mucronata*, Hall, another form of quite extensive range. The third form noted here is identified by a single specimen only, as *Spirifera maia*, Billings. There is no reason to doubt that portions of the series will hereafter be found as rich in fossils as the equivalent beds are elsewhere. The shales are useful only for road-making. The flint that they hold gives some promise of rendering service in this way. They would probably answer a better purpose than the Coal Measure limestones, which have lately been brought into Columbus at considerable expense, for this use. The whole section of the Corniferous limestone is nowhere completed in this locality, the highest beds seen in it belonging to about the middle of the Delaware division.

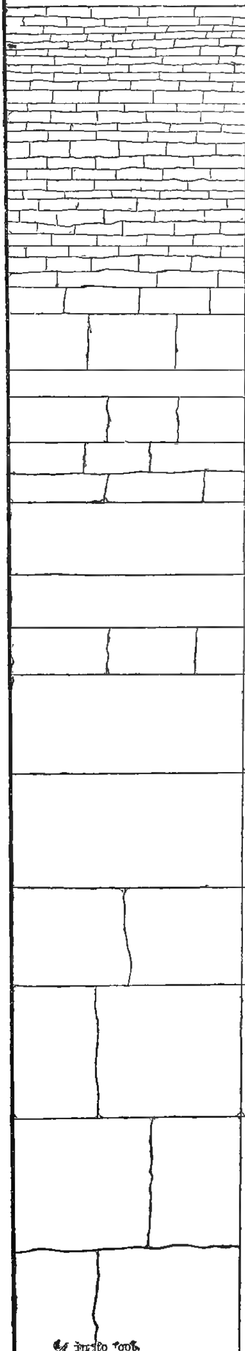
The general section shown at the State quarries is represented in the annexed wood cut. As these quarries occupy a large area, and, as the separate layers expand or shrink, or even disappear if they are followed far, many sections can be obtained that will not match in every particular with the one here given; but the aim has been to show the yield of the quarries where most extensively worked.

Twenty-six and a half feet are represented in the section.

The lowest course lies below the level of low water in the Scioto River. It was reached only when the quarries were being worked for the construction of the State-house. It is a massive bed, five and a half feet in thickness, though it splits into two nearly equal courses so easily, that it is almost as well to describe it as consisting, normally, of two courses. It can be raised in large blocks, and furnishes the best stone of the quarry for massive work. The columns of the State-house are derived from this layer, split, however, into two, as it generally is when worked.

Four other heavy courses, measuring respectively two feet ten inches, two feet three inches, two feet six inches, and two feet, come next in order. All are raised in blocks of good size, and all are available for the best

SECTION OF CORNIFEROUS LIMESTONE AT STATE QUARRIES.



	feet. in.
"*Calico Courses.*" *Yellowish and muddy.* *Building Stone.* (*4 in to 6 in.*) *Six feet above the summit of this section the bone bed occurs, overlain by the lowest courses of the Delaware beds.*	5,
	10,
"*Sheepskin.*" *Good Cutting Stone.*	6, to 9,
Rough Rock	1, 4,
	6,
Worked for Steps &c. Cutting Stone.	10,
Splits into "Twin Eights" Cutting Stone.	1, 4,
"*Top Hackletooth,*" *for columns, etc. Cutting Stone.*	1, 7, 1, 1
"*Bottom Hackletooth.*" *Bluest course in quarry. Cutting Stone,*	1, 2,
Joined in course above sometimes.	1,
Cutting Stone.	2,
Grayest Stone in quarry. Cutting Stone.	2, 6,
Quarried in massive blocks. Cutting Stone.	2, 3,
Same as above. Cutting Stone.	2, 10,
Lowest course ever reached at State Quarries. *Splits into two.* *Columns of State House from this course.* *Cutting Stone.*	5, 6,

uses in building. The prevailing color is light-gray, with yellowish and bluish tints intermingled.

The bottom hackletooth, which lies just above the courses already named, is the bluest stone in the quarry. It is fourteen inches thick, and quite free from flint, and is, therefore, counted as one of the most desirable layers found here. The top hackletooth is thirteen inches thick, and is raised in blocks adapted to columns, more easily than any other course, and thus comes to be used for this purpose quite extensively. It is light colored. It is overlain, as in the previous section, by a nineteen-inch course, which furnishes only building stone. The sixteen-inch course, next above, splits very readily into the "*twin eights*," two very serviceable layers, which are well known and widely used. The ten-inch course that covers them, like the upper hackletooth, is raised in long blocks, and so furnishes very convenient stone for steps, to which purpose it goes quite largely. The "rough rock" here falls below two feet, and is overlain, as in the Smith and Price quarry, by the "sheep-skin," one of the valuable, though thinner, courses of the quarries. The cutting stone of the quarries ends with this course. It will be observed that ten layers of stone here, deserve this name, or double the number that is reported at Smith and Price's. This is explained by the fact that the State quarries reach a lower horizon, a horizon which, everywhere in Ohio, yields the heaviest courses of the formation, and, also, from the fact that the latter quarries have been driven further back into the solid rock than the former.

An interval, varying between eleven and fourteen feet of quite thin layers, useful for lime manufacture, and, to some extent, as building stone, come in before the horizon of the bone bed is reached. This last division is highly fossiliferous, and contains many of the characteristic fossils of the formation, to which reference will again be made. The upper beds are softer, and occasionally particolored, and are sometimes styled the "*calico stone.*"

It is probable that the heavy course taken up from the bottom of the State quarries, nearly or quite exhausts the descending scale of the Corniferous limestone. It has not been found possible to settle this beyond question, but the facts are these: North of the county line, in the valley of the Scioto, the junction of the Waterlime and Corniferous is seen. It is there found that the thick beds shown at Corbin's Mills, and at Dublin, are very near the boundary of the formations. Again, in the valley of Big Darby Creek, below Georgesville, the contact of these two formations can be seen; and here, again, several massive courses mark the beginning of the Corniferous deposits. The boundary, at this point, is quite marked by the occurrence of high-colored clays, red and white, that hold the interval between the two formations.

One peculiar phase of the lower Corniferous limestone, in this region, deserves to be noted here. About twelve or fifteen feet above the base of the formation, deposits of a very fine-grained and sharp, silicious sand occur locally. None of these deposits have been noticed in Franklin county; but just beyond the line, in Jefferson township, Madison county, on the bank of Little Darby Creek, this Corniferous sandstone is found, and there is every reason to believe that other pockets of it will be found in the vicinity. Facts of the same sort are given in the report on Champaign county; and in northern Ohio, like deposits are known. The sandstone exactly agrees in character with the Hillsboro sandstone, of the Niagara group. That occurs, also, in local deposits, interrupting the continuity of a great limestone formation.

This Corniferous sandstone has long been known to the plasterers of the neighborhood. Whenever the finest quality of work was required, recourse was had to the thin layers of sandstone found in the section here referred to. More particular description of the deposit will be found in the report on Madison county. Its composition is ninety-two per cent. of silica, and seven per cent. of lime.

The Delaware beds appear in this section, also, in the very thin layers that cover the limestone at many points in the quarry. All that was said in regard to this stratum, under the previous section, applies to it as shown here.

Enough has now been said upon the stratigraphical relations of the Corniferous limestone, to give the reader a fair idea of the formation. Incidental reference has been made, in several instances, to its chemical composition, and, also, to its paleontology. These topics will now be treated a little more at length.

2. *Chemical Composition.*—Under the head of chemical composition, such analyses as are available, will be given. They will be arranged in ascending order, beginning with the lowest beds of the formation.

Analysis No. 1, is of the heavy course that lies just above low water at Dublin. As has been shown, it belongs very near the lower boundary of the formation. It shows itself to be a magnesian limestone, and this is true, to the same extent, of but few courses in the Corniferous limestone of Ohio. It will be remembered that the Waterlime and Niagara groups, which underlie the Corniferous for at least 200 feet of vertical descent, are both magnesian limestones—for the most part, containing more than forty per cent. of carbonate of magnesia.

All the beds of the Corniferous limestone, have more or less magnesia in their composition; but the courses in question are almost the only ones that attain this percentage. Their chemical relations are rather with the beds below them, than with those above.

No. 1.

Carbonate of lime	55.09
Carbonate of magnesia	41.07
Oxide of iron	.63
Silicious matter	1.96
Organic matter	.92
	99.67

Analysis No. 2 appertains to the same horizon. The specimen wa obtained from the quarries of the Roberts Bros., Jefferson township, Madi son county. (Bank of Little Darby Creek.)

No. 2.

Carbonate of lime	64.20
Carbonate of magnesia	34.44
Alumina and iron	.00
Insoluble matter	1.10
	99.74

Analysis No. 3 is of the rock that lies at the base of the Corniferous limestone, at Bellefontaine. (Stevenson's quarries.)

No. 3.

Carbonate of lime	56.40
Carbonate of magnesia	41.46
Alumina and iron	.20
Insoluble matter	1.20
	99.29

For comparison the analysis of the Lower Corniferous, from Paulding county, is appended. The stone here is very different in appearance from any other in the series, being non-fossiliferous and quite fine and even grained. The specimen analyzed is from Clark's quarries, Charloe.

No. 4.

Carbonate of lime	57.09
Carbonate of magnesia	33.14
Alumina and iron	2.97
Silicious matter	5.33
Organic matter	.88
	99.41

Nos. 5 and 6 are from the quarries of Smith and Price. The first of these represents quite favorably, the general composition of the most valuable stone of the quarry—viz., the cutting stone, while No. 4 shows the character of the "smooth rock," and of three or four feet immediately underneath it that are most valued for lime.

No. 5.

Carbonate of lime	81.14
Carbonate of magnesia	16.00
Alumina and iron	1.08
Silicious matter	1.94
	100.16

No. 6.

Carbonate of lime	93.28
Carbonate of magnesia	2.69
Ferric and aluminic oxides	2.18
Silicious matter	1.41
	99.56

It may be remarked, in regard to No. 5, that the percentage of silica alumina, and iron is exceptionally small. The bluer courses show a considerable increase, as is seen in analysis No. 7.

No. 7.

Carbonate of lime	83.20
Carbonate of magnesia	11.96
Alumina and iron	.80
Silicious matter	4.00
	99.96

No. 8 shows the composition of Stitt and Price's best lime. The specimen analyzed was selected from the kiln with reference to quality—and the results both of this analysis and of No. 6, will scarcely be sustained by any large quantity. Still, if lime of exceptionally good quality was desired, it could be secured from these known horizons of the quarry.

No. 8.

Carbonate of lime	94.80
Carbonate of magnesia	1.21
Alumina and iron	.80
Silicious matter	3.20
	100.01

Nos. 9, 10, 11, and 12, all represent the Delaware beds in their different phases. The first three analyses were made from the shales that are shown in the State quarry section. The varying proportions of silicious matter will be noticed. Samples could easily be selected that would yield much larger percentages than these.

No. 9.

Carbonate of lime	65.80
Carbonate of magnesia	8.02
Alumina and iron	1.20
Silicious matter	25.00
	100.02

No. 10.

Carbonate of lime	72.82
Carbonate of magnesia	5.99
Alumina and iron	2.80
Silicious matter	16.06
Organic matter	1.75
	99.42

No. 11.

Carbonate of lime	88.40
Carbonate of magnesia	1.96
Alumina and iron	3.80
Silicious matter	5.40
	99.56

No. 12 shows the character of the Delaware stone in the northern part of the county. The sample analyzed was the blue building stone of Ferris's quarry, in Perry township. It doubtless agrees with much of the Delaware stone proper in composition, as it does in general appearance.

No. 12.

Carbonate of lime	57.09
Carbonate of magnesia	33.14
Alumina and iron	2.97
Silicious matter	5.33
Organic matter	.88
	99.41

The analyses given above were all executed for the Geological Survey Numbers 2 and 3 were furnished by Prof. Wormley; numbers 5, 6, 7, and 8 were made by Dr. C. L. Mees, now of Louisville, Kentucky; and numbers 1, 4, 9, 10, 11, and 12 were executed by Mr. C. C. Howard, in the laboratory of the Ohio Agricultural and Mechanical College.

Application will be made of some of these analyses in treating of the economical geology of the formation.

3. *Paleontology.*—The Corniferous limestone is a great store-house of fossils. Almost all limestones are of organic origin, but this shows its origin in every layer. The substance of the rock is often composed of the exquisitely preserved fabrics of the life of the seas of this distant date. Sea-weeds and corals, chambered and univalve shells, bivalves and brachiopods, were strewn indiscriminately upon the floor of this ancient sea, and built it up thus by slow additions. Vast periods of time were used in this work. The species that flourished when the earlier beds were being deposited, had their day, and in many instances, gradually disappeared long before the series was completed. New forms came in from time to time, some of which are identical with species found in

widely removed places, while others are peculiar to the locality in which they are found. Some fossils are abundant through the whole extent of the formation, even entering it from seas of an earlier age. Others are equally abundant in the one limited horizon which they occupy. Through a foot or two of the limestone they are everywhere shown, but no fragment or trace is found above or below.

As in all other assemblages of fossils, many species are established on a very few specimens—oftentimes on but a single one. The wealth of the formation in this department is not yet appreciated in any adequate degree. When the same measure of interest and labor has been given to it that has been spent in the Cincinnati formation, for example, its list of species will be several times greater than it now is.

One strong hold upon our interest this formation possesses, in the fact that it contains the earliest undisputed remains of *land vegetation* and *vertebrated animals* that are found in the rocks of the continent. Its tree ferns and its fishes are altogether new types in the world. Special interest is drawn to these earlier forms on account of their bearing on questions of derivation.

A catalogue of fossils described from this formation, is here appended. No name is introduced except upon the authority of the paleontologists of the survey—F. B. Meek, Esq., and Profs. R. P. Whitfield and H. A. Nicholson. A large number of the species are represented in the collection of the Ohio Agricultural and Mechanical College. To the lists are added the generic names of a few well-marked, but undescribed forms, which have been recognized as distinct species by the authorities named above

CATALOGUE OF THE DESCRIBED FOSSILS OF THE CORNIFEROUS LIMESTONE OF OHIO.

PLANTS.

Fucoids abundant on surfaces of upper beds at State quarries, Columbus.
Spirophyton—cauda galli?

GENUS CAULOPTERIS.

(Tree ferns.)

Caulopteris antiqua, Newberry.
C. peregrina, Newberry.

GENUS LEPIDODENDRON.

(Club mosses.)

Lepidodendron, Gaspianum? Dawson.

GENUS DADOXYLON.

(Ancient pines.)

Dadoxylon Newberryi, Dawson.

SPONGES.

GENUS STROMATOPORA. DeBlainville.

Stromatopora granulosa, Nich.
" *Sanduskyensis*, Rominger (unpublished.)
NOTE—These two species may prove identical.
" *ponderosa*, Nich.
" *concentrica*, Goldf. ?
" *substriatella*, Nich.
" *nodulata*, Nich.

GENUS SYRINGOSTROMA. Nicholson.

Syringostroma densa, Nich.
" *columnaris*, Nich.

CORALS.

GENUS FAVOSITES. Lamarck.

Favosites gothlandica, Lamarck.
" *basaltica*.
" *turbinata*, Billings. (*F. hemisphericum*, Yandell ?)
" *pleurodictyoides*, Nich.
" *polymorpha*, Goldf.
" *invaginata*, Nich.

GENUS PHILLIPSASTREA. D'Orb.

Phillipsastrea ? gigas, Owen.

GENUS ACERVULARIA. Schweigger.

Acervularia profunda, Hall.
" *Davidsoni*, E. and H.

GENUS ERIDOPHYLLUM. Edwards and Haisne.

Eridophyllum strictum, E. and H.
" *Verneuilanum*, E. and H.

GENUS SYRINGOPORA. Goldfuss.

Springopora Hisingeri, Billings.
" *Maclurei*, Billings.

GENUS HELIOPHYLLUM. Hall.

Heliophyllum Halli. E. and H.

GENUS CYATHOPHYLLUM. Goldfuss.

Cyathophyllum rugosum, Hall.
" *Zenkeri*, Billings.

GENUS ZAPHRENTIS. Rafinesque.

Zaphrentis gigantea, E. and H.
" *prolifica*, Billings.
" *multilamellata*, Nich.
" *Wortheni*, Nich.
" *Edwardsi*, Nich.

GENUS CYSTIPHYLLUM. Lonsdale.

Cystiphyllum Americanum.
" *Ohioense*, Nich.
" *vesiculosum*, Nich.
" *sp.?*

POLYZOA.

GENUS PTILODICTYA. Lonsdale.

Ptilodictya Gilberti, Meek.
" *sp.?* Meek.

GENUS FENESTELLA. Lonsdale.

Fenestella, sp ?

CRINOIDS AND CYSTIDEANS.

GENUS MEGISTOCRINUS.

Megistocrinus (Actinocrinus) spinulosus, Lyon.

GENUS DOLATOCRINUS.

Dolatocrinus Marshi.
" *radiatus*, Hall.

GENUS NUCLEOCRINUS. Conrad.

Nucleocrinus Verneuili, Troost.

GENUS CODASTER. McCoy.

Codaster pyramidatus, Shumard.

TRILOBITES.

GENUS DALMANIA. Emmerich.

Dalmania Ohioensis, Meek; (*D. Helena*, Hall.)
" *calypso*, Hall.

GENUS PROETUS. Steininger.

Proetus crassimarginatus, Hall.
planimarginatus, Hall.

GENUS PHACOPS. Emmerich.

Phacops bufo, var. rana, Green.

BRACHIOPODS.

GENUS CENTRONELLA. Hall.

Centronella glans fagea ? Hall.

GENUS TROPIDOLEPTUS. Hall.

Tropidoleptus carinatus, Conr.

GENUS TEREBRATULA. Llhwyd.

Terebratula Sullivanti. Hall.

GENUS SPIRIFERA. Sowerby.

Spirifera acuminata, Conr.
" *duodenaria*, Hall.
" *euryteines*, Owen.
" *fimbriata*, Conr.
" *gregaria*, Clapp.
" *Grieri*, Hall.
" *macra*, Hall.
" *macronota*, Hall.
" *macrothyris*, Hall.
" *maia*, Billings.
" *Manni*, Hall.
" *mucronata*, Conr.
" *Oweni*, Hall.
" *varicosa*, Hall.

GENUS SPIRIFERINA. D'Orbigny.

Spiriferina raricosta, Conr.

GENUS MERISTELLA. Hall.

Meristella nasuta, Conr.
" *scitula*, Hall.

GENUS CYRTINA. Davidson.

Cyrtina Hamiltonensis, Hall.

GENUS NUCLEOSPIRA. Hall.

Nucleospira concinna, Hall.

GENUS ATHYRIS. McCoy.

Athyris spiriferoides, Eaton.
" *vittata*, Hall.

GENUS ATRYPA. Dalman.

Atrypa reticularis, Dalm.
" *aspera*, Schl. ?

GENUS RHYNCHONELLA. Fischer.

Rhynchonella carolina, Hall.

GENUS PENTAMERUS. Sowerby.

Pentamerus aratus, Hall.

GENUS ORTHIS. Dalman.

Orthis Vanuxemi, Hall.
" *propinqua*, Hall.

GENUS STROPHOMENA. Rafinesque.

Strophomena rhomboidalis, Wahl.

GENUS STROPHODONTA. Hall.

Strophodonta hemispherica, Hall.
" *demissa*, Conr.

Strophodenta sub-demissa, Hall.
" *Pattersoni*, Hall.
" *perplana*, Conr. (*S. fragilis*, Hall.)
" *inequistriata*, Conr.

GENUS STREPTORHYNCHUS. King.

Streptorhynchus Chemungensis, Conr.; *var Pandora*, Bill.

GENUS PRODUCTELLA. Hall.

Productella spinulicostae, Hall.

GENUS CHONETES. Fisch.

Chonetes laticosta, Hall.

GENUS DISCINA. Lamarck.

Discina. sp.?

GENUS LINGULA. Bruguières.

Lingula Manni, Hall.

LAMELLIBRANCHS.

(Bivalve shells.)

GENUS AVICULOPECTEN. McCoy.

Aviculopecten parilis, Conr.

GENUS PTERINEA. Goldfuss.

Pterinea flabella.

GENUS CONOCARDIUM. Brown.

Conocardium trigonale, Hall.
" *Ohioense*, Meek.
" *sp.* (undescribed)

GENUS PARACYCLAS.

Paracyclas Ohioensis, Meek.
" *elliptica*, Hall.
" *occidentalis*, H. and W.

GENUS SOLEMYA. Lamarck.

Solemya vetusta, Meek.

GENUS MYTILARCA.

Mytilarca ponderosa, H. and W.

GENUS CLINOPISTHA. Meek and Worthen.

Clinopistha antiqua, Meek.

GENUS SANGUINOLITES. McCoy.

Sanguinolites Sanduskyensis, Meek.

GENUS XENOPHORA. Fischer.

Xenophora antiqua, Meek.

GENUS PORCELLIA. Léveillé.

Porcellia Sciota, Hall.

GENUS NYASSA.

Nyassa arguta.

GENUS GRAMMYSIA. DeVerneuil.

Grammysia secunda, Hall.
" *bisulcata.* (?)

GASTEROPODS.

(*Univalve Shells.*)

GENUS NATICOPSIS. McCoy.

Naticopsis humilis, Meek.
" *levis*, Meek.
" *aequistriata*, Meek.
" *cretacea*, H. and W.

GENUS LOXONEMA. Phillips.

Loxonema Hamiltoniae, Hall.

GENUS ISONEMA. Hall.

Isonema bellatula, Hall.

GENUS ORTHONEMA. Meek and Worthen

Orthonema Newberryi, Meek.

GENUS TURBO. Linnaeus.

Turbo Shumardi, Yandell.
" *rotundata*, Hall.

GENUS EUOMPHALUS. Sowerby.

Euomphalus De Cewi, Billings.

GENUS PLEUROTOMARIA. Defrance.

Pleurotomaria Lucina, Hall.
" *Kearneyi*, Hall.

GENUS CYCLONEMA. Hall.

Cyclonema crenulata, Meek.

GENUS MURCHISONIA. De Verneuil.

Murchisonia Maia, Hall.

GENUS PLATYCERAS. Conrad.

Platyceras dumosum, Conr.
" *dumosumvar. attenuatum*, Meek.
" *multispinosum*, Meek.
" *carinatum*, Hall.
" (sp. undescribed)

GENUS PLATYOSTOMA. Conrad.

Platyostoma Lichas, Hall.
" *lineatum*, Conr.

GENUS TROCHONEMA. Salter.

Trochonema tricarinata. Meek.

GENUS BELLEROPHON. Montfort.

Belleriphon Newberryii, Meek.
" *propinquus,* Meek.

PTEROPODS.

(*Winged Shells.*)

GENUS CONULARIA. Miller.

Conularia elegantula, Meek.

GENUS TENTACULITES. Schlotheim.

Tentaculites, (sp. undescribed.)

NOTE.—This is the form commonly known as *T. scalaris.* Schl.

CEPHALOPODS.

(*Chambered Shells.*)

GENUS ORTHOCERAS. Breynius.

Orthoceras profundum, Hall.
" (sp. ? undescribed), College Cabinet.
" (sp. ? undescribed), " "
" (sp. ? undescribed), " "

GENUS GYROCERAS. Meyer.

Gyroceras Cyclops, Hall.
" *Ohioense,* Meek.
" *inelegans,* Meek.

GENUS CYRTOCERAS. Goldfuss.

Cyrtoceras Ohioense, Meek.

GENUS GOMPHOCERAS. Sowerby.

Gomphoceras (sp. undescribed). College Cabinet.

VERTEBRATES.

(*Fishes.*)

GENUS MACROPETALICTHYS. Norwood and Owen.

Macropetalicthys Sullivanti, Newb.

GENUS ONYCHODUS. Newberry.

Onychodus sigmoides, Newb.
" *sp.?* Undescribed.

GENUS COCCOSTEUS. Agassiz.

Coccosteus occidentalis, Newb.

GENUS ASTEROSTEUS. Newberry.

Asterosteus stenocephalus, Newb.

GENUS ACANTHASPIS. Newberry.

Acanthaspis armatus, Newb.

GENUS ACANTHOLEPIS. Newberry.

Acantholepis pustulosus, Newb.

GENUS LIOGNATHUS. Newberry.

Liognathus spatulatus, Newb.

GENUS MACHÆRACANTHUS. Newberry.

Machæracanthus major, Newb.
" *peracutus*, Newb.
" *sulcatus*, Newb.

GENUS CYRTACANTHUS. Newberry.

Cyrtacanthus dentatus, Newb.

GENUS RHYNCHODUS. Newberry.

Rhynchodus secans, Newb.
" *frangens*, Newb.
" *crassus*, Newb.

The above list is meant to comprise all of the fossils that have been described or identified from the Corniferous Limestone of Ohio. A considerable number of these are included in the two volumes of Ohio Paleontology, already published. Others have been described in the reports of other States from Ohio specimens, and still others are species that are common to the rocks of this age in various American localities, some of them, indeed, belonging to the Old World as well.

A few statements in regard to the horizons of some of the species will be added here.

The following fossils are found in Franklin county to have but very little vertical range:

About fifteen feet below the bone bed, *Cystiphyllum Americanum* often makes up a large part of the rock for four or five feet.

Eridophyllum Verneuilanum holds very closely to one horizon in Franklin county. It is found about three feet below the bone-bed, and is coëxtensive with the formation. Wherever the proper horizon is reached, this fossil is found. This horizon has not been identified with that which this fossil holds at Sandusky, but it is probably the same. The seas seem to have been paved with it at the time when this layer was forming.

Nucleocrinus Verneuili belongs between two flint courses just under the bone-bed. It is very abundant in this horizon.

Platyceras dumosum is also found abundantly in the same stratum, but it may not be limited to it.

Spirifera maia has been found only in the lowest courses of the Delaware beds. The same is true of *Athyris vittata*, which occurs *in* the bone-bed.

Grammysia bi-sulcata occurs near the bottom of the Delaware beds, but is rarely met.

Rhynchonella Carolina belongs very near the bone-bed—is found sometimes, indeed, in it.

The only tentaculite known in the system (*Tentaculites sp.?*) belongs in the Delaware beds, and mainly in the uppermost portions.

In the fifteen feet below the bone-bed the following forms are found. Those marked with a star are not known to occur elsewhere, but more extended observations on these points are necessary:

Spirifera acuminata.
*Spirifera manni.**
*Spirifera duodenaria.**
Spirifera gregaria.
Strophomena rhomboidalis.
Strophodonta hemispherica.
*Chonetes laticosta.**
Atrypa reticularis.
*Nucleospira concinna.**
*Platyceras dumosum.**
Proetus planimarginatus.
Dalmania Ohioensis.
Phacops bufo.
*Nucleocrinus Verneuili.**
*Cystiphyllum Americanum.**
Favosites.
Cyathophyllum Zenkeri?
*Eridophyllum Verneuilanum.**
Fenestella.

Allusion has already been made to the peculiar interest with which the remains of ancient fishes, contained in the Corniferous limestone, must be viewed. They mark the presence of a higher type of animal life in this formation than any of the strata below it contain. They constitute the lowest and oldest remains of vertebrates that we meet in ascending the geological scale of the continent. The vertebrate type appears here as well as elsewhere in its lowest class, viz., Fishes.

For the discussion of the zöological position, and the details of structure of these Corniferous fishes, the reader is referred to the chapters of Vols. I and II Paleontology, that treat of them. By reference to these chapters, it will be learned that many of these early fishes were of great size and in some respects, certainly, of quite high organization. Those of the present day which they most nearly resemble are the ganoids, represented in North America by the pike and the sturgeon, and the sharks which are widely distributed in existing seas.

The exact stratum in which they first appear cannot be pointed out, but it is certainly quite low in the Corniferous series. It is among the heavy courses that constitute the base of the system. The remains that are found at this lowest horizon are the cranial plates, often united in a symmetrical skull, of the great ganoid, *Macropetalicthys Sullivanti.* This, then, is the lowest and oldest of the fishes of the Devonian rocks of Ohio. The type specimens were furnished by Joseph Sullivant, Esq., of Columbus, to whose watchful and discriminating inspection of the State quarries when they were most largely worked, science is under great obligations. Quite a number of the most interesting fossils of the formation were gathered by him at this time. The remains of this fish so far known, all came from one horizon.

The next fish remains that we meet in ascending the series are those of *Onychodus sigmoides*, the teeth of which are not uncommon fossils in the middle Corniferous of Franklin county. The remains of this genus, perhaps of this species, also, are found throughout a considerable vertical range. They can be followed into the Huron shale, at least.

There came a time in the history of the Corniferous sea when fishes of this genus constituted its most conspicuous and abundant inhabitants. There was scarcely a square foot of the sea-floor for hundreds of square miles that did not contain a tooth or plate of jaw of some fish that had met its fate in the waters above. There were considerable areas that seem to have been the gathering grounds, perhaps the breeding stations, of these tribes of the sea. Here their remains are accumulated to the exclusion of almost everything else. A six inch layer is chiefly composed of these remains. It is the *bone bed* to which such frequent reference has been made.

Recent explorations show that over large areas on the floor of existing seas, the teeth of sharks are of very frequent occurrence. The dredge cannot scrape this floor for even a few minutes without bringing up one or more teeth, sometimes white and fresh, and sometimes hidden in mineral concretions. The deposits are growing very slowly in all such seas and the dredge very likely brings up in one haul the accumulations of scores, perhaps of hundreds of years. The reason why teeth are found so much more abundantly than other portions of the skeleton is that they are among the few portions that are thoroughly mineralized, and consequently able to resist decay. The framework of the shark is chiefly cartilaginous. These facts help us to understand the origin of the layer in the Corniferous limestone which we are now considering. The fact, itself, is one of great interest. Hardly had fishes appeared in the seas before they took almost complete possession of them. A bone bed made of their remains, is one of the earliest facts in their history, in the European rocks, as it is in our own.

IV. ECONOMICAL GEOLOGY.

A few additional statements will here be made in regard to the useful applications of the Corniferous limestone.

These applications are two in number, and have been already incidentally treated. The formation furnishes *building stone* and *lime*. The supply in Franklin county is indefinitely great. It can be counted by the square mile, in areas that require very little stripping and where railroad transportation can be made easily available. The abundance of the supply is best understood when it is remembered that the quarries are never less than twenty feet in depth, and that often thirty feet of stone, almost every foot of it available for some purpose, lie above the river level. Assuming the specific gravity of the limestone to be 2.5, an acre, worked to a depth of 25 feet, yields 85,000 tons, and a square mile yields under the same conditions 54,400,000 tons, an amount which can be readily expressed in figures, but of which we can form no adequate conception.

The character of the building stone furnished remains to be described. Very much can be said in its favor. It is a dense, compact limestone, with a specific gravity exceeding 2 5. It is very strong and can bear all of the burdens which architecture demands. A number of the courses yield *cutting stone* that is, the stone lies in the courses in pieces of several hundred feet square and can be raised in blocks large enough to answer for sills, window-caps, platforms and similar uses. When the stone comes out in this way, it commands four times the price that *building* stone, i. e., the stone that is raised in blocks too small for such applications, brings. It is generally worked with sufficient ease, though some courses that are otherwise suitable have too large a proportion of flint. Its color is very satisfactory, all the shades being cheerful and pleasant to the eye, and sufficient variety being afforded by judicious selection. It receives ornamentation to good advantage, moulding and other relief showing well upon it. Much of it can be made to take a very good polish. An establishment for rubbing the stone has lately been set up in Columbus and is doing good work.

As to durability, which after all is the main element in determining its value as a building stone, it can be said that the Corniferous limestone furnishes much material decidedly above the average of limestones. The chief drawback lies in its highly fossiliferous character. Sometimes the fossil is so firmly cemented in the body of the rock that there is no more tendency to the weathering of the stone about it than elsewhere, but oftener, there is a slight difference in composition between the fossil and the rock, the fossil being the firmer.

Along the line of union, atmospheric agencies take easy hold, and a few years are sufficient to give to the dressed block a rough and unpromising appearance. Examples enough can be found of this agency in the best building for which the limestone has yet been used, viz., the State Capitol. Thinner courses, those measuring six or eight inches, are generally the ones that show worse in this respect, and smoothly dressed surfaces are disfigured more than others. It is within the architect's province to so use the stone as to escape the appearance of weakness and decay, for the evil chiefly lies in the unsightly face which the slight weathering produces. The strength of the block when well laid is good for centuries.

The thickness of the several courses of cutting stone may have been already noted. Almost any required thickness can be furnished within the limits of four and sixty inches. To make an enumeration, we find—

A 4-inch course; a 6-inch course; a 7-inch course; an 8-inch course; a 10-inch course; an 11-inch course; a 12-inch course; a 14-inch course; a 16-inch course; a 19-inch course; a 24-inch course; a 27-inch course; a 30 inch course; a 34-inch course; a 60 inch course.

One other important use to which this limestone is put, is in the making of road-beds. Like other limestones, this one proves unsatisfactory for the surface of a much-used roadway. It grinds quite easily into fine dust, the lightness of which allows it to be lifted into the air very easily. But when used as a foundation for concrete or other surface, it serves a very useful purpose.

The principal quarries now worked, are the two of which sections have been given, viz., the State quarries, and Smith and Price's quarries. The former are taken to include the many openings that are made in the immediate vicinity of the quarries owned by the State, as well as these extensive excavations. Numerous parties are now engaged in quarrying, in a small way, on both sides of the river, for four miles above the city.

The other chief use of the formation is in the manufacture of quicklime. A large business of this sort is carried on in connection with the quarries referred to above. A notable part of the limestone, viz., eight to ten feet below the Delaware beds, is better adapted to this use than to any other. Too light for building purposes, it would need to be removed at great expense in order to reach the valuable courses below, were it not that it can be used in the lime-kilns with the best results. The analyses already given show the character of the lime produced. As has been already remarked, these quarries furnish the purest carbonate of lime burned, in the large way, in Ohio. It can easily be made to average in the kilns ninety per cent. of this substance; but the economy of throwing in the "spalls," or fragments of the building-stone, instead of leaving them out as waste, reduces the percentage somewhat. The lower courses, it will be remembered, have a larger proportion of magnesia in their composition. The character of the lime is changed, to some extent, by this element, but it is not safe to say that it is injured for all uses. The most approved plastering limes of Ohio to-day are those manufactured from the Upper Silurian formations, the Niagara and the water-lime, which are, chemically, double carbonates of magnesia lime, and of these, the Springfield lime may be taken as a representative. For paper factories, for glass-works, for blast-furnaces, and perhaps for gas-works, the product is to be valued in proportion to its percentage of lime; but in the wider use of lime, as mortar, a high percentage of this substance is not necessary to insure a high quality. The truth is, that the different kinds of limestone yield different kinds of lime, and use has much to do in the value set upon any one. They require different modes of treatment. Each will fail when subjected to the mode of working which the other requires.

The Columbus lime is a very hot, strong, white lime, that can be made to do the best work of its kind in every respect. To one important use, in addition to all others, to which it has been applied, it seems likely to be put, viz., to use as furnace flux. The furnaces that are already built, or are in process of erection in the Hocking Valley, have, it is true, layers of limestone in the hills which contain their ore and coal; but these layers are generally light, and it can scarcely prove profitable to follow them into the hills under cover, when limestone of such quality can be so cheaply furnished from the great quarries of Columbus and vicinity.

Columbus lime, like almost every other lime of Ohio, is burned with wood. Numerous attempts have been made to substitute bituminous coal for wood, in its manufacture. Most of these attempts have proved failures. The quality of the lime has been impaired in the process. But as lime is manufactured elsewhere, with coal for fuel, so it must come to be here. One apparently successful experiment deserves mention: The lime used in the plastering of the new Insane Asylvm was burned with coal. The stone was broken quite small, and the coal was distributed quite evenly throughout the kiln. A good deal of waste occurred, but it is said that the cost of lime was less than half that burned with wood.

The kilns in use are of various sorts, but the parties burning lime, in the larger way, make use of some sort of draw-kiln.

The largest manufacture is that of Stitt, Price & Co. They make use of two kilns of Page's patent, one of them capable of making three hundred and fifty bushels, and the other four hundred bushels per day, with a daily yield of seven hundred bushels for eight months in the year. They have several kilns of the old sort; also mainly used for the winter supply. One cord of wood is expected to burn sixty-six bushels of lime, a result which reaches the average of the best kilns of the State.

3. *Huron shale.*—The next element in the geological scale of the county is the Huron shale—the Ohio black slate—of the older State geologists. It occupies a much larger area than any other formation in the county, and has affected the physical geography much more. It is easily eroded, and, consequently, the valleys that have been wrought in it, are broad, the water-sheds being reached by long and gradual slopes. It makes an important contribution to the soils of the county, and impresses its own character upon considerable areas, notwithstanding the fact that this whole region is included in the Drift-covered territory of the State.

So great is the uniformity of material and arrangement in the formation, that it has not yet been found possible to establish divisions in it that can be followed from point to point, aside from one well-marked band at the bottom, and another at the top of the series. As there are no vertical sections that hold more than fifty or sixty feet, it has, therefore, been impossible to determine the thickness of the shale in Franklin county. It is probably not far from three hundred feet. In Ross county, the heaviest section yet measured in the State occurs. The shale is there three hundred and thirty-one feet thick. In Highland county, an included section measures but two hundred and fifty feet. There is little doubt, however, that careful enough study will reveal marks in the shale that will allow us to secure measurements here also.

At the base of the series, in this county, and also in Delaware county, there are thirty feet of blue shales, with calcareous bands running through them, about the assignment of which, question may be raised. They are included here with the Huron shale, although they are separated from it by as distinct a boundary as they are from the limestones which they cover, but they agree with it in the style of bedding, in the general absence of fossils, and in chemical composition, except that they lack the bituminous matter that colors the Huron shale proper. There are, however, thin seams of true black shale that are scattered through these beds. The same horizon at other sections contains a much larger proportion of black slate, and this fact helps to justify their reference to the same system.

In his report on Delaware county, Professor N. H. Winchell proposes for this blue belt the name of *Olentangy shale*, a convenient and unambiguous designation, which will be adopted here.

The Olentangy shale appears to be the stratigraphical equivalent of the beds termed *Hamilton shale*, by Dr. Newberry, which are found near Prout's Station, Erie county, and which are there highly fossiliferous, and contain only Hamilton fossils. All of these fossils, however, are also found in the limestone below, the difference in the two sections being this: In the lower beds true Corniferous fossils are associated with the rest, while in the upper, no Corniferous forms have been found. The Olentangy shale of Delaware and Franklin counties is very poor in fossils of any description; nothing characteristic is known to occur in them, unless certain fish remains, reported by Rev. H. Herzer, from concretions in these shales at Delaware, prove to be so.

The correlation of these Devonian limestones and shales of Ohio with the New York divisions of the same age, involves questions entirely similar to those that were met in the geology of our Lower Silurian deposits in South-western Ohio. Eight hundred feet of Lower Silurian limestones and shales are found there, which undoubtedly represent the Trenton limestone, in part, the Utica shale, and the Hudson River group of the New York scale; but no one can draw the line where one epoch ends and another begins. The growth of these beds was continuous. The interruptions that marked the epochs on the continental border did not make themselves felt in the central sea, but the life of the lower beds held on through the vast cycles of time required for such a growth. It was re-enforced from time to time with the forms belonging to higher horizons, and the result is, that there is here an extricable blending of the forms of life that characterize distinct formations at the east. In regard to the designation of these beds, all ambiguity is removed by giving them a name derived from the locality that shows them best. We refer them all to the *Cincinnati group*, making such divisions of them as the facts here warrant, and as convenience requires.

In like manner, the Devonian limestones, already described, grew in a sea in which the same general conditions were maintained, while very different strata were in process of formation at the east. The Columbus and Delaware limestones probably cover the age in which the Corniferous limestone, and the Hamilton group, in part, of New York were forming; but there seems no warrant whatever for identifying the subdivisions of our scale with the subdivisions recognized five hundred or a thousand miles away. A disturbance of previous conditions took place in this interior sea, which is marked by the change from the Columbus limestone to the Delaware limestone, but any correlation of this change, with epochal changes at the eastward, is, so far as the facts appealed to indicate, entirely arbitrary.

Nor does it seem necessary to restrict the application of the name "Hamilton" to the ten or twelve feet that underlie the Huron shale proper. The "Hudson River age" of the upper limestones of Cincinnati is universally recognized, though the most characteristic of Trenton fossils are found in the same beds. On very nearly the same grounds we can believe that the Hamilton group of New York covers a part of the Devonian limestones, as well as a part of the Devonian shales of Ohio.

The Olentangy shale is shown in but very few sections in this county. The best of them is on Slate Run, in Perry township, but north of the county line, in the Olentangy Valley, numerous sections are exposed. It contains calcareous concretions in considerable numbers. They are less regular than the concretions of the Huron shale proper, and are lenticular, rather than globular. Only obscure traces of fossils have been noted in its beds, and these were fragments of corals that have no significance in marking horizons.

The Huron shale proper begins with a boundary as definite as a black mark on paper. Its lowest layer is as characteristic of the formation as any layer in it, and from this point up, with wonderful sameness of composition, layer after layer testifies to conditions of an ancient sea that remained unchanged until the floor had been covered with at least five hundred feet of fine, and, probably, slowly, accumulating sediments.

The shale is brownish or blueish black in fresh exposures, but weathered surfaces have a distinctly blue color. The leaves of the shale are quite thin and fragile in all natural sections, but where the rock is freshly opened for ten or fifteen feet, the beds have a very solid and substantial look. They are unable, however, to resist the action of the atmosphere, and the solidest portions need but a winter to be turned into crumbling fragments that are excellently adapted to the making of sidewalks. The last stage in their decomposition is a very tenacious, light-colored clay, of which mention will be made again.

One of the most conspicuous features of the Huron shale is found in the concretions, great and small, which it contains in great numbers. They begin with the formation, and in the lowermost forty feet, all the varieties of their structure can be seen. The shape which the larger and more symmetrical take is that of flattened spheroids. Not unfrequently two are joined together by a ligament, uniting their centers. They are sometimes, but more rarely, disc-like, and many of them lack regularity of outline. In composition, some variety is observable. Very many of the smaller ones consist of the crystallized bi-sulphide of iron, and some of them consist of a symmetrical shell, or scale of this substance, around a softer nucleus, which gives them a strong resemblance to an iron casting. The nodules of this kind are often irregular in shape. The larger specimens invariably contain lime and iron, the former substance being sometimes found at the center, in the shape of calc spar, but more frequently occurring in a dark, semi-crystalline mineral, that is quite characteristic. The iron is always intimately associated with the lime, and gives to the weathering concretions the dark yellow, or ochreous color, that marks them all in this stage.

Rarer substances sometimes are met in the crystalline nuclei of the concretions. Heavy spar is one of these. As is now well known, there are sometimes found at the centers of these bodies organic nuclei, and among these, are some of the most interesting and remarkable fossils of the entire geological series. Wood is not uncommon in this connection. A species of ancient pine, *Dadoxylon Newberryi*, Dawson, furnished many of these centers.

The great fish bones, however, are the most remarkable forms to be met with here.

To Rev. H. Herzer, of Berea, Ohio, the credit is due of bringing to light, by his very sagacious and patient labors, the bones of the most remarkable of the great series of fossil fishes, that the rocks of Ohio have so far yielded.

Dinicthys, the fish to which reference is here made, is one of the remarkable fishes of this early age of the world as well. It united, in a surprising way, the characteristics of forms widely separated now. More than any other fossil, it has served to show that the great group of Ganoids, of Devonian time, to which group it belongs, "formed the parent stock from which, by differentiation, the fishes have branched off on one side, the amphibians and reptiles on another." It agrees so closely in dentition with the modern *Lepidosiren*, which most systematists rank as the highest of modern fishes, that the latter can scarcely be doubted to be derived from it by lineal descent. There are two species of this genus now described from the Huron shale of Ohio. Both were of great size and great power. Very full and interesting descriptions of them are given in the volumes of Paleontology already issued by the Survey.

Aside from the contents of these concretions, the Huron shale of Franklin county, may be described as nearly non-fossiliferous. One may look for hours on great banks of the shale, without finding a trace of vegetable or animal structure. The only forms known to occur are the following: On the surface of the layers, strap shaped impressions of marine plants, are occasionally found. In rarer instances, a thin film of coal represents the vegetable tissues. In the *waste* of the slate, silicified coniferous wood is often found, but it is believed that this is generally derived from the breaking down of the concretions already noticed, of which it often constitutes the nucleus. Of course it is quite possible that blocks of this ancient wood may have been preserved in the slate, without gathering around them concretions, but no specimen has been found *in situ* thus far, except in concretions.

Towards the upper limit of the slate, several localities have been found in which the teeth and rhombic plates, black and shining, of small ganoid fishes have been found. These agree almost exactly with the fossils of the same group from the Cleveland shale—a formation that is also identical in lithological characters. The best point for collecting these rare forms, is in the fine exposures of the shale in the valley of Big Walnut, near Central College, Blendon township.

A fine specimen of the crest of teeth peculiar to the dentition of *Onychodus*, was obtained from the shale of Slate Run, in Perry township, by Mr. W. Meteer, and was by him presented to the State collection. It has not been finally determined, but Dr. Newberry considers it to be *Onychodus Hopkinsi*, or else an undescribed species. The species referred to, *O. Hopkinsi*, was described from the Chemung group, of New York. The horizon of this specimen can not be definitely given, but it is within forty feet of the bottom of the series.

Such facts as these, while they illustrate the poverty of the formation in fossils, still justify considerable geological interest in it. It is to be remembered, that the formation is shown almost altogether by natural exposures. There is little to lead to its being worked for economical uses. Our knowledge of the great wealth in fossils of the Corniferous limestone would be very meagre, if we had not access to the extensive quarries where fresh exposures of all its strata are seen. Whatever fossils are found in the shale are quite likely to be either new species or species not heretofore found in Ohio; for the three hundred feet of this formation cover a long period of paleozoic time, from which we have, thus far, less than a dozen described species.

The economical uses of the Huron shale are quite limited. It is applied, on a small scale, to the making of roads and walks—and where no severe use is required, its materials are happily adapted to these purposes. They make a smooth and dry road bed, which is comparatively free from dust. Under heavy use, they wear into blue clay very soon, and to this complexion they all come at last.

The only other important use to which they are here applied, depends upon the change last noted. The clays into which they weather, have been found to constitute an excellent material for sewer pipes. The North Columbus factory depends chiefly on this source of supply for its extensive production. Little or no drift is found on the high ridge just east of High street, and wherever the shale has been thus exposed to atmospheric agencies, it has been turned into clay to a depth varying from two to six feet. The clay varies in color from whitish to yellow and blue, and passes by slow gradations into the undecomposed slate. The pyrites of the shale is often converted by weathering into sulphuric acid, and this has united with the lime derived from the concretions and other sources, to form sulphate of lime or gypsum in the clay. Little crystals of this substance, or selenite, sometimes occur to such an extent as to destroy the value of the clay for manufacturing uses. It does not interfere so much with the substance of the ware as with its surface. By chemical union with the common salt, used as a glaze, it prevents the formation of the required surface, leaving the ware lustreless and light colored. Such portions of the clay as are found charged with these crystals, it is necessary to carefully avoid. A large manufacture is based upon this geological element. The sales of the North Columbus factory have sometimes amounted to $70,000 in a year.

The Wassall Fire-Clay Works, of the city, also make use, to some extent, of these native clays for the same purpose. Both manufacture sewer pipe of the best quality.

It has already been stated that no divisions have been established in the Huron shale by which its several sections can be united into one general section. The failure to establish divisions results from two facts: The almost absolute uniformity of composition in the whole system, and the lack of fossils to characterize any particular horizon. It is highly probable that more careful study will detect some marks which will serve to identify separated portions of the same horizon. One bed remains to be noticed, that can be distinguished lithologically; but it occurs at a portion of the series where it can render no service of the kind named above. It is a red or chocolate-colored band, from fifteen to twenty feet in thickness, that makes the uppermost portion of the Huron shale. It is thus seen that the Huron shale ends, as it began, with shales of the same general character with the main body of the formation, but differing in color.

This red band is best shown at Taylor's Station, in Jefferson township, and at several points in Mifflin township, in the eastern bank of Big Walnut Creek. One exposure in particular may be named, which is very conspicuous, viz., the one seen in the slate cliff, opposite Central College. There is no black slate above it, but the passage to the shales of another formation is gradual. The question then can be raised, as in the case of the Olentangy shales, whether they belong with the Huron properly, or to the overlying bed. The fact that no change in the bedding of the shales occurs, leads to the reference already made.

4. *Waverly Group.*—The next formation in order, and the last in the scale of the county, is the Waverly group. Its area will be seen from the map to be much less than that of either of the two principal elements already named. It is found in three separate bodies, which are situated as follows: 1. A small outlier in the south-eastern part of Jefferson township; 2. The largest body of the county, which occupies all of Plain township, and parts of Blendon, Mifflin, Jefferson, and Truro, and finally, 3. A corner of Madison township, south of Winchester, which embraces but a few hundred acres.

The first of these is well shown in the Central Ohio Railroad cut, at Taylor's Station. The cut is made as the road ascends from the valley to the upland. The stream is now bedded in the black shale, and large exposures of it are shown in the valley to the eastward. The red band named on the preceding page is distinctly seen as the eastern margin of the valley is reached, and the grade of the road is laid in a soft, blue shale, very different in texture and appearance from the three hundred feet just below it. Ten feet above the track, the sandstone of the lower Waverly is shown in very characteristic courses.

The stone is generally thin bedded, the courses not being more than six or eight inches thick, except where by an unknown agency, the material of the layer is gathered up for a few square feet into an ungainly mass, from which the lines of bedding have been lost. These masses are sometimes two feet in thickness. The only explanation suggested, is the vague one that the rock was wrought into these shapes by concretionary force. The lower side of the lowermost layer is almost always beautifully ripple marked, and similar indications of shallow water occur again and again through the thirty feet succeeding. This particular section holds, however, but ten feet of the bedded sandstones.

The line of junction between the Huron and Waverly formations is shown with equal distinctness at several other points. On the land of E. Compton, adjoining the farm of S. R. Armstrong, in Jefferson township, in the valley of Black Lick, the contact of the two formations is plainly to be seen. Another of these points of contact is shown in Mifflin township, on the eastern bank of Big Walnut, extending through several miles. Still another point, at which these facts can be studied, is found in the bank of Rocky Fork, one mile east of Gahanna, and thence northward for a mile.

More than ordinary interest attaches to this boundary. It is the dividing line between two great divisions of geological time—the Devonian and the Carboniferous. The Devonian formations were mainly deep sea deposits, or, if great depth was not required for their origin, still there are but few traces of shores, or of the life of the land; but in the Carboniferous, all is changed. Vast regions of the old sea floor are lifted up to the level, and even above the level of the sea. We see this fact in the first layers that were deposited. They are ripple marked. It is the life of the land that gives interest and value to this great division.

A brief description of the Waverly series, as shown in Franklin county will now be given. It contains three well-marked element, viz., the Waverly shales, ten to twenty feet in thickness, the Waverly quarry system, certainly sixty feet and probably more, in thickness, and the Cleveland shale of Dr. Newberry, or the Waverly black shale of Professor Andrews. This last division is exposed at but one point in the county, so far as known, and does not attain there a thickness of more than fifteen feet. These can be shown in tabular form:

		FEET.
Waverly group of the Sub-carboniferous period..	Cleveland shales.......	15
	Waverly quarry system.	60
	Waverly shales	10–20

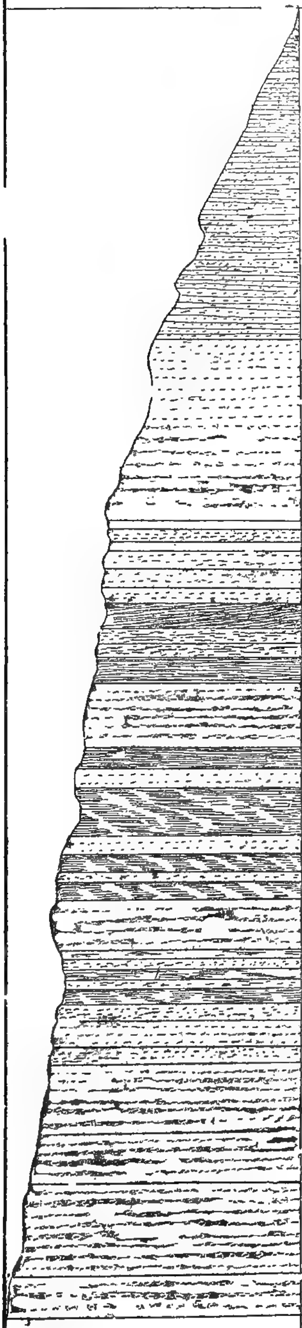
(*a*) The Waverly shales have been already briefly characterized in the description of the Taylor's Station section. They consist of light blue or drab, non-fossiliferous clay shales. They lack the fine lamination of the Huron. They weather more easily, so that the outcrop is always covered with muddy waste. This division in the counties south has a much greater thickness than we find here. In Ross county, it is never less than sixty feet thick, and in Pike it measures ninety feet. As stated above, in Franklin county, it does not exceed twenty feet, and in one of the sections already named, it measures only eight feet.

(*b*) The Waverly quarry courses can be seen to the best advantage on the land of S. R. Armstrong, Esq., just where the Central Ohio Railroad crosses Black Lick. The stone has been quite extensively worked here. It can also be seen in various neighborhood quarries in Plain and Mifflin townships in the banks of Rocky Fork and Big Walnut Creeks. The Black Lick section is much heavier than either of the others, and will alone be considered here.

It measures forty-eight feet. Its lowest bed belongs to the Waverly shales, but this course is seldom reached in the operations of quarrying. The annexed wood cut gives the divisions of the system as it is here exhibited. It will be seen that the courses marked as valuable are quite widely separated and constitute but a small proportion of the quarry. Only those courses that furnish stone in blocks adapted to cutting have been thus designated. Much of the remainder furnishes building stone, the quality of which is quite equal to the cutting stone, excepting only in the size of the blocks in which it is raised. The waste, however, is considerable. It includes concretionary masses in which no bed lines can be seen, but which look like masses of mud to which a rolling motion had been given before they were solidified. These courses are most numerous near the bottom of the system, and are characteristic of the lower Waverly throughout central and southern Ohio. Some of the best cutting stone is found in portions of the courses that are marked concretionary. Their courses of shale contribute also to the waste, but the largest element is thin-bedded sandstone that has little strength and as little durability. It is light yellowish in color. The layers are from one to four inches in thickness. The presence of so much useless material would render the quarrying quite expensive if it were carried on to any great extent.

The best of the courses are, in color, light blue, and quite uniform in texture, and work well under the saw. The Ohio Institution for the Blind is built of stone from these quarries. The foundations of the Union Depot at Columbus were also supplied from Black Lick, as well as several fronts of newer blocks in the city. Like the rest of the lower Waverly, these quarries furnish some unreliable stone distributed through the best of courses. No selection is possible in the process of quarrying by which the perishable portions can be separated from the more durable. The element of time must necessarily come in, and the stone should never be laid until the quarry water has all escaped, for the exfoliation, which disfigures the surface of these treacherous portions, is generally connected with the escape of this quarry water. The Waverly of central and southern Ohio is less silicious in composition than the northern Ohio stone of the same age, and it is in connection with the aluminous constituents which replace a part of the sand that this uncertainty of quality comes in.

SECTION OF WAVERLY SANDSTONE
AT ARMSTRONG'S QUARRIES, BLACKLICK STATION



Thin – Worthless.	12,4
Massive in quarry. Irregular when quarried.	7,
Shale.	[illegible]
Stone.	7"
Shale.	[illegible]
Stone.	10
Stone.	8"
Stone.	6"
Shale.	10"
Shaly Stone.	8"
Shaly Stone.	6"
Shale.	1,
Stone. Massive. Valuable.	2·4,
Shale.	10"
Stone.	9"
Blue Shale.	1,9"
Stone.	8"
Shale.	9"
Rotten Stone.	[illegible]
Shale.	8"
Stone. Solid. Valuable course.	1,11"
Stone.	1½"
Shale.	[illegible]
Shaly Stone.	3"
Shaly Stone.	[illegible]
Stone.	7"
Stone.	
Stone.	1
Stone.	[illegible]
Thin Courses. *Concretionary Course.* *Thin Courses.*	8,4"
Concretionary Course. Valuable Stone	1,6"
WAVERLY SHALE.	10,

This belt of building stone is of great importance to the eastern portion of the county. The Huron shale covers a large area and this is entirely destitute of stone for ordinary uses. The margin only of the Waverly furnishes exposures for quarries, so that broad belts both east and west of this line depend mainly on this source of supply. Quarries of this horizon are quite extensively worked north of the county line in Harlem, Berkshire, and Trenton townships of Delaware county. The best known of these quarries are those located at Sunbury. The Sunbury stone is erroneously referred in Vol. I to a higher division of the Waverly, viz , the Berea Grit, but it certainly belongs to the lowest of the sandstone courses of this formation, and can be traced without interruption, from Sunbury to the points here named. Like the lower Waverly generally, these beds are almost entirely non-fossiliferous. A few fucoids are seen upon the surface of the layers, and the burrows of sea-worms are also sometimes found.

(*c*) The Cleveland shale of Dr. Newberry, the Waverly black shale of Professor Andrews, as has been already stated, is known at but a single locality in the county, viz., at Ealy's Mills, in Jefferson township, on the banks of Rocky Fork. From ten to fifteen feet of this formation are here shown within the compass of an acre. The stone immediately underlying the black shale is quarried for local use, so that the line of junction is very distinctly seen at several points. The black shale lies upon the flat surface of the sandstone without the interposition of any other material whatever. A geological boundary cannot be more distinct than this. The change is equally marked in other respects Below this horizon, sandstones and shales, blue and black, are found for at least four hundred feet, representing periods of great length in their formation, and throughout them all, it is a very rare occurrence to find any trace of the life of the world in the ages to which these beds belong, but the moment that the Cleveland shale is reached, all this is changed. The beds are charged with ancient life, and that too, of the highest divisions of the animal kingdom, viz., vertebrates. The surfaces of many slabs are thickly covered with the teeth, and plates, and bones of the sharks and ganoids of this early day. Two brachiopods also, *Lingula melie*, Hall, and *Discina Newberryi*, Hall, are abundant here, sometimes wholly covering the surface of the beds. The anomalous but very interesting fossils termed *conodonts* are found in great numbers, and in exquisite preservation in the shales of this locality. The best interpretation of their structure seems now to be that they constitute the jaws of annelids. (See Silliman's Journal, September, 1877, page 229.)

The shale is heavily charged with bituminous matter. No analysis of these beds has been made, but they are as rich in this material, to all appearance, as any of the exposures in the State, and not less than twenty per cent. of bituminous substance has been found in the southern outcrops.

The formation is of special interest in establishing the unity of the series of rocks that make up the floor of the State. It is a wonderfully persistent bed, as is shown by the records of deep borings made far to the eastward. Southward, it has been traced from Ross county to the Ohio River. It undoubtedly exists in Pickaway and Fairfield counties, though its presence has not been determined in either, except at a point just beyond the Franklin county line, to the south of Canal Winchester.

It marks a period of deeper submergence of the regions where it is found than that which characterized the Waverly. The latter formation has abundant signs of shallow water in its beds, as sun-cracks, ripple marks and oblique stratification, but nothing of this is seen in the black shale.

We learn, then, that the deeper submergence of the Huron shale in which three hundred feet of fine and even sediments were gathered on the ocean floor, was followed by a period of elevation, in which at least one hundred feet of shales and sandstone were accumulated at very little depth below the surface. The shore line itself is often seen in the ripple-marked layers of the Waverly. But this period of elevation was brought abruptly to an end, and the conditions of the earlier Huron were, for a time, restored. A deeper sea and abundant marine life—especially of sea-weeds and fishes—are attested by the fifteen to sixty feet of the Cleveland shale, followed in turn by re-elevation of the ocean floor for the growth of the later Waverly beds.

An outcrop of black shale, on the farm of Lorenzo Taylor, Esq., of Plain township, may prove to belong to the Cleveland shale; and other exposures will possibly be found in other portions of Plain and Jefferson townships.

III. DRIFT.

The Drift deposits of the county are far more important than the bedded rocks on which they rest, so far as useful applications are concerned, for they furnish its soils and water supply, and all of the minor modifications of the surface upon which drainage and tillage depend, are much more closely connected with them than with the rocky substratum. The drift of Franklin county falls into the two great divisions that appear in so many other parts of Ohio, viz., the unstratified and the stratified deposits. Both of these are shown with perfect distinctness, but by no means in equal force. The first named division is by far the most important. Each of these will be very briefly treated.

1. *Unstratified Drift, Boulder Clay, Glacial Drift, Till.* Of the twenty counties belonging to the Third Geological District, none shows this most important phase of this anomalous formation so well as Franklin. This is doubtless connected with the fact already noted, that the valley of the Scioto constitutes a broad and deep furrow through this central district of the State. It must therefore have formed a favorable line of advance for the glacial agencies.

The bowlder clay of Franklin county is essentially an unstratified deposit. The bulk of its materials is found in a tumultuous and unassorted condition. There is a noticeable absence of the lines of deposition which always characterize beds of clay or sand that have reached their resting places through suspension in water. To make the usual absence of these lines more conspicuous, there are seams of sand and deposits of clay of limited extent, scattered throughout the formation, that conform in all particulars to the normal appearance of aqueous deposits. The contrast between the two divisions of the drift depends also upon these points, the presence in one, the absence in the other, of the usual marks of deposition in water.

As the name indicates, the composition of the formation is largely clay. The clay, however, holds considerable quantities of sand, pebbles and bowlders, distributed irregulary throughout its mass. These bowlders are so marked a feature of the formation that they deserve a brief description. Whenever they are limestone, greenstone in any of its varieties, fine-grained quartzites or slates, they are almost invariably polished and striated. Rocks of this character can receive and preserve such markings, while most granites, gneisses and coarse grained rocks generally, are unable to do either. The greenstones are the most abundant of these polished blocks, and as they are excessively hard, their planed surfaces bear impressive testimony to the immense force to which they have been subjected.

Wherever the bowlder clay is shown, these most characteristic blocks abound. They are found in great numbers within the limits of the city of Columbus. The grading of streets, the construction of sewers, and the usual excavations for buildings, all show them abundantly.

The cut of the Short Line Railroad, just east of Georgesville, as the grade rises from the valley of Big Darby, is carried through ten or fifteen feet of the bowlder clay, and very striking examples are shown in it of this work. Some of the most interesting specimens are blocks of Corniferous limestone, the sources of which can not be far away. They show all the marks of mechanical violence that the igneous rocks of the Great Lakes show. It is certain that they have been subjected to the same tremendous abrading agency. There are some explanations of the bowlder clay that appeal to local glaciers, on the flanks of distant highlands, for the polishing of these lost blocks, but that deny anything but aqueous agencies for all the phenomena that we find here. It is not easy to see how these Corniferous limestone bowlders, thoroughly striated and polished as they are, can be made to match with such a view.

An interesting fact in this connection, also, is the great number of the peculiar spherical concretions of the Huron shale in the Drift of the county. They abound in both divisions—viz., the unstratified and the stratified. Scarcely a half dozen cubic yards of drift can be moved without unearthing one or more of these interesting bodies. They are often partially decomposed, and almost always perish speedily after being brought to the air. Their geological association and also their structure will be remembered. They belong in the Huron shale, and are interstratified with the thin and perishable layers of that formation. They themselves are hard and heavy, as they generally contain a notable quantity of iron in some combination. The shale would be the first element, of course, to succumb to the glacial agencies, while these concretions would prove, often, as well able to resist them as even the firmest rocks of the north. It is to be noted, that the great numbers of these bodies indicate the destruction of an immense body of the shale. This fact matches well with others that have already been recognized in our State geology. There is reason to believe that the Huron shale once stretched across from its present outcrop to the Indiana line in an unbroken sheet. Its destruction would supply a large amount of clay, quite similar to that which we find in our unmodified drift-beds.

The bowlder clay is generally blue in color, as one of the names by which it is oftenest designated, implies. There are, however, blackish streaks or pockets frequently seen in it, the color of which is due to vegetable substances intimately intermingled with it. These beds have the appearance of soils, pre-glacial in origin, that were pushed forward and worked over by the glacier as it advanced.

More interesting specimens of vegetable growth are not lacking in the bowlder clay. It is not an uncommon occurrence to find the trunks, branches, or roots of trees deeply buried in it. Most of these specimens seem water worn, or at l ast there is no indication of their having grown where we find them. In this respect they are very different from the buried tree-growths reported in Highland county (Report of Progress, 1870), and in other portions of southern Ohio. A true *inter-glacial* soil and forest growth seems to be met in these cases, but in Franklin county the wood found buried is *pre-glacial*. It is generally found to be red cedar, when the structure is well enough preserved to allow identification. Not less than a score of cases have been collected in which wood has been found in the digging of wells. The examples come from Jefferson, Truro, Madison, Norwich, and Prairie townships.

2. The *stratified drift* covers a very large area in the central and south-eastern portions of the county. The finest farming districts of the county are to be referred to this division. All the characteristic features of the Drift of the Champlain period are shown here.

The *Kames* or gravel knolls are well represented in Baker's Hill, three miles south of Columbus, on the Groveport pike. It rises fifty feet above the general level of the country around it, and consists of well washed sand and gravel, that were placed where we find them by some eddy in the great lake that occupied the Scioto Valley so extensively at this time. When Baker's Hill was under water, there was very little of Hamilton or Madison townships out of water, and the Scioto, if we shall call the great sheet by that name, must have been not less than twelve miles in breadth at this point.

The soils and water supply of the county furnish very interesting topics, the consideration of which must be omitted here for lack of space.

CHAPTER LXXXV.

REPORT ON THE GEOLOGY OF THE HOCKING VALLEY COAL-FIELD.

BY M. C. READ.

PROF. J. S. NEWBERRY, *Chief Geologist:*

At your request, I have prepared the following special report upon the Great Vein Coal Region of Ohio, making use of the accumulated observations recorded in my not books, the previous volumes of this report, pamphlets published by Professors Andrews and Hunt, and Colonel Whittlesey; the excellent sections made by Mr. Nichols, manuscript reports by Professor Wcethee, and information generously furnished by the officers of Railroad, Mining and Iron Companies; to all of whom I am indebted for valuable facts. I have supplemented these by as thorough a re-exploration of the whole field as time would permit. The work has grown upon my hands, and I regret that a whole summer could not have been given to observations in the field, to eliminate errors and make the report more complete. Very respectfully, yours,

M. C. READ.

HUDSON, OHIO, July 1, 1877.

A territory, comprising parts o Perry, Hocking and Athens counties, has acquired the name of the Great Vein Coal Region, from the unusual thickness which Coal No. 6 attains here. On approaching the region from the north or south, this coal is found to gradually increase in thickness, until, in the center of the field, it reaches a maximum of a little over thirteen feet. The territory, which may be properly included under this head, comprises the greater part of Salt Lick, Pleasant and Monroe townships of Perry; Trimble, Dover and York of Athens, and Wood and parts of Green and Starr in Hocking county. In the townships of York, Starr, Green and Dover the coal ranges in thickness from six to eight feet. In the other townships its average thickness is not less than ten feet, not including the surface valleys or one channel of ancient erosion passing diagonally through the field, and which will be subsequently described. In the northern and north-western part of the district the coal crops out in the sides of the hills, from fifteen to one hundred feet or more above the beds of the streams; but, dipping gently to the south-east, it passes beneath the surface, and in Trimble township is reached by shafts sunk to the depth of from seventy to eighty feet in the bottoms of the valleys.

The most careful estimates I can make indicate that we have in all these townships, in this single deposit, the equivalent of a continuous sheet of coal averaging ten feet in thickness and covering an area of 100,000 acres. Estimating a cubic yard of such a body of coal to weigh one ton, and that it could all be mined, this one district is capable of producing over 1,600,000 000 tons of coal, or over 100,000,000 tons in excess of all the coal mined in the United Kingdom of Great Britain from 1854 to 1870, both inclusive.

The average annual production of coal in the United States for the last three years past is a little under 48,000,000 tons. This coal-field would suffice to produce that amount continuously each year for thirty-three years. It is not, however, so much the increased thickness as the remarkable change in the character of this coal that has attracted to it so much attention. Coal No. 6 is the most persistent seam in the State, and furnishes a large portion of the coal mined in it. It is ordinarily a melting or coking coal, with high heating power, an excellent steam and mill coal, but contains too much sulphur to make a valuable coke for the smelting furnace. It leaves a peculiar purple ash, so that in nearly all the counties of the State where this coal is used the refuse heaps from the stoves and furnaces discloses the fact to the trained observer, who is rarely misled by this indication. But in the Great Vein Region this coal becomes very hard and dry burning. It melts or swells in the fire, but slightly, is remarkably free from sulphur, and burns with little smoke, leaving a white ash. It is not an open burning, but a remarkably dry burning coal. It has not, generally, the finely laminated structure and thin bands of charcoal of the Block Coal, which causes the latter to split up so readily when fired, but, when best developed, is almost as compact and homogenous as anthracite, and, after the volatile matter is driven off, leaves a mass of glowing coals much resembling an anthracite fire. It partakes somewhat of the character of cannel, and in places, especially in the upper bench, resembles a splint coal. It has been classed as both of these, and has been sold in New York as "Ohio Cannel." The appearance of the coal, and its chemical analysis indicate, and practical tests have demonstrated, its great excellence for smelting iron, and good results are obtained from its use in the smelting furnace without any mixture of coke. As a domestic fuel, it is not excelled by any coal in the State. Careful comparative tests, made by weighing large quantities of the coal and burning it in grates and stoves, and comparing the character and quantity of the residuum, show that, on the average, it leaves a rather larger percentage of ash than Coal No. 1, but a less quantity of cinder, burning almost entirely to a fine white ash.

For purposes of comparison, the territory may be divided into four separate districts.

STRAITSVILLE DISTRICT.

This comprises the greater part of Salt Lick township, Perry county, embracing the mining villages of Straitsville, New Straitsville and Shawnee, and the territory north and west of them. In these directions from Shawnee, the Great Vein Coal is at first found near the tops of the hills, and at an elevation of about 150 feet above the valleys. Commencing at these points, with a varying thickness of from five to seven feet, it becomes thicker to the southwest, and is found lower in the hills, so that in the neighborhood of Shawnee and Straitsville it is from 30 to 50 feet above the valleys, and averages about eleven feet in thickness.

The following section of the coal at Straitsville gives the general character of the seam in this neighborhood:

Blue shale at top.	
Coal	6 feet 10 inches.
Shale parting	3½ to 4 inches.
Coal	1 foot 8 inches.
Shale parting	2 to 3 inches.
Coal	2 feet.
Fire clay.	

There is but slight variation in the thickness of the different benches in the openings around Shawnee and New Straitsville, except where a part of the upper bench is cut away by the sand-rock above, in the eastern part of the Shawnee district. A small part of this territory is here affected by the ancient valley of erosion, which passes down by the little village of Hemlock, and traveling eastward separates the Upper Sunday Creek or Moxahala region, from that of the Lower Sunday Creek, and which will be subsequently described. Near Shawnee, on the east, the erosion sufficed to cut away the shale overlying the coal and remove a part of the upper bench of the coal itself, leaving it with an irregular undulating surface, covered by a sandstone roof. When the coal has thus been disturbed it is generally somewhat deteriorated, and contains a larger percentage of sulphur. The roof, also, is not ordinarily evenly bedded, and more care is required in mining. The area of the coal here damaged by this disturbance is quite small, and in all other places it is of great excellence. The two lower benches furnish coal of the greatest purity, compact and homogeneous, containing a small amount of ash and a large amount of fixed carbon. The upper bench is more laminated, has generally a large percentage of ash, and occasional thin bands of "bone coal." The partings vary in thickness from one to four inches, and are ordinarily carbonaceous shale; while the lower benches are the most valuable for ordinary uses, as the coal from them has the highest heating power; the combined product of the three benches is preferred for the smelting furnace.

The seam is well up in the hills, so that good drainage is obtained; and the shale above the coal ordinarily impervious to the water, so that in the best openings the mines are quite dry, and in none of them is there any serious trouble from this cause. In so thick a seam it was anticipated that the cost of timber for supporting the roof would be excessive; for supports ten feet or more in length, must of necessity be large and straight, or of no value. But it is found, when the roof is undisturbed, that rooms forty feet in width can be worked with no danger, without supports, and there is probably no place in this county where the cost of mining coal is so small as here. Indeed, in the depression of the coal business, proprietors of mines have contracted to deliver coal upon the cars at the rate of sixty-two cents per ton, rather than suspend operations. This would leave little margin for profits, but it will be difficult to find any other locality where coal of any quality can be sold for that sum.

The following tables of analyses of this coal, exhibit its characteristics in this part of the field:

McGINNIS' BANK, OLD STRAITSVILLE.

	1.	2.	3.	4.	5.	6.	7.
Specific gravity	1.291	1.239	1.307	1.247	1.248	1.244	1.241
Water	7.90	7.20	7.60	6.00	5.35	7.55	8.15
Volatile matter	34.63	32.29	29.65	32.15	30.48	35.61	27.46
Fixed carbon	54.29	59.44	52.77	59.41	57.21	54.90	61.73
Ash	3.18	1.07	9.98	2.44	6.96	1.94	2.66
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Sulphur	0.98	0.73	0.68	0.50	1.22	1.05	0.78
Color of ash	Dull white	Reddish.	White.	Ye'sh gr'y	Grayish.	White.	Reddish
Nature of coke	Compact.	Pulv't.	Pulv't.	Pulv't.	Pulv't.	....	....

No. 1. From bottom layer.

No. 2. From middle layer.

No. 3. From bottom of top layer.

No. 4. From middle of top layer.

No. 5. From upper part of top layer.

No. 6. Second sample of middle layer.

No. 7. Second sample of bottom layer.

NEW STRAITSVILLE COAL.

	1.	2.	3.	4.
Specific gravity	1.260	1.281	1.262	1.276
Water	7.70	7.40	7.20	5.30
Volatile matter	30.70	29.20	30.10	31.00
Fixed carbon	59 00	60.45	57.55	55.75
Ash	2.60	2.95	5.15	7.95
Total	100.00	100.00	100 00	100.00
Sulphur	0.49	0.93	0.57	1.18
Sulphur left in coke	0 082	0.015	0.26	0.082
Sulphur per cent. in coke	0.13	0.023	0.41	0.128

These four samples were taken from the same opening, and represent different parts of the bed from below upwards.

These analyses, copied from Prof. Andrews's report, were made by Prof. Wormley, of the geological corps, as are the other analyses given in this report, except where credit is given to other chemists. They indicate a peculiarity in regard to the manner in which the sulphur is combined in the coal, to the practical importance of which Prof. Wormley first called attention. It will be seen that a very large percentage of the sulphur passes off with the volatile portion of the coal, so that if the raw coal is used in the smelting furnace, the coke in the stack, where the iron is reduced, is remarkably free from sulphur.

For purposes of comparison we give the following table of analyses of selected specimens of the best qualities of the Mahoning Valley coal:

Number.	1.	2.	3.	4.	5.	6.
Specific gravity	1.271	1.261	1.291	1.285	1.275	1.277
Water	4.20	3.30	4.20	3.40	3.70	3.10
Ash	3.00	2.20	1.50	1.00	2.00	2.00
Volatile comb. matter	29.80	30.10	27.80	30.60	30.30	31.90
Fixed carbon	63.00	64.40	66.50	65.00	64.00	63.00
Totals	100.00	100.00	100.00	100.00	100.00	100.00
Sulphur	1.09	1.04	0.87	0.82	1.01	1.29
Sulphur in coke	0 82	0.60	0.54	0.46	0.35	0.90
Per ct. sulphur in coke	1.24	0 90	0.79	0.69	0.62	1.39
Cubic feet of gas per lb	3 50	3.50	3.35	3.42	3.35	3.54
Color of ash	White	Yellow.	Yellow.	Yellow.	Yellow.	Yellow.
Coke	Compact.	Compact.	Compact.	Compact.	Compact.	Comp'ct

1. Brookfield, Trumbull county.
2. Liberty, Trumbull county.
3. Liberty, Niles Coal Company.
4. Shenango Coal Company.
5. Andrews Coal Company, Vienna.
6. Love Bank, (Andrews and Hitchcock) Vienna.

These specimens were carefully selected, and represent the best grades of the Briar Hill or No. 1. coal, in the Mahoning Valley.

They contain an average lower per cent. of water, and a greater per cent. of fixed carbon, and their heating power is certainly greater than that of the coal of this territory. While in respect to the amount of sulphur contained, the Great Vein coal has the advantage.

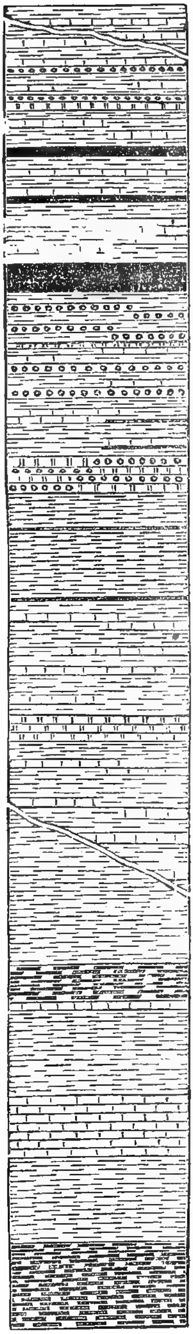
The average amount of sulphur in the six selected specimens of Briar Hill is 1.02 per cent.; in the four specimens of Straitsville coal 0.79 per cent. In the Briar Hill coke the average is 0.93 per cent.; in the Straitsville coke 0.172 per cent.

From a careful study of the whole field, I regard this as an eminently fair illustration of the comparative value of these two coals. It should be added that coal No. 1 is never persistent over large areas, and often changes abruptly its character both in respect to the thickness of the bed and the amount of impurities. The Great Vein coal of this field is unusually persistent, having only one or two lines of erosion through it, from the points of maximum thickness, thinning in all directions very gradually, and no where abruptly acquiring peculiarities that interfere with its value. While the field is remarkable for the persistency of this coal, it is almost equally remarkable for the want of continuity, and the irregularities in its other mineral deposits. The few members of the series which are substantially continuous, vary much in their character and thickness, and the intervals between them, and the nature of the including rocks is constantly changing.

The following is a general section of the rock strata in the Straitsville and Shawnee region, extending northward to McCuneville, and supplemented by the strata disclosed in boring for salt at that place:

SECTION OF ROCKS ABOUT SHAWNEE.

Vertical scale 1 inch to 80 feet.



75	Shales and sandstone.
1 to 3	Iron ore.
3 to 15	Sandy shale.
1 to 6	Limestone capped with ore.
15 to 25	Sandy shale.
2 to 4	Coal.
18 to 22	Sandstone and shale.
1 to 2	Coal.
25 to 55	Shale and sandstone.
8 to 12	Coal No. 6, Great Vein.
	Shales with iron ore.
20 to 30	Coal with ore below.
1 to 2	Sandy shale or sandstone.
18 to 22	Shell ore 10 feet below coal.
1 to 3	Iron ore.
	Coal.
25	Shales and sandstone.
	Coal.
15	Blue limestone with ore.
15	Shales.
?	Coal ?
30	Shales.
?	Coal ?
50	Sandy shales.
10	Maxville limestone.
	Sandstone and shale, with salt water.
700	
	Shale.
	Black shale.
19	White sandstone.
	Salt water.
35	
	Red shale.
25	Gray sand-rock.
	Dark shale.
35	
41	Hard shale, probably Huron shale.

Above the Zoar limestone, as given in the section, in places, two seams of coal are found, before reaching the coal next below the Great Vein. Two seams are also frequently found below the blue limestone, which again, at times, forms the roof of another important coal seam. I have not observed the outcrop of any of these coals in this neighborhood, but the outcrops of four such coals are to be seen in the hills in the neighborhood of Maxville, and I have indicated their position in the section.

Of the iron ores the upper one, which is found at an altitude varying from ninety to one hundred and fifteen feet above the Great Vein, and one called the gray ore, found at a distance of thirty-five to forty-five feet below the Great Vein, are the most important and the most valuable.

The first exhibits its best characteristics at Iron Point, north of Shawnee, where it reaches a maximum thickness of three feet, and appears to form a continuous stratum extending through the hill. It seems to have been originally a blue carbonate, now mainly changed in the outcrops to a sesquioxide. It roasts very readily and yields a large percentage of iron, which is a little cold short unless a mixture of other ores is used. Indications of its presence are to be seen near the top of almost every hill which reaches its horizon, and its outcrops have been observed in many places. It is the ore used in both of the furnaces at Shawnee, mixed with about one-sixth Lake Superior ore. The gray ore appears to be quite persistent, ranging in thickness generally from one to three feet, sometimes thinning down to a few inches, and in places disappearing altogether. It is the ore used in Mr. Baird's Pioneer Furnace, west of Shawnee, and produces a good mill and foundry iron, without any admixture of foreign ores.

It is largely developed and of excellent quality in the hills about Old and New Straitsville, and in nearly all the hills which reach its proper horizon, to the west line of Monday Creek township. Separated in a few places by shale intervening between it and coal No. 5, its ordinary position is directly beneath the fire-clay of this coal, and it is often associated with a cherty drab limestone. When the ore is well developed it seems to take the place of the coal, the latter showing only a faint trace of carbonaceous matter. Where drifts have been carried into the hill, the ore has been found, on an average, nine feet below the coal, the interval being filled with fire-clay, and the ore resting on flint, limestone and sometimes in sand-rock.

It is generally oxydized and contains a large percentage of sesquioxide. Although here called the gray ore from its color when not oxydized, may well bear the name of the "Baird ore" from the name of the proprietor of the furnace which demonstrated its excellence. It has produced a better iron when used alone than the Iron Point ore.

There are, besides these, several other horizons of valuable ore in this district.

The limestone about seventy-five feet above the Great Vein contains an important percentage of iron, and frequently carries a valuable ore on its surface.

In the shales directly beneath the Great Vein, there are, in places, four horizons of ore, which show outcrops of from two to twelve inches, and of good quality; these have been but slightly exposed.

Sixty feet below the Great Vein, on Moss and Marshall's land, are two exposures of ore, measuring, in one place, four feet, and in the other seven feet in perpendicular height. The ore is mainly a red and yellow sesquioxide, soft, homogeneous, without lines of stratification, and without seams or fissures. I have not found outcrops of it, however, in other places in this neighborhood, and it presents many indications of being a recent local deposit from the chalybeate waters coming down from the ores above. The following facts indicate that this is its real character: It is on an exposed, sloping outcrop of rock, capped with shale; the deposit is not continuous; is made up of fragments of shale, colored by the ore, and imbedded in the ore; the latter is without any lines of stratification, or of cleavage; in short, just such a deposit as would occur in a mass of shale broken up by a slip, into which ferruginous water penetrated, with a slight covering of earth above.

About one hundred and sixty feet below the Great Vein, on the property of the Straitsville Great Vein Coal and Iron Company, and near the level of Monday Creek, is a fine-looking solid block ore, about eighteen inches thick, in two layers, and resting on a blue calcareous shale. This is the horizon of the blue cherty limestone, which here ordinarily carries ore on its surface, and sometimes seems to be entirely replaced by it.

The Maxville Limestone, also, which is found a few miles further west, often carries a considerable amount of good ore on its surface. Indeed, all the limestones of this region are ferriferous, and, not unfrequently, the limestone stratum is wholly wanting, and its place occupied by ore.

The shales directly above the Great Vein Coal contain ore in small, rich nodules, and explorations on this horizon will probably disclose valuable deposits. All of these ores appear to be nearly continuous through the hills, and are of remarkable excellence around Straitsville and in the adjacent territory. This field will, also, afford a market for ores from the north and west, beyond the limits of the iron-making coal, if the supply in the hills holding the coal should ever fail.

The following is a section of the ores and including strata, as exposed on Kitchen Run, Green township:

Great Vein Coal in top of hills, with nodules of ore below	10 feet.
Shales	35 "
Coal No. 5	6 to 18 inches.
Fire-clay	9 feet.
Baird ore, with patches of limestone below	2 "
Sandstone and shale	40 "
Coal, with limestone locally above	18 inches.
Shale	18 "
Coal, lower bench	30 "
Shales	15 feet.
Block ore	4 to 10 inches.
Shales	12 feet.
Block ore	10 to 16 inches.
Shales	3 feet.
Block ore	4 to 6 inches.

The character of the ores and their association with abundance of limestone, and with one of the best iron-making coals of the State, early suggested this as an inviting field for future iron manufacture. But when financial difficulties and the low price of iron had closed a majority of the smelting furnaces in the country, it was generally supposed that the development of this industry here must be deferred indefinitely, or until iron should command a much higher price.

In 1874, Mr. Samuel Thomas, President of the Columbus Rolling Mill and Smelting Furnace Company, estimated the cost of a ton of iron in the Sunday Creek region, where the conditions are similar to these, as follows:

Eighty bushels coal, at $1.15 per ton	$3 68
Two and three-fourths tons ore, at $2.50	6 97½
Three-fourths ton limestone	56¼
Labor and incidentals	4 00
Total	$15 21¾

Others made similar estimates, and all who explored the region, concurred in the opinion that iron could here be manufactured at a minimum cost.

The first furnace erected was built by Mr. Samuel Baird, and located on his lands, west of Shawnee, and about three miles from the nearest railroad station. Professor Andrews published a description of this furnace, in the *American Manufacturer*, in January, 1876, and furnished the following estimate of the cost of a ton of iron:

Two and three-fourths tons coal, at 50 cents, $1.37½, say	$1 40
Two and three-fourths tons ore, at $2.25	6 00
Three-fourths of a ton limestone, at $1.30 or $1.05, say	1 10
Labor	3 00
Repairs	1 00
Interest and discount	50
Total	$13 00

This was at a time when the iron trade was greatly depressed, but the quotations for stone-coal pig in the markets of the United States, ranged from $21 to $30 per ton. This would leave a large margin for profits, and it is not surprising that the estimate was received with considerable incredulity, but the practical results show that it was remarkably accurate. The furnace is erected upon a side-hill, with the top of the stack so far below the level of the Great Vein Coal that the fuel can be carried down a gentle decline, and dropped at the top of the stack. The coal is here nine feet thick in three benches, is dry-burning, and an excellent one for smelting. The limestone is, in part, obtained from the Zoar Limestone, which appears in the ravine before the furnace, and in part from the Maxville bed, which is found in the deep ravine to the west. After one year's experience, Mr. Baird gives the cost of one ton of iron as follows:

Ore from Furnace land	......	$3 85
Ore, if purchased	$6 00	......
Coal	1 60	1 60
Limestone	1 00	1 00
Labor, repairs and interest	4 40	5 40
Totals	$14 00	$11 85

The Akron Iron Company have used the pig from this furnace for the manufacture of their special grades of bar iron, and pronounce the quality good. The cost of the furnace was about $45,000. The pig must be hauled three miles to the nearest railroad station, and Mr. Baird informed me that, reckoning the cost of constructing these three miles of road as a part of the current expenses, the net profit of the first years' run was $25,000. The success of this enterprise has induced the construction of other furnaces, three of which are now in successful operation—one at Gore Station, on the Logan Branch of the Hocking Valley Railroad and two at Shawnee, the present terminus, at the south, of the Newark, Somerset and Shawnee Railroad.

The following is a condensed description of these furnaces:

	Baird.	Fannie, at Shawnee.	XX, at Shawnee.	Thomas Iron Co., at Gore Station.
Height of stack	44 ft.	48 ft.	50 ft.	47 ft.
Size of top	5 ft. 6 in.	6 ft.	7 ft. 6 in.	6 ft. 9 in.
Size of hearth	5 ft.	5 ft.	5 ft.	5 ft. 6 in.
Size of bosh	11 ft. 8 in.	12 ft.	13 ft. 6 in.	12 ft. 6 in.
Batter of bosh	3½ in. to 1 ft.	3½ in. to 1 ft.	3½ in. to 1 ft.	3½ in. to 1 ft.
Number of tuyeres	4	6	8	4
Size of tuyere nozzles	4 in.	3½ in.	3 in.	3¾ in.
Present daily products	13 tons.	14 tons.	21 tons.	19 tons.
Date of blowing	October, 1875.	Sept. 15, 1876.	Jan. 17, 1877.	Dec. 8, 1876.

The Superintendent of the furnace has furnished me, from his books, the average amount of material consumed in the manufacture of a ton of iron, during one week's run, the product being 136 tons, 440 pounds:

Native roasted ore	1 56-100 tons.
Lake Superior ore (New York mines)	28-100 "
Coal	3½ "
Limestone	75 100 "
Labor, per ton	$2 72

William Shields, the Superintendent of the Fannie furnace, estimates the average cost of his iron as follows:

Three tons coal	$2 00
Two and a half tons ore	5 00
Three-fourths ton limestone	1 00
Labor and superintendence	3 00
Interest and repairs	1 00

The present capacity of this furnace is fifteen tons per day, and an additional stack of larger dimensions is now in course of construction. The proprietors of the XX furnace are, also, preparing to erect another furnace; and believe they will thus reduce the labor account by one dollar per ton, making the cost of the pig $11.00 per ton.

Isaac B. Riley, C. E., of Newark, Ohio, who has carefully studied the iron industries of this region, and to whom I am indebted for much statistical information, estimates the cost of the raw material for a ton of iron as follows:

Two and three-fourths tons coal, at 50 cents, say	$1 40
Two and one-fourth tons roasted ore, at $2.00	4 50
Three-fourths ton limestone	60
Total	$6 50

The testimony of all parties conversant with the facts is that the cost of iron made from the native ores, with one-fifth to one-sixth Lake Superior ore, will not vary much from $12 per ton at present rates of wages, and certainly will not exceed $14. The native ores prove richer in metallic iron than was anticipated, and are easily reduced. No coke is used with the coal, and I think this practice may be continued, with satisfactory results.

The following table exhibits the character of the iron ores, so far as they have been determined by chemical analyses. This and the other tables of analyses of the ores of the Great Vein coal-field disclose the presence of oxide of manganese in so large quantities as to have a very important influence in determining their value.

Practical experiments have demonstrated that the presence of phosphorus in steel in such quantities as would necessarily make it quite worthless, may be rendered innoxious by the addition of a proper percentage of manganese. "There can no longer be much doubt that manganese exerts upon steel a body-giving, toughening influence, as well as a neutralizing, upon the hardening or cold shortening due to phosphorus. Though these properties of manganese have been suspected for some time, the mutual dependence, and, to a certain extent, interchangeability, of carbon and phosphorus were not fully appreciated, until M. Tessié du Motay succeeded in producing, with ferro-manganese, a good steel rail, containing about 0.12 per cent. of carbon, 0.25 of phosphorus, and 0.75 of manganese."

Prof. S. F. Baird, in quoting the above remarks, says: "In the light of recent investigations, therefore, phosphorus is no longer entitled to the evil distinction of being, as a well-known metallurgist has expressed it, 'the very scourge and pestilence of the steel workers.' And the time is probably not far away when many rich deposits of ore now esteemed to be worthless will find ready utilization."

	No. 1.	No. 2.	No. 3.	No. 4.	No. 5.	No. 6.	No. 7.	No. 8.
Silica	0 59	13.99	10.20	16.45	33.44	10.60	10.11	9.47
Oxide of iron	56.02	40.67	48.07	57.77	56.03	74.66	......	......
Carbonate of iron	......	......	......	......	......	......	......	......
Protoxide of iron	......	......	......	......	......	......	33.26	41.09
Sesquioxide of iron	......	......	......	......	......	......	15.60	8.24
Alumina	......	4.73	3.20	4.83	3.14	6.69	1.14	1.82
Phosphate of alumina	......	......	......	......	......	......	......	......
Oxide manganese	2.02	0.42	0.44	1.62	0 91	4.49	3.99	2.89
Magnesia	3.80	2.87	1.49	0.95	Trace.	......	2.91	1.45
Phosphate magnesia	......	......	......	......	......	......	......	......
Carbonate "	......	......	......	......	......	0.60	......	......
Lime	8.28	4.40	2.68	1.72	......	......	4 17	4.92
Carbonate lime	......	......	......	......	Trace.	2.35	......	......
Phosphate "	......	......	......	......	......	......	......	......
Phosphoric acid	1.62	0.24	0.95	0.94	0.39	0.54	......	......
Carbonic acid	24.60	28 50	3.04	4 45	......	......	26 80	28.05
Sulphur	0.10	0.07	0.06	0.22	0.14	0.13	0.29	0.13
Moisture	......	......	......	......	5.74	......	0.78	2.30
Metallic iron	43.58	31.63	37.39	41 59	39.72	52.26	36.79	37.72
Phosphorus	0.70	0.10	0.41	0.41	......	......	0.21	0.10

No. 1, Iron Point ore, Shawnee, by E. G. Love.
No. 2, Baird ore, " "
No. 3, below Great Vein, " "
No. 4, " " " "
No. 5, Iron Point ore, (raw), Shawnee, by E. S. Gregory.
No. 5, " (roasted), " "
No. 7, Blue Limestone ore, Shawnee, by S. B. Newberry.
No. 8, Thomas ore, Section 19, Monday Creek township, by S. B. Newberry.

Mr. Gregory also furnishes the following analysis of the pig-iron from the Fannie furnace:

Silica	3.89
Iron	91.45
Graphite	2.31
Combined carbon	0.24
Sulphur	0.03
Phosphorus	0.79
Manganese	0.65
Iron	0.64

The number of tons of coal shipped from this region since it was opened by railroads is shown in the following table:

	1871.	1872.	1873.	1874.	1875.
Logan Branch H. V. R. R	89,999	277,484	342,396	143,617	256,355
N. S. & S. R. R	......	*53,882	228,687	170,728	266,243
Total each year	89,999	331,366	571,083	314,345	522,597

Although but few mines were opened when the general depression in business greatly reduced the consumption of coal, and caused the work in many mines to be suspended, the low price of mining here enabled

* From July, 1872.

the owners to continue operations and to introduce their coal into nearly all the markets to the north and west, while no inconsiderable quantity found its way to Baltimore and New York. But the most important result is the demonstration that in facilities for iron-making the owners of these lands are substantially independent of tariffs and of panics. There is really no danger that the price of iron will become so low that it can not be here manufactured at a profit.

THE MOXAHALA OR UPPER SUNDAY CREEK REGION.

The Upper Sunday Creek region is separated from the rest of the Great Vein field by a formidable barrier, viz., the bed of an ancient water-course which flowed through the old Carboniferous marshes in the ages immediately succeeding the subsidence which covered the Great Vein with argillaceous mud, since consolidated into shale. This stream came from the north along a line midway between Buckingham and Shawnee, its precise location being in some places yet undetermined, but passing under Priest's Branch and along the valley where is now the little village of Hemlock, and trending eastward it followed nearly the line which now separates Perry and Athens counties. It cut away the shales above the Great Vein, and, in places, the whole thickness of the coal; in others it left a part of the coal varying from a few inches up to the normal thickness, and gradually filled the excavation with coarse material now consolidated into sand rock. This channel invades the eastern part of the Newark Coal Company's property at Shawnee, but left the greater part of the coal undisturbed. It thinned down that on the western part of the "Carbon Hill" property in the Moxahala region; left a thin body of coal at the point now worked at Hemlock, and a little to the east of this probably cut it all away.

An expensive experiment has determined more accurately its course and extent after striking the north line of Salt Lick township. Borings have been made through the horizon of this coal at the following named places, and with the following disclosures:

In Section 36, Salt Lick township, at south-west corner, the coal is thirty-five feet from the surface and two feet four inches thick; near the south-east corner of the lot it is at the same depth and two and one-half feet thick; near the center of Section 31, Monroe township, it is entirely wanting; at the south-east corner of the same section the first coal struck is six inches thick, and is found sixty-four feet two inches from the sur face and covered with forty-two feet six inches of sand rock, which occupies the place of the Great Vein, the channel here extending some twenty-five feet below this coal and cutting away the upper part of the Lower Moxahala coal. In the north-west corner of Section 36, Trimble township, the coal is thirty-seven feet below the surface and one foot thick; a little north of the center of Section 29, Monroe township, it is forty-one feet below the surface, three and one-half feet thick, and covered with fifteen feet of sand rock; north-west of the center of Section 28 it is seventy-four feet from the surface and three feet thick; south-east of center of same section it is seventy-five feet from the surface and four inches thick; near the south-west corner of Section 33 it is fifty-one feet below the surface, six feet six inches thick, and covered with thirty-three feet of sand rock; south-east of the center of the same section it is seventy-one feet below the surface and three feet thick; north-west of the center of Section 26 it is seventy-four feet six inches from the surface and nine and one-half feet thick; in the north-west corner of Section 23 it is fifty feet from the surface and eleven feet thick; in the southern part of Section 24 it is ninety-one feet ten inches from the surface and one foot thick; in the north-west corner of Section 36 the Norris coal is forty-one and one-half feet from the surface and four and one-half feet thick. The section below the Norris coal is as follows:

	FT.
Fire-clay	4
Blue shale	63
White limestone	9
Black shale	4
Shale	28
Total	108
Total from surface	154

Near the center of the northwest section of Homer township, Morgan county, and directly east of the center of Section 6, Trimble township, a deep boring gives the following section with no show of coal:

	FT.	IN.
Earth	9	..
Soft blue shale, argillaceous	20	..
Blue shale, hard	9	4
Sand rock	53	..
Shale	2	..
Sand rock	4	..
Dark shale	17	..
Iron ore	2	..
Sandy shale with nodules of iron ore	17	..
Dark shale	2	..
Same with hard nodules	4	..
White limestone	16	..
Total	155	4

The extreme eastern borings, disclosing heavy beds of limestone and no coal, suggest the probability of deep local open water at the east during the time of the deposit of the coal at the west, in which no coal plants could grow, and into which this ancient water course emptied.

The territory covered by these borings is a good illustration of the uncertainty of all inferences as to the existence of coal in any territory where its horizon is below the surface of the valleys. This Great Vein, as has been already stated, is remarkably persistent, changing very gradually both its character and thickness. North, and west, and south of this territory it was known to be a regular deposit from eleven to thirteen feet in thickness, the line of maximum development passed north and south through the western part of Monroe and Trimble townships cutting this territory in the center. Before any of the borings were made, in company with others I made a careful exploration of this territory. All the strata exposed above the lines of drainage were evenly bedded, in their normal relations, the abundance of argillaceous shales denoting a deposition in quiet waters. None of us could discover any indication whatever of the deep seated erosion which has rendered a part of this very promising territory quite worthless.

All the surface indications and the results of the borings point to erosion after the coal was deposited as the cause of the absence of the coal. But Mr. Nichols' admirable charts, compiled from a system of levelings carried through the territory, disclose the fact that the coal was never here deposited in its normal thickness. The subsidence immediately preceding the deposition of this coal, left a long ridge protruding into the center of the coal marsh of too great elevation to support a large growth of carbonaceous vegetation, and some of it, perhaps, at all times above the level of the swamp, so that along this channel the coal was originally quite thin, and in places may have been wanting altogether. But the undulating roof of the coal on the margin where it approaches its normal thickness, and the coarse materials of the sandstone roof, are sufficient evidence of the existence of this ancient channel which swept away the most of the thin coal deposited in the shallow parts of the marsh.

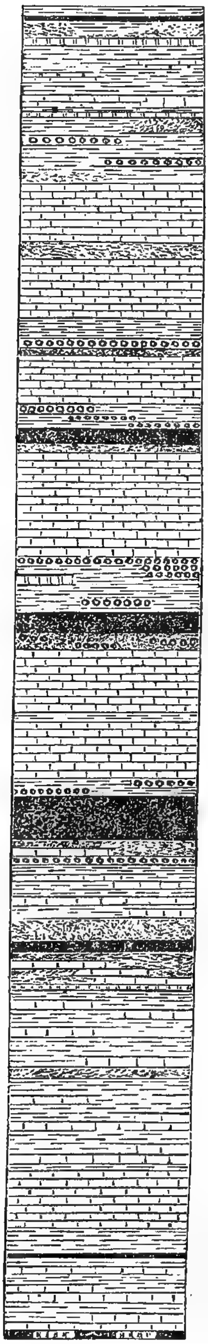
This territory thus isolated from the rest of the Great Vein region, furnishes exposures of nearly all the Lower Coal Measure rocks. The lower coals crop out in the ravines north and west of New Lexington, and passing thence southward the outcrops of the higher strata may be observed up to the shales of the Barren Coal Measures in the tops of the hills south of Moxahala.

Near New Lexington the Great Vein coal is comparatively thin. It has been mined for some time at Cluny station, where it is from four feet to four feet nine inches thick—a good steam and mill coal but not as well adapted to smelting purposes as that found further south. It here takes the name of the Upper Lexington Coal, which gradually thickens to the southward, on the south side of the divide reaching in places the magnificent height of thirteen feet.

The section here given exhibits all the coals and associated rock strata of this neighborhood.

Twenty-five feet below the cherty limestone—the lowest stratum indicated in the section— a bed of coal two feet in thickness is disclosed in the ravines northwest of New Lexington, but it is not at the bottom of the Coal Measure rocks. The coal at the outcrop is of very fair quality, breaks up into small cubes, and has the appearance of Coal No. 1.

SECTION OF STRATA ABOUT MOXAHALA.



FT.	IN.	
1	6	Coal.
4	5	Fire clay and shale.
2		Limestone.
20		Sandy shale.
1		Limestone.
18		Fire clay and shale, with nodules of iron ore.
16		Sand rock.
4		Fire clay.
16		Sand rock.
6		Shale.
2		Iron ore (Iron Point ?)
16		Fire clay.
		Sand rock.
6		Shale iron ore.
4	6	Coal (Stallsmith.)
		Fire clay.
31		Sand rock.
15		Iron ore ("Sour Apple,") and limestone shales, with nodules of iron ore.
6		Coal (Norris.)
4		Fire clay, with nodules of iron ore.
16		Sand rock.
3		White shale.
14		Sand rock.
4		Shale, with ore.
12		Coal, Great Vein.
4		Fire clay and sand rock.
		Iron ore.
16		Sandy shale.
6		Fire clay.
5½to3½		Coal, "Lower Moxahala."
9		Fire clay and sand rock.
	10	Ore.
20		Sandy shale.
3		Fire clay.
25		Sandy shale.
16		Sand rock.
7		Shale.
1	6	Coal.
		Sandstone and shale.
19		Cherty limestone and coal.
		Sandstone and shale.
2 to 3		Coal.

It is, however, probably the Coal No. 3, and from eighty to ninety feet above the Maxville limestone, judging from the sections given by Prof. Andrews in the Report of Progress for the year 1869. It is substantially on this horizon that the Calcareous iron ore, containing fossils, is found, which has been mined north-west of New Lexington, and taken to the Zanesville furnaces.

The interval between the coal and cherty limestone above referred to, is disclosed in a well sunk near the base of the limestone, and a short distance from the depot at New Lexington. It is there a thin-bedded sandstone, passing into sandy shale upon approaching the coal below. The limestone coal above it shows an outcrop from two to two and one-half feet, not of good quality. The limestone above is from two to four feet, cherty, in places passing into black flint, and was here mined by the aborigines for the manufacture of flint implements. Their old excavations are to be seen just north of the railroad at New Lexington. The limestone is capped with an iron ore which is thin at the places of exposure, but further explorations should be made for it on this horizon.

About twenty feet above this limestone is a thin coal of no value, and eighty feet above this, according to Mr. Nichols' measurements, is the coal called here the Lower Moxahala, which reaches, in places, a maximum thickness of five and one-half feet; is a hard, dry-burning coal, of light specific gravity, containing some sulphur, and yielding a white ash. This coal is also mined at Cherry Station, where it is dry-burning, of good quality, and five feet thick.

The Great Vein coal, twenty to twenty-five feet above the last, is also mined at Cherry Station, where it is four feet to four feet nine inches thick, more bituminous than it is further south, and with too much sulphur for a smelting coal. At an exposure in Section 13, Pike township, the upper bench is cut out and the middle and lower benches measure ten inches, and from twenty to thirty inches respectively. Near north-west quarter of Section 17, Bearfield township, the upper bench is twenty inches, middle bench twelve inches, lower bench twenty-six inches; upper bench quite shaly. In the south-west quarter of the same section the coal is five and one-half feet thick, with six feet of carbonaceous shale above. The changes that occur in the coal southward are indicated by the following section near the North Tunnel of the Atlantic and Lake Erie Railroad:

Drab shale at top.	
Shaly coal	14 inches.
Shale	2—4 "
Coal	12 "
Shale	1—2 "

Coal	8 inches.
Shale	1 "
Coal	12—18 "

In some of the neighboring mines there is four feet of good, dry-burning coal, with little sulphur and well adapted to smelting purposes. It was with coal from this neighborhood that the first practical tests of this seam were made in smelting furnaces. About one thousand tons were hauled by wagons to the railroad for the use of the Ohio Iron Company, at Zanesville, and gave good results.

At the new town of Moxahala, several entries have been made into a coal which has been regarded as No. 6*a*, or the Norris coal. It is here, by survey, fifty-two feet above the bottom of the coal in the shaft of the Moxahala Iron Company, which is regarded as the Great Vein, but which is only four feet seven inches thick. This coal is mined by Mr. Black, north of the village, and at all the openings is a dry-burning coal having all the characteristics of the Great Vein. Explorations for it show that it is not continuous; has an undulating roof and floor of sandstone or sandy shale, with thin patches of fire clay both at the bottom and top. The great sand rock, the Mahoning sandstone, which is a characteristic feature in the geology of this region, is just above it, and the interval between it and the coal below is filled with the blue sandy shale (containing comminuted fragments of coal plants) which is ordinarily interspersed between the same stem and the Great Vein. A section here would disclose the following strata:

	FT.	IN.
Mahoning sandstone	40	..
Coal	0 to 7	..
Blue sandy shale	52	..
Shaft coal	4	7

This massive sandstone, at the top of the section, can be traced southward to its normal position above the Great Vein coal, and with the Norris coal, or No. 6*a*, above it. The coal at Moxahala, directly below the sand rock, extends but a short distance, in undulating patches, north or south. At the south-east corner of Pleasant township, its place is designated by a narrow, waving band of carbonaceous matter at the base of the sandstone, while the Great Vein coal, of normal thickness, is disclosed by boring from twenty to twenty-five feet below its base. Farther explorations are required before the true relations of these coals can be regarded as demonstrated. All the facts now accessible, point to the conclusion that, at Moxahala, the Great Vein is represented both by the shaft coal and the local coal there, fifty-two feet above it. If this is correct, a local subsidence interrupted the deposition of the Great Vein coal at this point, and deposited over the lower bench these fifty-two feet of sandy shale, above which there was again deposited patches of coal on the horizon of upper benches of the Great Vein. An opening in the Great Vein, on Section 5, Pleasant township, where it is in its proper position below the sand-rock, and a little north of the place where it assumes its normal thickness, tends to confirm this conclusion. It is there very irregular in thickness, in two benches, with compact sandstone parting. A section is as follows:

	FT.	IN.
Sandstone.		
Sandy shale	6 to 8	..
Coal	1½ to 3	..
Sandstone	......	3
Coal	2 to 4	..

South of this point, it assumes all of its best characteristics, and appears a little above the bottom of the valleys, in thickness from nine to thirteen feet, and dipping to the south-east a little faster than the fall of the streams, so that in the south and east parts of Monroe, it is found beneath the surface of the lowest valleys. In the east part of South Lick township, it is somewhat thin and higher up in the hills, so that it is there easily accessible by drifting.

The following is a section of this coal on Benjamin Saunders's land, Section 19, Monroe township:

	FT.	IN.
Coal	3	1
Shale	..	2 to 3
Coal	5	4
Shale	..	2
Coal	4	..

On Rector's Fork is a very fine exposure of the coal, where the stream, for a long distance, has cut away the upper and most of the middle bench, and flows upon a solid bed of coal.

The three benches here measure as follows:

	FT.	IN.
Upper bench	3	10
Middle bench	5	6
Lower bench	3	..

In the south-east quarter of Section 24, Salt Lick township, and on the margin of the old channel of erosion, is an exposure of the coal, of which the following is a section:

	FT.	IN.
Sandstone.		
Coal	2	10
Shale	..	1 to 2
Coal	2	11

The middle bench in this neighborhood should be over five feet in thickness. The rapid waters, which brought in the coarse material of the sandstone, cut away all the shales which normally cover the coal, the whole of the upper bench, and between two and three feet of the middle bench of the coal.

On the south side of the West Fork, Section 19, Monroe township, is the following exposure of the coal:

	FT.	IN.
Clay shale.		
Coal	1	1
Shale	..	3
Coal	5	9
Shale	..	1½
Coal	7	..
Whole thickness of coal	10	2½

On the north-east quarter of the same section, is an exposure, as follows:

	FT.	IN.
Coarse sand-rock.		
Coal	1	..
Shale	..	2½
Coal	5	2½
Shale	..	1
Coal	3	..
Total	9	6

With part of the upper bench removed.

On the Akron Iron Company's property, a shaft has been sunk through the coal, where the top of the deposit is a little below the bottom of the valley, disclosing this section:

	FT.	IN.
Sandy shale.		
Blue clay shale.		
Coal	3	11
Shale	..	2½
Coal	5	10
Shale	..	¾
Coal	..	4
Shale	..	¾
Coal	2	9
Total	13	2

On the south side of the valley, and some twenty rods from this shaft, the fine column of coal was taken out which was exhibited (by the Hurd Coal and Iron Company) in the Ohio collection of minerals at the Centennial Exposition in Philadelphia.

In the north-east quarter of Section 7, Monroe township, the coal is wenty-eight feet below the surface, and twelve feet thick.

On Section 23, Monroe township, the coal is fifty-three feet from the surface, and ten feet ten inches thick.

On Section 15, of same township, north-west quarter, the coal is twenty-nine feet from the surface, and eleven feet six inches thick.

On Section 9, north-east quarter, the stream has exposed the upper portion of the coal, and at this point Sands's bank was opened, and an entry driven some thirty or forty yards.

The following is a section of the strata:

	FT.	IN.
Sand-rock.		
Shale	6½	..
Coal	2	11
Shale	..	1
Coal	5	3
Shale	..	2
Coal	2	10
Total thickness of coal	11	3

These sections will suffice to show the general character of the coal, and to indicate its continuity over all this field. A marked change will be observed in the relative thickness of the different benches. At Shawnee and Straitsville, the lower benches furnish the purest coal, and are about two feet thick each. Here the lowest bench is often three feet, and the middle bench between five and six feet, and neither of them in any respect inferior to the corresponding benches at Shawnee or Straitsville. Indeed, a careful study of all the exposure shows that here is the maximum development of the coal, both in thickness and in quantity, only one improvement being to the north of this, viz., a smaller percentage of water in the coal.

The coal is here dry, being free from sulphur, susceptible of being mined in large blocks, is more laminated, showing thin seams of mineral charcoal, which make it more open burning and an excellent furnace coal.

The following table of the analyses of the coals from this neighborhood will sufficiently indicate their character:

	1.	2.	3.	4.	5.	6.
Specific gravity	1.300	1.295	1.313	1.323	1.299	1.306
Moisture	5.60	4.95	5.06	4.68	6.42	5.34
Ash	2.03	5.25	6.70	5.96	5.54	5.09
Volatile comb. matter	29.92	31.05	30.86	31.28	33.87	31.40
Fixed carbon	62.45	58.75	57.36	58.06	54.17	58.17
Total	100.00	100.00	99.98	99.98	100.00	100.00
Sulphur	0.79	0.84	1.10	0.77	0.89	0.88
Sulphur in coke	....	0.54	0.54	0.37	....	....
Permanent gas	....	3.60	3.30	3.53	....	3.48

No. 1, Benjamin Saunders's bank.

No. 2, average 2 samples, A. Saunders.

No. 3, average 12 samples, Richter's bank.

No. 5, average 5 samples, Sands's bank.

No. 6, average of all the above.

Professor Andrews says, in regard to these analyses: "The samples analyzed were all selected by myself, and my sole aim was to secure such samples as most fairly represented the seam. In some cases, each foot of coal in the vertical range is represented by a sample."

If my conclusions are correct as to the true relations of the coals about Moxahala, a local section there would differ from the general one given above, in this respect: the Great Vein (lower part) would be reduced to four feet seven inches; the sandy shales above increased to some fifty feet, and patches of coal inserted above and at the base of the Mahoning sandstone.

THE NORRIS COAL.

At an average elevation of about forty-five feet above the Great Vein, is a coal which, in all its characteristics, bears a great resemblance to Coal No. 6 in other parts of the State. It is here regarded as No. 6*a*. Going south from New Lexington, it makes its first appearance near Moxahala, above the Mahoning sandstone, and has been mined for many years near the little village of Oakfield. It extends southward through this field, but in places, as in the Akron Iron Company property, seems to be cut out, and its horizon is occupied by massive sandstone; and again, in other places, it passes into a bituminous shale or disappears altogether. Its best exposure is at the old Norris bank, near Millertown, which has given it its name. The following is a section of the coal, including strata:

	FT.	IN.
Sand-rock.		
Yellow shale	8	..
Blue shale	2	..
Shaly coal	1	..
Shale parting	..	1
Coal	1	8
Shale parting	..	3
Coal	2	..
Cannel coal, impure	..	10

It is a black, lustrous, moderately melting coal, showing considerable sulphur in combination with iron, and leaving a purple ash. It has evidently high heating power, and will prove a valuable coal for all purposes in which the sulphur present will not prove objectionable. Professor Andrews describes the out-crops and openings in this coal as follows: "The middle, or Norris, seam is found on the Neesly McDonald farm, Section 22, Monroe township; at J. B. Latta's, Section 4, Pleasant township; at J. Pyle's, in Pleasant township; at Benjamin Saunders's, Monroe township; above the great seam, at the Sands bank, Section 9, Monroe township; at Moxahala village, and at many other points. At the Sands bank, the middle coal has been well opened, and measures four feet two inches, with four feet of clay-slate roof. No slate partings were seen, and the coal appeared to promise well. Here the interval between this seam and the great one below, is fifty feet. At Benjamin Sanders's on West Fork, the middle seam measures only two feet six inches, and the quality is poor. At Ferrara, on the Nelson Rogers farm, the place of the middle coal is seen, but only a few inches of coal are found. The middle seam appears in the hills near Moxahala village, and, at one exposure, measured four feet two inches, with a two-inch slate parting a little above the middle. On Thomas Kinsell's farm, it is thinner, measuring only two feet, with two inches of slate in the middle. The upper bench is quite sulphurous. This is forty to forty-five feet above the place of the great seam. In the hills northward, toward New Lexington, the middle seam is not often found, it being replaced by the heavy sand-rock almost everywhere found over the great seam, here called the upper New Lexington seam."

The thin bed of cannel coal at the bottom of the seam, is too impure for use; but a hasty examination showed coprolites, fish-scales, and teeth, indicating a promising field of exploration for the paleontologist.

The following is a copy of Professor Wormley's analyses of two specimens of this coal, from the Norris bank:

	1.	2.
Specific gravity	1.277	1.350
Water	3.80	3.80
Ash	4.60	6.30
Volatile combustible matter	38.80	37.00
Fixed carbon	52 80	52.90
Total	100.00	100.00
Sulphur	3.59	4.89
Cubic feet of gas per pound	3.03	3.08

COAL NUMBER SEVEN, OR THE STALLSMITH SEAM.

From twenty-five to forty-five feet above the Norris coal is a seam which reaches a maximum thickness of between four and five feet, and is called, sometimes, the Four-foot coal, sometimes the Stallsmith seam. It is a bright, hard coal, with a resinous lustre, highly melting, and much prized for domestic uses.

On the West Fork, near the town site of Buckingham, where it has been mined by Mr. Benjamin Saunders, the following section is obtained:

	FT.	IN.
Argillaceous shale	4	..
Coal	..	8½
Thin band pyrites.		
Coal	4	..

The lower four feet is in one bench, and contains little visible sulphur, presenting the appearance of a strong, coking coal, of excellent quality for mining purposes. Mr. Stallsmith's mine, south of Mr. Saunders's, presents similar characteristics.

Specimens from these two mines have been analyzed by Professor Wormley, with the following results:

	1.	2.
Specific gravity	1.294	1.254
Moisture	(dried)	3.80
Ash	2.80	4.14
Volatile combustible matter	41.70	40.21
Fixed carbon	55.50	51.85
Total	100.00	100.00
Sulphur	2.56	2.62

These coals are not as persistent as the Great Vein, and there are much more rapid changes, both in the thickness and character of the coal. Above them, there are, in places, two and three thin seams, but at no point observed are they of any economic value, except at the village of Bristol, west of Moxahala, where the hills rise about 250 feet above the

Great Vein. There, near the top, a coal is mined which is, locally, four and one half feet thick It is a soft, melting, bituminous coal, of very fine quality. Mr. Nichols's section makes this coal 230 feet above the Great Vein.

IRON ORES.

The outcrops of iron ores, apparently of good quality, are abundant on the slopes of most of the hills, but few of them have been systematically explored. Enough has been done, however, to demonstrate their presence in considerable quantities, and of excellent quality.

The lower ore, about 140 feet below the Great Vein, is below the surface; but, at the north-west of Lexington, it has been extensively mined, and shipped to the Zanesville furnaces. It is a fossiliferous ore, associated with the limestone, and contains characteristic limestone fossils. It is not accessible in the immediate vicinity of any of the openings in the Great Vein, but all the ore on this horizon can be made accessible by transporting it a short distance.

About ten feet below the lower Lexington coal, is the out-crop of the Baird ore, ten inches thick. A stratum of sandstone separates it from the coal above. Search should be made throughout this part of the field for this very important ore, the true place of which is directly under the fire-clay of this coal.

Immediately below the Great Vein are frequent outcrops of a compact, very hard, blue carbonate, which appears of good quality, the nodules, sometimes, being of large size, and found at varying distances from the coal. I know of no explorations on this horizon about here, but in other parts of the field, from fifteen to twenty feet of these shales contain ores of good quality, and of workable thickness, found at varying distances below the coal. This horizon is accessible in most of the territory north of Moxahala village, and the indications of the presence of the ore are in all respects favorable.

A similar ore is also found in the shales, directly above the Great Vein, sometimes scattered in nodules and thin bands through an interval of eighteen feet; but this horizon has likewise been little exposed, although one exposure of good ore, one foot in thickness, was observed.

About forty feet above the Great Vein, at Moxahala Station, a remarkably fine ore has been opened, called there the Norris Coal ore, because it was believed to be near the horizon of that coal I would suggest for it the name of the Moxahala ore. It is in large, massive nodules, the seven feet of shales exposed disclosing the equivalent of from four to five feet of solid ore, in part a brown oxide, and in part a blue carbonate. Both roast easily, and the blue, in roasting, changes to a black oxide. The dark ore yields, on analysis, 41 65-100 per cent. of metallic iron, and the blue 25 per cent.—the latter containing lime enough for a flux. Its horizon is just below the Norris coal. It has, sometimes, a limestone below it, and shows, in other places, one foot of ore.

The character of this ore indicated its identity with the shaft ore of Trimble township and the limestone ore of Shawnee, but its supposed position a little above what was regarded as the Norris coal, was incompatible with this conclusion. A drift into the hill shows that it has fallen much below its true horizon, and while this mass of ore was found at the base, its proper place is at the top of the Mahoning sandstone. The coal here called the Norris, being now recognized as on the normal horizon of the Great Vein, this ore falls readily into its proper place, and its identity with the Shawnee limestone ore, Ewing's shaft ore, and Andrews' "Sour Apple" ore, which he locates a little above the Mahoning sandstone, may be regarded as established, and these may all be called the Moxahala ore. On Section 10, Pike township, it is, by the barometer, sixty-five feet above the coal, and is exposed one foot thick; an excellent, compact, nodular ore, mainly a sesquioxide, resting on a fire-clay. Parties are here engaged mining the ore, by stripping, under an agreement to deliver to the Ohio Iron Company, of Zanesville, fifty thousand tons. It pays a royalty of fifty cents, and the cost of mining is ninety cents per ton. All the openings here made on the proper horizon disclose the ore in sufficient thickness to be profitably mined, and of good quality. On the Moore farm, the ore is in moderate sized nodules, running through four feet of shales. A non-fossiliferous, compact limestone, of good quality, is to be seen in the neighborhood on the same horizon, but its thickness was not determined.

On the Bennett farm, Section 9, Monroe township, several openings have been made in an ore which I regard as the equivalent of the Bessemer ore. It is here from seventy-five to eighty feet above the Great Vein, and at the openings visited measures respectively 2½, 3, 1¼, and 3 feet. It is in hard, compact, grey nodules, forming a nearly solid mass of good ore, much of it well oxidized, consisting largely of the sesquioxide. All the hills in the neighborhood are reported to contain it, and the openings visited indicate its presence in large quantities.

The Iron Point ore has been opened, so far as I can learn, in only a few places, although its general presence is indicated. The Moxahala ore below it is so largely developed and of so fine a quality that it has attracted much more attention. At Moxahala an opening has been made in a stratum one hundred and sixteen feet above the Great Vein, which shows a large quantity of good ore in small nodules, mingled with nodules of calcareous ore; the exposure is made by sinking a pit near the outcrop, and the condition of the opening was such when visited that an accurate measurement could not be made. About fifteen feet above it is a limestone from one to one and a half feet thick, of good quality, and by analysis said to contain eighty per cent. of lime carbonate. This ore I regard as the equivalent of Prof. Andrews' Latta ore, which he locates fifteen feet above the Stallsmith coal; it is found in nodules or blocks sometimes two feet in thickness, and he traces it through all the hills of this region. If this is correct, the Iron Point ore, when exposed, is not as rich in this neighborhood as about Shawnee, and the gray ore below it, which is largely developed and of excellent character, will be of the most importance. I have, however, noticed various outcrops of ore about twenty feet above the horizon of the Latta ore, of fine quality, and explorations will doubtless be rewarded by important and valuable developments. This is regarded by local explorers as the true horizon of the Iron Point ore. The "Moxahala Iron Company" has been organized for the manufacture of iron at Moxahala. A shaft has been sunk to the coal, the thick bed of ore, above described, opened, and preparations made for the immediate erection of the furnace. There is no question as to the abundance and excellence of the materials for iron-making in this neighborhood, provided the ore opened on the slip shall be found of similar character on its true horizon. The coal at the shaft is slightly melting, and will probably produce the best results if used with a moderate quantity of coke. This is to be determined by trial, and I think everywhere in the Great Vein region, where coke is required, it can be supplied by coking a part of the two lower benches of that seam. One fact ought to be considered and one caution regarded in this whole territory. Iron-making is yet every where largely conducted by what is called "the rule of thumb," and in a region where there is so great variety in the character of the ores and limestones, the first trials should be made with some care; should be rather tentative until by practical tests it is determined what ores, or what mixture of ores, work the best and produce the best results. One temporary failure in the beginning of enterprises of such importance, and when success is practicable, is a public calamity which ought by all means to be avoided, and can easily be, if proper care is observed in the first experiments.

These remarks are not made because of any special danger in this locality, where all the material appears to be of excellent quality, but are applicable to the whole territory, and because of the tendency to conclude, when experiments have been successful in one part of the field, that in all others the ores and limestones may be poured indiscriminately into the stack and good results obtained. With proper care in the first experiments in each locality, success will be certain.

The following analyses of ores from this neighborhood have been made:

	1.	2.	3.	4.	5.	6.	7.	8.	9.
Water	8.43	10.00	10.90	8.00	10.00	10.70	17.70	12.00	5.80
Silicious matter	35.88	13.04	14.90	20.94	17.92	13.76	6.30	14.96	15.32
Iron carbonate	....	....	....	....	....	....	....	....	....
" sesquioxide	54.19	72.63	68.94	66.13	69.96	73.80	68.88	66.44	66.66
Aluminum	.01	.20	.70	1.80	.60	.10	.20	8.20	2.3
Manganese	....	....	1 75	Trace.	....	.50	....	.50	....
Magnesia phosphate	.18	....	....	....	.96	....	....	2 05	....
Lime phosphate	.05	.68	.76	1.24	.41	.41	1.28	.51	.89
" carbonate	1.64	....	.07	.08	....	.78	2.96	....	4.84
Magnesia carbonate	....	3.54	1.09	1.20	....	.07	2.49	....	1.39
Sulphur	.08	.04	....	.05	.02	Trace.	....	.08	.13
Totals	100.63	100.13	99.11	99.44	100.60	99.72	100.81	99.74	99.03
Metallic iron	37 93	50.84	48.26	46.29	48.97	57.66	48.22	46.51	46.66
Phosphoric acid	.12	.31	.35	.57	.63	.19	.83	1.35	.41

	10.	11.	12.	13.
Water	8.90	1.60	....	....
Silicious matter	25.60	15 96	8.47	7.58
Iron carbonate	....	44.91	....	....
" sesquioxide	59.07	28.57	48.36	28.23
Alumina	1.56	.40	2.08	.35
" phosphate	.59	....	....	....
Manganese	2.40	.42	1.86	.96
Magnesia phosphate	.70	....	2.26	35.42
Iron phosphate	1.10	....	2.67	22.9 0
" carbonate	....	2.80	.35	.10
Magnesia carbonate	....	4.69	31.90	2.87
Sulphur	Trace.	.33	.16	.1 0
Totals	99.88	100.00	....	....
Metallic iron	41.31	41.68	37.62	21.96
Phosphoric acid	1.21	.32	.15	.04

No. 1. Two and one-half miles east of Rushville, Perry county......Wormley.
2. Garrison's, Rushville, Perry county........................ "
3. N. Axline's, " " .... "
4. " " " .... "
5. Near Crossenville, " .... "
6. Between Bremen and Maxville, Perry county .... "
7. Reading township, Perry county .... "
8. Moxahala, south of New Lexington .... "
9. " W. Moore's farm, New Lexington................ "
10. Latta farm, south of New Lexington .... "
11. Moxahala ore..Gregory.
12. " ....Love.
13. Limestone, Akron Iron Company, Monroe township.......... "

FIRE-CLAYS.

The coals and ores here, as in other parts of the field, ordinarily rest upon fire-clays of varying thickness and quality. At Moxahala, above the Norris coal, is a bed of compact, non-plastic fire-clay about six feet thick, the lower four feet of which appears to be of good quality. It is reported to have been tested in the fire-brick works at Columbus with good results.

LOWER SUNDAY CREEK REGION.

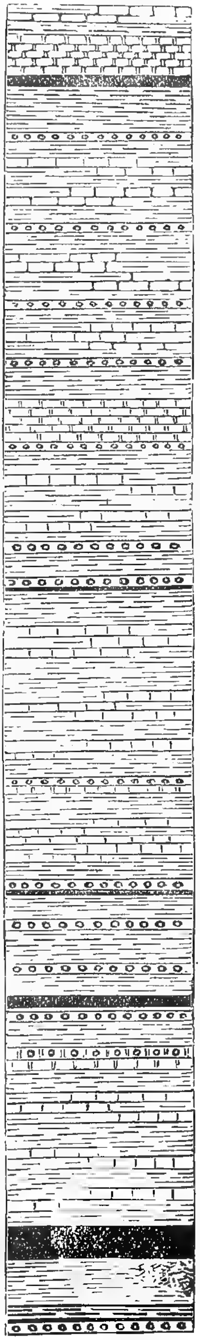
This division embraces that part of the territory east of Snow Fork, and north of the Hocking River, separated from the Moxahala region by that old channel of excavation or upheaval on the north line of Perry county. The proprietors of these lands have made systematic explorations by boring, and it has been mainly at their expense that the outline of the *want* at the north has been located, and the character and position of the Great Vein in this region determined. The valley of Snow Fork exposes the coal in its normal position, but to the eastward the dip carries it beneath the surface of the lowest valleys, and without these explorations its presence in the greater part of Trimble and Dover townships would be an inference only, rendered very probable by the known facts, but far from a certainty.

The relations of the rock strata in this territory, so far as they are explored, are indicated by the general section here pictured. The strata below the Great Vein are given only to the depth of recent borings, as the logs of the old salt wells are not accurately preserved, and it is evident the section does not reach the bottom of the Coal Measures. It covers 537 feet of the Coal Measure rocks, from the top of the hills in the east part of Trimble township, to the bottom of the deepest well drilled for coal. Authentic records of the wells drilled for salt would add four to five hundred feet to the base of the section.

Commencing at the base of the section, as given, there is a coal two and one-half feet thick at the point explored, which appeared to be a dry, burning coal, of fair quality, but of no present value. It is doubtless the equivalent of the lower Moxahala seam, which, at the north reaches a thickness of five feet, and is there a valuable coal.

SECTION OF ROCKS ON LOWER SUNDAY CREEK.

Scale.—1 inch, 64 feet.



	Ferruginous shale and sandstone.
3 to 15	Limestone.
4 to 6	Coal No. 8.
20 to 50	Shale.
	Iron ore No. 14.
30 to 60	Shale and sandstone.
	Iron ore No. 13.
26	Shale and sandstone.
	Iron ore No. 12.
20	Shale and sandstone.
	Iron ore No. 11.
12	
3 to 15	Ames limestone.
	Iron ore No. 10.
34	Shale and sandstone.
	Iron ore No. 9.
10	Shale.
	Iron ore No. 8.—Coal.
68	Shales and sandstone.
2½	Iron ore No. 7.—Cambridge limestone.
37	Shales and sandstone.
	Iron ore No. 6.—Coal.
11	Shale.
	Iron ore No. 5.
14	Shale.
	Iron ore No. 4.
10	Shale.
4 to 6	Coal.—Iron ore No. 3.
16	Shale.
	Limestone ore No. 2.—Limestone.
60	Sandstone and blue shales.
7 to 12	Coal—Great Vein.
17	Fireclay and light shale.
21	Dark shale.—Coal.
22	Iron ore No. 1.

About twenty feet above this, is the Great Vein coal, which is here finely developed, and, with the iron ores and limestones, constitutes the great mineral wealth of this region.

This coal is mined by the New York and Ohio Coal Company, by drifting, near the north-west corner of Section 4, York township, where the coal is nine feet thick, and where large quantities have been mined and shipped. The section is here, from above:

	FT.
Sandstone, exposed	20
Shale	6
Coal, in three benches	9

The sandstone approaches abnormally near to the coal, and northward it has, in places, cut away all of the shale and the upper part of the coal.

Along the valley of Snow Fork, from the north line of Ward township to the north line of Section 4, the coal is well exposed, generally a little above drainage, and is of remarkable excellence.

At the Cawthorn bank, on Monday Creek, above its junction with Snow Fork, the following measurements were taken:

	FT.	IN.
Shale	15*	..
Coal	4 to 6	..
Shale	..	3
Coal	..	22 to 24
Shale	..	1½
Coal	..	22 to 24

The coal is of good quality, with little sulphur, and in all respects much like that of Shawnee and Straitsville.

A full section of the rock strata, exposed at this point, is as follows:

	FT.
Ferruginous shales	50
Crinoidal limestone	3–4
Shaly sandstone	50
Coal (reported thickness)	3
Not exposed (to bench in hill)	20
Sandstone	70
Calcareous iron ore	5
Ferruginous shale	20
Drab limestone, with iron ore	4
Shaly sandstone and yellow shale	30
Coal	4
Ferruginous shale	30
Coal, Great Vein	9
Blue shale, with iron ore	8

*Blue shale, with nodules of iron ore, eight feet.

The large preponderance of shales above the Great Vein are characteristic of much of this territory, indicating the deposit of the overlying material in deepened, quiet water, and rendering it quite improbable that any of the coal has been cut out.

On Jay Follett's land, north-west quarter, Section 2, Ward township, the Great Vein is nine feet thick; the two lower benches twenty to twenty-two inches each; shale partings, one inch and from two to three inches; in every respect like the Straitsville coal. The bottom of the coal is about fifteen feet above thestream.

On J. Twiner's land, Section 5, north half of south-east quarter the coal is nine feet thick, and very similar to the last.

On Alexander Marshall's land, south half of south-east quarter, Section 35, Salt Lick township, is a very fine exposure of the coal, the bottom below drainage. It is reported to be thirteen feet thick. The upper bench varies from six to six and one-half feet, with a shale parting below of three to four inches. The lower bench or benches are only partly exposed, and are reported to be over six feet thick, substantially in one bench. The coal is of excellent quality, hard dry, being free from sulphur, and, in all respects, equal to the best exposures of this seam. The upper part of the upper bench inclines toward a splint coal.

A rude opening was formerly made, the water pumped out, and coal mined for local use. It was claimed that twelve and one-half feet were mined, and one foot of the top coal left for a roof. If this statement was correct, it is the thickest coal in the field. There are many other exposures of the coal along the valley of Snow Fork, but all of a similar character to those given above. On the east side of the divide, and in the valley of Sunday Creek, explorations have been made by drilling, as follows:

1st. In the south-east corner of fraction 26, Trimble township, near the junction of Mud Fork with Strait Branch of Sunday Creek, the Blonden well, in which the Great Vein was struck ninety-six and one-half feet from the surface, and twelve feet two inches thick.

2d. Near the center of the south-west quarter of Section 7, Trimble township, the Chappolear well, in which the Great Vein was struck one hundred and two feet ten inches from the surface, and eight feet four inches thick.

3d. Near the center of Section 25, Trimble township, the Roswell well, in which the coal was struck one hundred and twenty feet six inches from the surface, and seven feet thick.

4th. Near the south-east corner of Section 19, Trimble township, the Hughes well, in which the coal was struck ninety-four feet from the surface, and ten feet thick.

5th. In the west half of fraction 18, Dover township, the Burge or Bayley's Run well, in which the coal was struck at seventy-seven feet from the surface, and eight feet two inches thick.

At the Blonden well a shaft has been sunk, and the accuracy of the observations by boring, verified. The coal is disclosed here with all the characteristics of the very best grade of this coal, and of the same thickness as indicated by boring.

The section of the coal at the shaft is as follows:

	FT.	IN.
Shale roof.		
Bone coal	1	..
Splint coal	2	..
Cannel coal	1	..
Coal	3	..
Shale parting	..	½
Coal	5	..

The two feet of splint coal is very dry, being pure and free from sulphur.

The cannel coal has a larger percentage of ash than the ordinary Great Vein coal, but in other respects is of equal purity. Professor Wormley's analyses of it gives the following results:

Moisture	3.90
Volatile combustible matter	32.70
Fixed carbon	47.60
Ash (dull white)	15.80
Total	100.00
Sulphur	0.43

The coal of the two lower benches is not excelled by any in the Great Vein region. It is much more laminated in its structure, with more mineral charcoal than in any other parts of the Great Vein region, much of it in external appearance greatly resembling the best laminated specimens of the Briar Hill coal. It will be more open burning than the average of the Great Vein.

The following condensed tables of analyses, made by Prof. Wormley and reported by Prof. Andrews, in a pamphlet on "The Lower Sunday Creek Valley," with analyses of the Ashland (Ky.) coal, and the Brazil (Ind.) coal will give a comparative idea of the character of this coal.

The table, No. 1, gives the average of five analyses of coal from these five wells.

No. 2 gives the average of the analyses of thirty-two samples of this seam in the other parts of Sunday creek.

No. 3 gives the average of eighteen samples from this seam, in the immediate valley of the Hocking and about Straitsville.

No. 4, an analysis of the Ashland, Kentucky, furnace coal.

No. 5, an analysis of the Brazil, Indiana, furnace coal.

	1.	2.	3.	4.	5.
Water	3.85	4.59	6.22	6.65	5.46
Ash	6.94	6.01	4.66	4.53	1.80
Volatile combustible matter	33.61	32.50	32.55	34.54	38.75
Fixed carbon	55.60	56.88	56.57	54.28	53.99
Totals	100.00	100.00	100.00	100.00	100.00
Sulphur	0.96	0.92	0.95	1.07	0.75
Sulphur remaining in coke	0.40	0.46	....	....	....
Gas per pound (cubic feet)	3.38	4.43	3.01	....	....

As the analyses, condensed in column No. 1, are from chips brought up in the sand pump from drilled wells, it is quite probable the amount of ash is increased by the presence of shale from the roof of the coal. In all other respects the coal is fully up to the standard of this coal, and it will be observed that there is an important improvement in the diminished amount of combined water. The sulphur is also quite low, and the greater part of it passes off in the volatile matter, leaving a coke almost free from this impurity. The analysis of the borings from the well on Green Run, showed 0.60 per cent. of sulphur, while there remains in the coke only 0.054 per cent.

The following is the result of the analysis of a specimen from the lower bench of the Shaft coal, made by Spencer B. Newberry:

Moisture	6.11
Volatile combustible matter	35.22
Fixed carbon	51.19
Ash	7.48
	100.00
Sulphur	1.02

In the coke used in the Cleveland iron district, England, Mr. Bell reports the average amount of sulphur to be about 0.60 per cent., or nearly twelve times as much as that remaining in the Green Run coke.

All the wells sunk in this field, disclose the coal at its proper horizon, and there are no indications of erosion. At Chauncy, it has been mined by a shaft 100 feet deep, for more than thirty years, is from six to seven feet thick, and of good quality. All the facts indicate that the coal is persistent over this whole area, and that it is of strictly first class quality. It is quite natural that the coal should be first worked where it is well up in the hills, and can be mined by drifting; but when its horizon is at a moderate depth below the bottom of the valleys, there is the marked advantage that no coal has been lost through the erosion of the valleys—there is no poor "crop coal." Shafts may be sunk in immediate proximity to the valley roads, the cost often being much less than that of the construction of the long trestles which are needed to connect the mines on the hill sides with the roads in the valleys. These coals are not ordinarily the first to be developed, but the whole cost of mining is no more than the average of drift mining, and the area of workable coal may be regarded as equal to the surface area, so that the ultimate value of the land is much greater than where erosion has carried away a large percentage of the coal.

BAYLEY'S RUN COAL, OR COAL NUMBER SEVEN.

At an average distance of about seventy or seventy-five feet above the Great Vein, there is here another important coal, which has ordinarily been regarded as the equivalent of the Stallsmith coal of the upper Sunday Creek, although the interval between it and the Great Vein is considerably less. But the Stallsmith coal is clearly No. 7, and the thin coal above the Bayley's Run, with its associated iron ores, is everywhere suggestive of its identity with No. 7. A revision of the sections at Millertown, and west of Buckingham, where are the openings which have given the local names to these coals on the upper Sunday Creek, shows clearly that the Bayley's Run and the Norris coals are the same, although the interval between it and the Great Vein is on the average considerably greater on the lower Sunday Creek. The coal has also peculiarities quite different from the ordinary character of No. 7.

It is a bright black, with a resinous lustre, burns with a long light flame, and shows little sulphur; in some of the openings forming a single bench, in others having a thin shale parting near the top. In thickness it ranges from four and one-half to five feet, and is generally a little above drainage, so that the loss by erosion is small. The following table of analyses by Prof. Wormly indicates its character:

	1.	2.	3.	4.	5.
Water	4.20	4.20	4.50	3.60	3.40
Ash	2.60	3.00	6.80	2.60	5.90
Volatile comb. matter	35.20	33.10	31.30	35.00	34.40
Fixed carbon	58.00	59.60	57.80	58.80	56.30
Totals	100.00	100.00	100.00	100.00	100.00
Sulphur	1.04	1.20	1.15	1.29	1.09
Sulphur remaining in coke	0.41	0.46	0.52	0.49	0.60
Percentage of sulphur in coke	0.67	0.73	0.80	0.79	0.96
Gas per lb. in cubic feet	3.95	3.35	3.12	3.84	3.84
Color of ash	Gray.	Gray.	Dull white.	Gray.	Gray.
Character of coke	Compact.	Compact, metallic.	Compact, metallic.	Compact.	Compact, metallic.

No. 1, from C. Southerton's bank, Bayley's Run, Section 34.

No. 2, from Section 7, Trimble township, lower part of seam.

No. 3, " " " upper "

No. 4, from Chappalear bank, near line between Dover and Trimble.

No. 5, from Allen bank, mouth of Mud Fork.

The average percentage of water is 4, but little more than that of the Briar Hill, which is 3.84. The average percentage of ash—excluding that of No. 3, which is exceptionally large—is 3.77, comparing favorably with our best coals. The average percentage of fixed carbon is 58.10, while that of the sulphur is 1.15, of which all, except 0.49, passes off in coking.

Prof. T. Sterry Hunt, in a pamphlet on "The Hocking Valley Coal-field and its Iron Ores," p. 42, says, in reference to the above analyses: "The proportion of sulphur in the Bayley's Run seam, though somewhat larger than that of the Great Vein, is not large when compared with most other coals in Ohio and elsewhere. From the analyses of Ohio coals published by Prof. Wormley, I select a few samples. The average amount of sulphur in seven (7) samples of the coal mined at Cambridge, in Guernsey county, is 1.98 per cent.; that of nine (9) from Coshocton county, 2.21; of nine (9) from Stark county, 1.94; of ten (10) from Holmes, 2.15; and of seven (7) from Columbiana, 1.95. Of the coals of Great Britain, as appears from an extended series of analyses, made a few years since for the British Admiralty, the average amount of sulphur in thirty-seven (37) Welsh coals was 1.42; of twenty-eight (28) from Lancashire, 1.42; of eight (8) Scotch coals, 1.45; and of seventeen (17) from New Castle, 0.94. The coke of Durham, esteemed in England as the best fuel for iron smelting, retains from 0.60 to 0.80 of sulphur. So that it will be seen that the coal of the Great Vein of the Hocking Valley and that of the upper or Bayley's Run seam are more than ordinarily free from sulphur."

This coal in a raw state will be found an excellent fuel for all domestic and manufacturing purposes where its melting character is not objectionable, and it gives promise of furnishing a better coke than any other coal in the state. Experiments have been made in a small way by coking it in a single new oven not thoroughly dried, at Shawnee, and under these unfavorable circumstances, the product was a hard, bright metallic coke, evidently containing little sulphur, which is highly commended by good judges of coke. The following is the analysis of it, made by S. B. Newberry:

Carbon	86.95
Ash	13.05
Total	100.00
Sulphur	1.68

This specimen shows a larger percentage of sulphur than the average analysis of the coal would indicate, and probably larger than the average of the coke.

So thoroughly persuaded is Prof. Andrews, who has carefully explored this region, of the excellent coking character of this coal, that he says he is inclined to believe that in the future the Bayley's Run coal in the Lower Sunday Creek region will be even more valuable than the great seam underlying it. It has been mined for local consumption in some half dozen places, and in all of them appears of excellent quality.

Above the Bayley's Run coal are several thin seams of coal, none of which have been specially explored, and none of them disclosing outcrops which give promise of a workable thickness until the Pittsburgh coal is reached. The latter belongs to the upper Coal Measures, and is found in the hills east of Sunday Creek at an elevation a little less than five hundred feet above the Great Vein. It ranges in thickness from four to eight feet, is a soft, melting coal with a high heating power, but containing apparently a rather large per centage of sulphur. Its character and location will prevent its being mined, except for local consumption, for very many years. There is doubtless much valuable coal on this horizon, but it constitutes a part of the reserve supply for consumption in the indefinite future, when the more valuable coals are approaching exhaustion.

IRON ORES.

Prof. J. P. Weethee, who lives near the town site of Ewing, has devoted much time to the study of the iron ores of the lower Sunday Creek

Valley, and I adopt his numbering of the ores, as amended by Mr. Nichols in his chart, both in this description and in the section given on a previous page.

Prof. Weethee made the shaft ore—the equivalent of the Moxahala ore—his No. 1, and from thence carried his series to the top of the hill. I find that Mr. Nichols, in his charts, has made the ore next below the Great Vein, which has no outcrop on these lands, No. 1. So that his numbers, minus one, represent Prof. Weethee's numbers. In the shales directly above the Great Vein, and in the interval between it and the "Baird ore," there are important ores which are quite persistent and deserving of a place in the series. This numbering is, however, provisional, and can be only temporary. A revision of this report, or a new report altogether, made under better auspices when all the ores are thoroughly opened and tested, will revise the system and give permanent names and numbers to the ores.

Ore No. 2 is the Moxahala ore. It is located from fifteen to twenty-eight feet below the Bayley's Run coal, resting on a heavy body of limestone, and has been pronounced by experienced iron manufacturers a valuable ore. It is a calcareo-silicious ore, massive and at the Blonden shaft measures four feet in thickness, according to the report of those who sunk the shaft. On Fraction 31, Section 15, Trimble township, on H. Johnson's land, it is exposed in the bed of the stream two feet nine inches in thickness, resting on four feet of lime rock; the ore is ten feet below the Bayley's Run coal, which is here four feet eleven inches thick, but has the appearance of being below its proper horizon. Massive slips upon the slopes of the hills are throughout this whole region so numerous that there is great difficulty in securing accurate measurements of the intervals between the ore and coal beds, and the measurements reported can be verified only after the regular opening of the mineral deposits. The ore at this place shows excellent characteristics, and is apparently richer in iron than at the shaft, when analysis of a single specimen showed twenty-five per cent. The ore can be mined with the limestone which underlies it, both being above drainage in the deepest valley.

Ore No. 3 is from one to six feet below the Bayley's Run coal. Its outcrops, where observed, show a maximum thickness of thirteen inches of a clay-iron stone, in small nodules, well oxydized, and what is often called in this neighborhood a siderite. Taking this term as a designation of the carbonate of the protoxide, nearly all the ores, when not subjected to atmospheric influences, are siderites, a greater or less portion of the base being replaced by lime, manganese, and magnesia, and mechanically mixed with silica, alumina, etc. At the outcrops the iron is largely changed to a sesquioxide.

Ore No. 4 is called the shale ore, and is found in the shales generally about ten feet above the Bayley's Run coal, sometimes consisting of a dozen or more bands of smallish sized nodules extending through four feet of the shale.

A sample analyzed yielded a trifle over thirty-three per cent. metallic iron. It varies in thickness from two to three feet at the points opened, and gives promise of being persistent over a large area. It is exposed in Section 17, Trimble township; at J. S. Jennings's ford, Section 7; at the mill, in Section 8; below the mill, Section 16, Dover township; on George Nye's farm, near Chauncey, and on J. Morris's farm, on Bayley's Run.

Ore No. 5 is about fifteen feet above No. 3, and is called by Prof. Weethee the "Great Vein Ore," as it reaches a thickness in places of over five feet. One specimen of the unroasted ore yielded forty-two per cent. metallic iron, and the average of several analyses was thirty-five per cent. Its outcrop may be seen on Section 17, Trimble township; Section 11, on the Follet land; on the Moody farm in Fraction 36, on the Blonden, Johnson, and Hope lands, on Mud Fork; on Jones' Run, Fraction 1; on the Russell lot, in the village of Trimble; on the Jennings's farm, at the Dug Way, Section 7, and at the mill-dam in Millfield, in Dover township; also, on Section 5 and 18, Dover township, etc. Its very numerous and heavy outcrops indicate that it may be found at this horizon throughout nearly the whole valley. It consists of layers of nodules, some of quite large size, bedded in shale, some of the nodules containing considerable silicious matter, and others twenty to twenty-five per cent. of carbonate of lime. The iron exists mainly in the form of a sesquioxide, but some of it as a carbonate.

At the Dug-way, north of the town site of Ewing, the ore is opened up so as to disclose in a vertical height of six feet the equivalent of five feet of solid ore, while above this are five feet of red ferruginous shales containing nodules of rich ore indicating valuable deposits above the massive nodules. The lower stratum is blue, but burns to a black oxide which is highly magnetic, and all the strata appear to lose their silicious character, which marks some of them at the outcrops, as they are followed into the hill. This is a magnificent exposure of the ore; and several other entries give promise of an equal thickness. Different openings in Trimble and Dover townships give the following measurements of solid ore: Five feet, three feet, four feet, two and one-half feet, etc. There can be little doubt that this fine bed of ore is continuous through all the hills in this neighborhood, and of sufficient thickness to mine by drifting. The ore rests upon a white fine clay, and is bedded in clay colored red by the iron. This ferruginous clay extends up to a thin seam of coal five to ten feet above the ore, and is generally so compact as to constitute a good roof. The ore can be mined without blasting, but the nodules are sometimes so large as to make it difficult to handle them. One was observed which probably contained sixty cubic feet of ore. Ore No. 6, is about thirty-six feet above the Bayley's Run coal, and generally about eleven feet above No. 4, and rests upon a seam of splint coal which is reported to be in places four feet thick. The deposits on this horizon vary greatly in character. On Jones's Run, fraction 1, Trimble township, it is a calcarous ore three feet thick, yielding twenty-nine to thirty-three per cent. iron. At the Dug-way it is a lean black band two to four feet thick. Its outcrop can be seen on L. Weathee's land, section twelve, Dover township; on the Fulton farm, Green Run; on sections eleven and seventeen, Dover township, and in nearly all the localities where No. 5 is found. This is substantially the horizon of the Iron Point ore of Shawnee, and the Black Band of the Tuscarawas Valley. The ore there rests upon the coal. An impure black band is here found in the same position, but the great body of the ore is at a lower horizon, generally resting on fine clay, bedded in fine clay, and often with the fine clay continuing above to the coal. It is evident that substantially at the same time over a greater part of the coalfield of Ohio there were conditions which brought in and deposited coal and iron ore in and about on the same horizon. The fact also that in this horizon the amount of ore bears an inverse ratio to the amount of the underlying coal tends to confirm Professor Hunt's theory of the mode of the deposit of the iron ore, and that the carbonacous matter where the ore deposits are the largest was consumed in effecting the deposition of the iron.

Ore No. 7 rests upon the Cambridge limestone, about forty feet above No. 5. It has been imperfectly opened in two localities only, sections twelve and thirty, Dover township. It is a rich ore, well oxydized and six to thirteen inches thick as far as exposed. The clay above is filled with small nodules of ore indicating a thick bed when the roof rock is reached. The limestone below it is also quite ferruginous, and the indications are favorable for the development of a large quantity of valuable ore on this horizon.

On section twenty-four, Dover township, an opening has been made seventy-three feet below the Ames limestone, which shows a peculiar conglomerate ore, No. 7*a*, a mixture of very hard blue carbonate with iron oxide in small fragments cemented into solid nodules as though the two

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varieties of ore had been firmly comminuted, thoroughly mixed and re-cemented. It presents the appearance of a rich ore, and the stratum measures eighteen inches in thickness.

Ore No. 8 is sixty-eight feet above No. 6, and fifty feet below the Ames limestone. It is called "Cave ore," being usually found directly under a round rock. It is massive, about two and one-half feet thick, and in some localities appears to be a rich ore. Its outcrops may be seen on sections eleven and twelve, Dover township, and on section nineteen, Green's Run.

Ore No. 9 is about ten feet above the last, and forty feet below the Ames limestone. In all places now opened it is about two and one-half feet thick, in small, solid, and closely packed nodules, and contains about forty-two per cent. metallic iron. It has been opened on section nineteen, fractions one and thirty-six, Trimble township, and on sections thirty and thirty-three, Dover township. It is an ore of great promise, and appears to be present in large quantities. Substantially on this horizon, thirty-five feet below the Ames limestone, in fraction eighteen, section twenty-one, Trimble township, is a solid massive exposure of conglomerate ore composed of small fragments of ore, limestone, and silicious matter, with a few quartz pebbles and fragments of fossilized wood, the whole four feet thick, and evidently containing quite a large percentage of iron. This opening is on Laurel Branch of Mud Fork.

Ore No. 10.—This is called the Fulton ore because first opened on the farm of D. Fulton, section 29, Dover township. Its position is a few feet below the Ames limestone, and indications of its presence in many places may be observed. It has been opened only on the Fulton farm and on fraction 36, Trimble township. On the Fulton farm the opening has been carried some fifty feet into the hill, but no roof reached. The maximum thickness at places observed by me is eighteen inches, but the nodules and fragments of ore, some of considerable size, in the earth above, indicate a thicker stratum when the rock cover is reached. This is a remarkable Coal Measure ore, a yellow sesquioxide of iron, almost pure, yielding a fraction over sixty per cent. of metallic iron, of sulphur a mere trace, and of phosphoric acid 0.19 per cent. only. Prof. Weethee reports finding at one point a solid block of the ore ten inches thick, and one foot above the regular stratum, constituting no part of the latter, which measured at that place twenty-five inches. This makes the whole thickness of ore at that place thirty-five inches. He also says, "In one corner of the opening it is nearly all ore for six feet deep. It has the appearance of fragments of solid layers, and as they must have occupied a higher position, these must be fragments of other layers. Its blossom follows the Ames limestone."

Ore No. 11 is about fifteen feet above the Ames limestone, and is described by Prof. Weethee as consisting of two massive layers one foot thick each, constituting nearly a solid mass two feet thick, occurring in irregular rough nodules, some of the blocks weighing two hundred pounds each. He describes it as a siderite, yielding from thirty to thirty-four per cent. iron. In section 30, Dover township, on W. Johnson's and L. D. Linscott's land, it is a yellow hydrated sesquioxide much like the Fulton ore. At another opening in the same section it is in solid masses of irregular shape, many of them weighing several hundred pounds each, and is a blue calcareous ore, apparently a blue carbonate with lime.

Ore No. 12 is from thirty-five to forty feet above the Ames limestone, is nodular and similar to No. 9, and in places two and one-half feet thick. It may be seen on the Davis farm, section 30, Dover township, and on the William Mason farm, in Ames township. At one opening in Dover township it is from twenty inches to two feet thick, a yellow hydrated sesquioxide resembling the Fulton ore, and apparently of equal richness.

Ore No. 13 is also found on the Davis farm, section 30, Dover township, eighty feet above the Ames limestone, and resembles the Fulton ore, but is rather more sandy.

Ore No. 14 has its horizon from twenty to fifty feet below the Pittsburgh Coal, and is found in hard, brown nodules scattered through thirty feet of ferruginous clay. No opening has been carried to its bed. Some of it resembles the "Needle ore" or gothite, and from the manner in which it is distributed gives promise of being of good thickness and a very valuable ore. It yields by analysis 55.36 per cent. metallic iron, 0.51 per cent. phosphoric acid, 0.07 per cent. sulphur. The iron is in the form of a sesquioxide, of which the ore contains 79.09 per cent. A remarkably fine ore.

Careful measurements have been made by Prof. Weethee to determine the relative position and thickness of these ores, and the general accuracy of his work is confirmed by Mr. Nichols's notices and my observations. While these ores are largely developed and widely distributed, none of them are to be regarded as absolutely persistent. In places, massive sand-rocks and in others, shales occupy the horizons of the ores without any sign of their presence; and the calcareous ores also sometimes pass into limestone, and frequently outcrops of ores are noticed which cannot be referred to any of the foregoing numbers. In section

30, Dover township, about fifty-five feet above the Ames limestone, is the outcrop of a conglomerate twelve feet thick, a mixture of small lime iron ore and small stone nodules, containing evidently so large a percentage of iron as to make it a valuable ore if it contains no deleterious substances. In this immediate neighborhood forty feet of the shales above the Ames limestone are highly ferruginous, and bands of good ore are to be seen at so many elevations that their outcrops cannot be reduced to a system. The ore is most of it well oxydized, apparently rich and like the Fulton ore, and there are places where it is probable that this whole thickness of forty feet will be worked for the ore. The upper, soft ores, which are remarkably rich and well oxydized, will probably present very different characteristics when the excavations are carried into the hills and beyond the reach of atmospheric influences. They are nearly all blue carbonates changed at the outcrops to sesquioxides. Some are calcareous, and from the soluble character of the limestone this is often dissolved out, so that the ore is concentrated as well as peroxydized, and such will pass into ordinary calcareous ores when impervious cover is reached.

The following analyses of these ores have been made by competent chemists:

	1.	2.	3.	4.	5.	6.	7.	8.
Silica	18.23	11.23	15.11	7.75	17.26	7.13	18.90	12.62
Sulphur	0.17	0.48	0.20	0.06	0.15	0.12	0.19	0.16
Protoxide of iron	....	25.87	....	33.10	23.70	26.57	....	18.23
Sesquioxide of iron	24.55	16.21	55.69	16.89	11.66	7.61	31.58	3.06
Alumina	1.15	2.66	3.11	0.27	7.64	2.14	1.97	0.19
Oxide of manganese	2.27	7.18	11.35	2.90	3.53	4.95	1.83	7.14
Lime	28.52	8.25	9.58	8.14	7.12	14.45	24.70	20.15
Magnesia	1.78	1.78	2.01	2.03	2.75	3.32	1.04	3.53
Phosphorus	0.05	0.07	0.03	0.05	0.36	0.04	0.04	0.05
Water	1.90	1.70	0.10	0.95	2.07	0.82	3.13	3.10
Carbonic acid	22.05	24.25	3.05	28.85	23.70	31.55	19.80	30.85
Totals	100.80	99.70	100.23	100.99	99.54	98.70	100.18	99.08
Metallic iron	17.19	31.49	38.98	37.57	26.60	25.90	22.10	16.32

No. 1, Dover township, seventy-three feet below Ames limestone. By S. B. Newberry.
No. 2, ore No. 4, Section 7, Trimble, (raw) .... "
No. 3, " " " (roasted).................... "
No. 4, " No. 5, Jones' land, Trimble township.................... "
No. 5, " " Mud Fork.................... "
No. 6, " " Hope bank, Trimble.................... "
No. 7, " No. 8, Jones' land, " .... "
No. 8, " No. 4, shale ore, " .... "

	9.	10.	11.	12.	13.	14.	15.
Silica	......	18.14	21.96	15.97	5.48	6.08	17.04
Sulphur	0.10	0.06	Trace.	0.06	0.07	Trace.	0.07
Carbonate of iron	12.87	31.16	......	19.38	......	......	......
Oxide " "	......	......	......	......	......	......	47.02
Sesquioxide of "	36.70	26.68	59.49	28.86	79.09	85.90	......
Alumina	1.60	2.20	0.80	0.90	0.60	1.40	3.48
Oxide manganese	6.20	5.20	1.40	......	0.80	1.90	1.30
Lime	......	......	......	......	......	......	4.09
Phosphate lime	0.89	0.21	Trace.	0.69	1.11	0.41	......
Carbonate "	20.96	5.25	1.60	22.24	0.51	1.98	......
Magnesia	......	......	......	......	......	......	2.14
Carbonate magnesia	3.63	4.54	2.72	4.24	0.14	0.07	......
Water	7.90	6.15	12.50	5.85	11.90	2.50	......
Carbonic acid	......	......	......	......	......	......	22.33
Total	99.21	99.9	100.47	99.14	99.70	99.94	......
Metallic iron	31.90	33.72	41.57	29.56	55.36	60.13	36.57
Phosphoric acid	0.41	0.10	Trace.	0.31	0.51	0.19	0.92

No. 9, Ore No. 5, Trimble township .... Wormley.
No. 10, " No. 4, " .... "
No. 11, " No. 5, Dugway, Trimble .... "
No. 12, " No. 5, " " .... "
No. 13, " No. 14, " .... "
No. 14, " No. 10, Fulton ore, Dover .... "
No. 15, " No. 5, Mud Fork .... Love.

THE NELSONVILLE REGION.

The Nelsonville region is more varied in its characteristics than any other subdivision of the Great Vein territory. It embraces Ward and York townships and the extension of the Great Vein to the west of Ward and the south-east and west of York, where the coal either thins out, or is so deeply buried as to be unavailable for present uses.

In the greater part of Ward township, the Great Vein coal has the same characteristics as in Salt Lick and the western part of Trimble township. It is every where above the drainage of the valleys, and only when approaching Nelsonville becomes thinner and more bituminous. Its slightly melting character about Nelsonville made the coal from that point a favorite domestic fuel, as it ignites more readily and burns with a rather larger flame. But those who have been accustomed to the dryer coal of Straitsville and Shawnee regard the latter as equally valuable for domestic uses. Whether the coal immediately about Nelsonville can be successfully used in the smelting furnace without coke, is not regarded as fully settled. Its composition, as shown by chemical analysis, differs but slightly from that of the thicker parts, and the percentage of impurities is very small. It melts slightly, and the surface becomes a little pasty in burning, but not more than the coal from the Mahoning Valley. Professor Hunt regards it as a good iron-making coal, and I have no doubt that it will prove an excellent fuel for the smelting furnace with a moderate admixture of coke.

Mr. A. B. Waters, cashier of the bank of Marietta, formerly superintendent of a furnace at Zaleski, states that about the year 1867, under the superintendency of Mr. Haseltine, the Nelsonville coal was tested in that furnace, and with very satisfactory results. The coal was from Peter Hayden's mine, and the product of the smelting was converted into bar iron of good quality.

At the Hayden mines, in Green township, the Great Vein is three hundred feet above Lake Erie, about two hundred feet above the valley of Monday Creek, and six feet thick, the general dip bringing it down in the valley of the Snow Fork to about one hundred feet above the lake, the coal varying in thickness from six to eleven feet. It is every where above the valleys of Monday Creek, Poplar Run, Dixon's Run, Brush Fork, and Snow Fork. In all this region, until approaching the valley of the Snow Fork, it appears to be wholly undisturbed, gradually growing thicker from Haydenville to the east, and from Straitsville growing thinner and more melting to the north, the changes being all gradual, and the result of conditions controlling the original deposition of the coal. Along the Snow Fork there is considerable evidence of ancient erosion, the shales having been removed, and a sandstone roof covering the remaining coal. The coal is more reduced in thickness by this cause in the northern part of Ward township than elsewhere, but at none of the outcrops, where this erosion is shown, have drifts been carried into the hill far enough to determine the extent of the disturbance. At the Ogden Furnace, section 2, an opening is made under the sandstone, which in a short distance rises above the coal, giving the latter a shale roof, unevenly bedded, and still showing the results of disturbance. The coal, which contained much sulphur under the sandstone, has greatly improved in character and increased in thickness, till the promise is good for a very valuable mine. In some places to the north of this, the coal is reduced to a few feet; and in all places where this sandstone comes down upon the coal, there is a liability of the coal being suddenly so reduced in thickness, as to be of little or no value. In all such cases, entries should be driven into the undisturbed coal, or borings made in the hill to the horizon of the coal, and its thickness and quality determined before large expenditures are made by the owners of the mineral rights.

There is a large amount of good coal in this valley at such an elevation above drainage as to be mined with facility, entries on the west side running up the dip: but there are localities where the coal is of little value, and the extent of these can be determined only by explorations on the horizon of the coal. Westward and southward the shales appear in their normal position above the coal. In the neighborhood of Bessemer, the coal is six to ten feet thick, with shale above, and of good quality. In the north-west quarter of section 17, on middle branch of Snow Fork, the coal is five feet ten inches thick, of good quality; but east of this an outcrop was observed, only one and a half feet thick, of sulphury coal, with heavy sand-rock above. Passing over the hills from this point toward Carbon Hill, the shales come in above the coal, which assumes its normal thickness and character. On the east part of fraction 32 an outcrop shows ten feet of coal, whose thickness below the upper parting is eight and a half feet.

At a new entry driven near Carbon Hill, the following section is shown:

	FT.	IN.
Coal	3	1
Shale	..	2 to 3
Coal	2	4½
Shale	..	1
Coal	1	10

Showing an increased thickness of the middle bench, and a thinning down of the upper bench, compared with the Straitsville entries. The coal, in its characteristics, does not differ materially from that at Straitsville.

On approaching the Hocking River the coal becomes thinner, mainly by a reduction of the upper bench, the coal at W. B. Brooks's bank showing the following section:

	FT.	IN.
Coal	2	..
Shale	..	3 to 4
Coal	2	4
Shale	..	1
Coal	1	7
Total	6	4

And at Peter Hayden's bank the following:

	FT.	IN.
Coal	2	4 to 5
Shale	..	3 to 4
Coal	2	5
Shale	..	1 to 2
Coal	1	3
Total	6	4 to 7

It is here called the "six and a half feet coal," and averages about that thickness.

This diminution of thickness is local, and on the south side of the Hocking it increases to eight feet, but the thickening up in that direction, as well as in all the territory east from Moxahala to the Hocking, is due almost wholly to the increased dimensions of the middle and lower benches, as the sections given by Professor Andrews, and in this report, clearly show.

Mr. Roy, the State Inspector of Mines, attributes the diminished thickness here to the splitting of the upper bench by a local submergence of the old coal marsh, which brought in a wedge-shaped deposit of mud, and has left a bed of shale twenty feet thick at Haydenville, ten feet at Brooks's mine, four feet at Longstreth's, thinning out and disappearing near Doanville, the growth of the coal vegetation being at this time uninterrupted in the rest of the marsh, and gradually spreading over this submerged position, leaving a thin bed of coal, which, in places, is twenty feet above the Great Vein, and in others constitutes a part of the upper bench. I am inclined to the opinion that his explanation is correct, but that the greatest difference in the thickness of the coal is not to be attributed to this cause. The thickest coal is on a line running north and south through the western parts of Monroe and Trimble townships, and here the combined thickness of the two *lower* benches is, in places, nearly ten feet. This thickening of the lower benches indicates the deeper parts of the original coal marsh, which was comparatively shallow in Salt Creek and Ward townships, where the lower benches are thinner.

In the eastern part of the coal basin, where the whole coal is the thickest, the upper bench is comparatively thin. It has its maximum thickness about Shawnee and Straitsville, and from thence down the Snow Fork to Doanville, and along this line the deposition of vegetable matter forming the upper bench continued, after it had ceased in other parts of the field. The local thickening of the upper bench is apparently due to this cause; the increased thickness of the two lower benches can not be so explained, but simply indicate the deeper parts of the old marsh.

South of the Hocking the coal becomes thicker than at Nelsonville, the increase being in the lower benches, so that the conditions during the deposition were there similar to those in the west parts of Trimble and Monroe townships.

On Meeker's Run, Section 16, York township, the coal shows the following sections:

	FT.	IN.
Upper bench	2	2
Middle bench	3	8
Lower bench	2	2
Total	8	..

Coal of excellent quality.

At John Collins's bank, Section 22, York township:

	FT.	IN.
Upper bench	2	7
Middle bench	3	6
Lower bench	..	10
Total	6	11

Showing a marked thinning out of the lower bench (and that at the commencement of the deposition this was near the western margin of the marsh), a slightly diminished thickness of the middle bench, and an increased thickness of upper bench.

At the Laurel Hill mine, two and a half miles south-west of Nelsonville, the coal is six feet thick in three benches. At Lick Run mine it is also six feet thick, of good quality, and presents its ordinary characteristics, but terminates abruptly at the west, the horizon of the coal being occupied by a massive sandstone. On Section 8, Starr township, it is reported to be six feet thick. About eight miles south-west of Nelsonville, near the south line of Starr township, five feet of the coal is exposed on the bank of a small stream. About four feet of this is good coal, with more sulphur than usual, and the upper bench quite shaly.

At the mouth of Meeker's Run, Section 10, York township, the section of the coal is—

	FT.	IN.
Shale	6	..
Coal	1	6
Shale	..	3 to 8
Coal	3	..
Shale	..	3 to 4
Coal	1	10

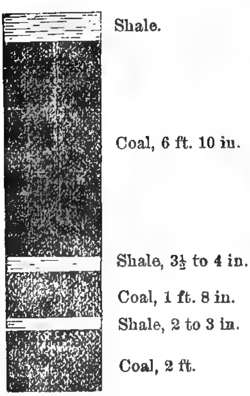
There is a good deal of controversy as to the identity of the coal mined at Carbondale, in the north-west corner of Waterloo township, but following down the valley from an outcrop near the south line of Starr, toward the coal road leading to Carbondale, the Great Vein coal is seen to pass below the surface, and another coal, fifty feet higher up, with a sand-rock a little above it, approaches the bottom of the valley. This sand-rock, and rude openings into the coal below, can be traced continuously around the hill to the east, and up the Coal Railroad to Carbondale, making the identification of the coal above the last and that mined at Carbondale quite positive. So that if the coal which plunges beneath the valley west of Carbondale hill is the Great Vein, this coal is certainly about fifty feet below the Carbondale coal, and of this fact I have very little doubt. It is true that by the barometer it is only five feet above this last outcrop of the Great Vein to the west, but the average dip to the east fully accounts for this fact. This Carbondale coal is much split up, varies greatly in thickness, and is more melting and more sulphury than the average of the Great Vein. The following is a section of the thickest part measured by me:

	FT.	IN.
Sandstone.		
Shale	1 to 4	..
Coal	..	8
Shale	..	4 to 6
Coal	2	6
Shale	..	1 to 2
Coal	..	6
Fire-clay.		

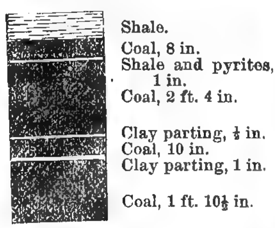
One mile below the mouth of Meeker's Run one exposure of the Great Vein made by a railroad cut shows that the sandstone has cut away the upper part of the coal. But in the greater part of York township there is a body of shale above the coal, and the latter often reaches a thickness of eight feet. South-easterly it gradually passes below the surface, and is reached only by shafting.

The following sections illustrate the local peculiarities of this coal in different parts of the field when no part of the coal originally deposited has been removed by erosion:

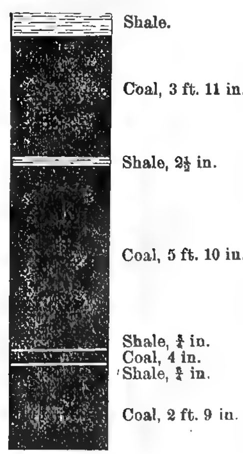
Maginnis's Bank, Straitsville.



Gaver's Mill, Salt Lick township.



Akron Iron Company, Monroe township.



These three sections are nearly on a line commencing at Straitsville and bearing a little north of east. In the first the upper bench is six feet ten inches thick; the combined thickness of the two lower benches, three feet eight inches. In the second the upper bench is reduced to three feet with a band of pyritiferous shale, and the lower benches together measure two feet ten and one-half inches. In the third the upper bench is three feet eleven inches, the combined thickness of the lower benches being eight feet eleven inches. These and the other sections given demonstrate the truthfulness of the statement previously made, that the thinning down of the coal from the Straitsville region toward the Hocking River is due to a loss of a part of the upper bench, and that the increased thickness in the valley of Sunday Creek and in the territory north of the Hocking is due solely to the increased thickness of the lower benches, the thickest coal of all being, in fact, found where the upper bench is nearly three feet thinner than at Straitsville and Shawnee. This line of greater thickness of the lower benches passes southward from near Moxahala through Monroe, Trimble, and Dover townships, and after crossing the Hocking, extends westward into York township. This line indicates the center of the original basin unless, as is more probable, there were three such deep marshes, one in Monroe township, bounded on the north by an elevation where the coal is wanting, one south of this "want," extending through Trimble and Dover townships, and one in the territory north of Nelsonville. In the Straitsville region the coal approaches the maximum thickness solely on account of the longer continued deposition after the submergence which deposited the shale parting below the upper bench.

When undisturbed, the changes in the thickness of the coal, especially of the lower benches, and in its character, are ordinarily very gradual, the maximum purity being generally coincident with the maximum thickness. The most important of these gradual changes in character are two. From Straitsville northward the coal becomes a little more melting until crossing the Hocking, when, with an increased thickness, it becomes somewhat more dry-burning. In the eastern part of the field it is more laminated, contains a greater number of thin bands of mineral charcoal, and will prove more open-burning. Careful trials show that a very large part of it will swell a very little in burning, and become slightly pasty on the outside, and that while a large part of it can be used successfully in a raw state in the smelting furnace, better results may be anticipated if a moderate admixture of coke is used. Where this is really needed, it is believed that the lower bench of this seam will make a coke which will answer the purpose.

The shipments of coal from this region, so far as I can obtain the statistics, have been as follows since the opening of the Hocking Valley Railroad:

Year.	By railroad. Tons.	By canal. Tons.	Total exported. Tons.
1869	53,644	Not reported.	53,644
1870	193,581	Not reported.	193,581
1871	213,767	3,905	217,672
1872	377,397	1,748	379,145
1873	464,476	1,804	466,280
1874	341,458	3,287	344,745
1875	496,614	2,517	499,131
1876	......	......	782,283
1877, to July 1	......	......	389,089
Totals	2,140,737	13,261	2,154,198

HUDSON, OHIO, *August* 13, 1877.

T. J. JANNEY, *Auditor H. V. R. R. Co.:*

MY DEAR SIR: I had the pleasure of receiving from you some time ago a statement of shipments of coal over your main and branch roads up to and including the year 1875. Can you favor me with a supplemental statement of amount shipped in 1876, and six months of 1877? My report will go to press in a few days, and I would like to add these statistics.

Very respectfully,

M. C. READ.

COLUMBUS, OHIO, *September* 3, 1877.

M. C. READ, ESQ..

DEAR SIR: Below you will find number pounds of coal shipped from stations on the C. and H. V. Railway during the year 1876 and the first six months of 1877:

Number pounds from Straitsville for 1876	700,234,270
" " Gore "	1,560,000
" " Haydenville "	121,404,500
" " Lick Run "	116,787,000
" " Oreville "	10,323,150
" " Nelsonville "	554,798,300
" " Floodwood "	34,161,000
" " Salina "	25,298,000
Total for 1876 (pounds)	1,564,566,220

Number pounds shipped from Straitsville for first half of 1877	330,053,000
" " " Gore " "	1,692,000
" " " Haydenville " "	100,932,500
" " " Lick Run " "	54,240,000
" " " Nelsonville " "	257,734,000
" " " Floodwood " "	18,916,000
" " " Salina " "	14,612,000
Total for first half of 1877 (pounds)	778,197,500

Yours, etc.,

T. J. JANNEY, *Auditor C. and H. V. Ry.*

The following tables of analyses of this coal from localities in this neighborhood will suffice to show its chemical characteristics:

	1.	2.	3.	4.	5.	6.	7.
Specific gravity	1.259	1.285	1.272	1.284	1.271	1.258	1.340
Water	6.80	6.20	6.65	5.00	6.45	5.30	5.45
Volatile matter	33.27	31.30	33.05	32.80	32.74	30.12	29.88
Fixed carbon	57.46	59.80	58.40	53.15	58.56	63.49	55.31
Ash	2.47	2.70	1.90	9.05	2.25	1.09	9.36
Sulphur	0.74	0.96	0.41	0.94	1.19	0.64	1.63
Color of ash	Dull white	Reddish	White..	Yel'sh gr'y	Grayish.	White..	Reddish
Nature of coke	Compact	Pulv'rnt	Pulv'rnt	Pulver'ent	Pulv'rnt	Pulv'rnt	Pulv'rnt

	8.	9.	10.	11.	12.	13.
Specific gravity	1.278	1.290	1.257	1.284	1.287	1.274
Water	7.15	6.80	5.85	6.15	5.80	3.05
Volatile mattter	35.28	36.16	37.10	33.22	35-42	38.39
Fixed carbon	55.16	54.99	55.12	55.75	51.15	47.51
Ash	2.41	2.05	1.93	4.88	7.63	11.05
Sulphur	1.35	1.07	1.42	1.88	1.01	4.04
Sulphur left in coke	0.81	0.79	0.51	1.00	0.50	2.02
S. per cent. in coke	1.31	1.30	0.85	1.56	0.81	3.35
Color of ash	Fawn ...	Fawn ...	Fawn ...	Gray	Cream...	Gray ....
Nature of coke	Compact.	Compact	Compact	Compact	Very com't	Very com't

Nos. 1 to 4, Brooks mine, Nelsonville.

No. 1, average sample; No. 2, lower bench; No. 3, middle bench; No. 4, upper bench.

Nos. 5 to 7, Hayden's mine, Haydenville.

No. 5, lower bench; No. 6, middle bench; No. 7, upper bench.

Nos. 8 to 13, from Section 24, Ward township, "Lost Run" specimens taken at regular intervals from the bottom to the top of the seam, Nos. 8 to 11 representing the lower eight feet.

Prof. Wormley has made ultimate analyses of a few of the coals of this and other States. Of these I select for comparison the following:

	1.	2.	3.	4.	5.
Carbon	75.00	73.80	71.48	81.27	78.99
Hydrogen	5.80	5.79	5.47	5.66	5.92
Nitrogen	1.51	1.52	1.26	1.66	1.58
Sulphur	0.64	0.41	0.57	0.98	0.56
Oxygen	15.96	16.58	16.07	7.08	11.50
Ash	1.09	1.90	5.15	3.35	1.45
Total	100.	100.	100.	100.	100.
Moisture	5.30	6.65	7.20	0.90	2.47
Composed of hydrogen	0.59	0.74	0.80	0.10	0.27
" oxygen	4.71	5.91	6.40	0.80	2.20

No. 1. middle layer, Hayden's coal.
No. 2, middle layer, Brooks' coal.
No. 3, New Straitsville, lower part of upper layer.
No. 4, Youghiogheny, Pa., coal.
No. 5. Briar Hill, Youngstown, Ohio.

The composition of the ash of two specimens of the Great Vein coal has been determined by Prof. Wormley, which is shown in the following table with that of one specimen of the Youghiogheny coal:

	1.	2.	3.
Silicic acid	58.75	55.10	49.10
Iron sesquioxide	2.09	13.33	3.68
Alumina	35.30	27.10	38.60
Lime	1.20	1.85	4.53
Magnesia	0.68	0.27	0.16
Potash and soda	1.08	1.00	1.10
Phosphoric acid	0.13	0.41	2.23
Sulphuric acid	0.24	0.58	0.07
Sulphur combined	0.41	0.22	0.14
Chlorine	Trace.	Trace.	Trace.
Total	99.88	98.86	99.61

No. 1, New Straitsville coal, lower part of upper layer.
No. 2. New Straitsville coal, upper part of upper layer.
No. 3, Youghiogheny, Pa., coal.

It will be noticed that the amount of sulphur remaining in the ash is somewhat larger in the Straitsville specimens; while the phosphoric acid is in one about one-twentieth and in the other about one-fifth that of the Youghiogheny coal. The amount of iron in specimen No. 2 is somewhat remarkable, amounting to 13⅓ per cent. of the ash and 1.06 per cent. of the coal.

The change in chemical composition of the coal from that at Shawnee and Straitsville is very slight; and this would everywhere be regarded as among the best of bituminous coals.

The levels carried to different outcrops of this coal by Messrs Jennings and Riley, Civil Engineers, enable us to determine approximately the direction and rate of the dip of the Great Vein:

1. From Section 1, Green township, to Section 8, Trimble township (Ewing), distance 11 miles, the dip is east 302 feet; dip per mile, 27.45 feet.
2. From McCuneville to Ewing, 14 miles, the dip to the south-east is 330 feet; dip per mile, 23 57 feet.
3. From Old Straitsville to Ewing, 12 miles, the dip is south-east 305 feet; dip per mile, 25.42 feet.
4. From Carbon Hill to Ewing, 8.75 miles, the dip is 219 feet; dip per mile, 28.03 feet.

5. From Snow Fork, Section 31, Trimble to Ewing, 4.25 miles, the dip is 107 feet; dip per mile, 24.93 feet.

6. From Section 7, Ward township, to Snow Fork. 1.77 miles, the dip is 45 feet; dip per mile, 25.42 feet.

7. From Section 19, Ward, to Section 7, Ward, 2 miles, the dip is 46 feet; dip per mile, 23 feet.

8. From Section 1, Green, to Section 19, Ward, 3 miles, the dip is 104 feet; dip per mile, 34.66 feet.

Nos. 1, 5, 6, 7, and 8 are on the same parallel, No. 1 being the entire distance, of which 5, 6, 7, and 8 are parts showing the moderately undulating horizon of the coal.

To determine the line of strike, I select distant points where the coal is found at the same elevation. In Section 17, Ward township, the coal is 167 feet above the lake; at Ferrara, north line of Section 22, Monroe township, it is at the same level. The bearing is north 33° east, which is the line of strike, and the line of greatest dip is south 57° east.

In the north part of Section 19, Ward township, the coal is 231 feet above the lake, and near the centre of Section 32, Pleasant township, it is at the same level. The bearing and line of strike is north 26° east, distance 13¼ miles. The line of dip is south 64° east. Near the centre of Section 32, Ward township, it is 270 feet above the lake, and in the south-west part of Section 24, Pleasant township, it is at the same level, distance 14¼ miles. The bearing and line of strike is north 22° east; line of dip south 68° east.

It will be noticed that to the eastward the line of strike makes a greater angle with the meridian than at the west.

In Section 21, Salt Lick, the coal is 289 feet above the lake, and in Section 6, Trimble township, 76 feet; the distance is 8½ miles, and substantially on the line; dip per mile, 25.05 feet.

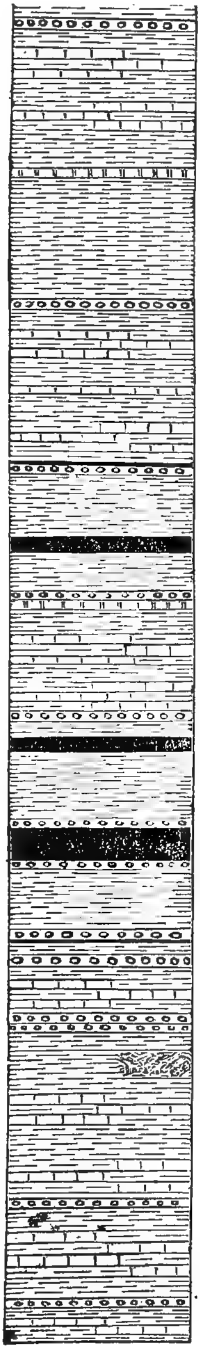
These observations indicate that the average dip is about 25 feet per mile, and that the line of greatest dip generally varies from south 68° east to south 57° east.

Mr. Nichols's section, from Haydenville to Section 2, Trimble, is 12 6-10 miles; dip, 300 feet; dip per mile, 24.38 feet. His section, from south part of Dover to Moxahala, is 18.86 miles; dip to the north, 218 feet; dip per mile, 11½ feet. Had he made the northern terminus of this section at Marshallville, a little less than eleven miles, the dip would have been south about 19 feet per mile. With these irregularities and undulations, which are admirably illustrated by Mr. Nichols's charts, and which effect the strata at different horizons very differently, so that they are constantly approaching or receding from each other, it is evident that both the direction and the amount of the dip are factors which are constantly varying, and can be determined only by careful observation in each locality; and that any general statements that suggest the inference that there is a uniform dip in any particular direction, are calculated to mislead. In the mine at Haydenville, where now worked, the dip is one foot in thirty-five, or over 150 feet per mile: and observation shows that the local dip may be in any direction, and that it constantly varies in amount within very wide limits. Observations and calculations made on widely separated data at different points will show the general dip of the rock strata. After all, these irregularities and undulations are eliminated or disregarded, but they are calculated to mislead the practical miners, unless supplemented by minute and detailed work in each locality, requiring more work than can ordinarily be given to a State survey.

The relation of the seam to the other mineral deposits is illustrated in the section here given:

SECTION OF ROCK ABOUT NELSONVILLE.

Vertical scale, 1 inch to 52 feet.



30 to 50	Ferruginous shale.
	Iron ore and limestone fossils.
40 to 50	Ferruginous shale and sand-rock.
2	Black limestone.
35 to 40	Ferruginous shales.
	Iron ore.
45 to 60	Sandstone and shale.
	Iron ore and coal (Iron Point ore.)
13 to 25	Shale.
2 to 5	Coal No. 7 (Bayley's Run.)
10 to 20	Shale.
1 to 5	Limestone—ore above.
30 to 40	Shale and sand-rock.
	Calcareous ore.
5 to 10	Shale.
1 to 4½	Coal No. 6*a*.
20 to 36	Shales.
6 to 10	Great Vein coal, with iron ore above and below.
20 to 25	Shale.
4 to 8	Coal No. 5; fire-clay in places; shale.
	Iron ore ("Baird's ore.")
15 to 35	Shales and sandstone.
2 to 3	Iron ore—blue carbonate.
5 to 15	Shale.
	Heavy fire-clay.
40 to 55	Shale and sandstone.
22 inch.	"Drift ore" (Haydenville.)
	Coal.
25 to 35	Shale and sandstone.
	Blue calcareous ore.
	Sandstone and slate to bottom of exposure.

More difficulty has been experienced in harmonizing the observations of different localities in this than in other parts of the field, and the attempt to make a *general* section, of necessity, results in one that is only approximately correct for any special locality. In places many of the minerals designated will be wanting, and the associated rock strata will vary both in thickness and character.

Of the coals below the Great Vein, of which indications of four have been observed, no one is known to be of workable thickness. That directly below the "Drift ore," at Haydenville, was cut by the tunnel on the coal railroad, and showed twenty-two inches of coal. Coal No. 6 *a*, according to levels made by Mr. Hayden's engineer, is here thirty-six feet above the Great Vein,* and shows from twelve to thirty inches of shaly coal. On George W. Gill's land, on Meeker's Run, south of Nelsonville, it is twenty-eight feet above the Great Vein, is three and one-half feet thick, and, so far as opened, appears to be of good quality.

The Bayley's Run coal is here seventy-five to eighty feet above the Great Vein, four to five feet thick, a hard, bright, compact, melting coal, showing little sulphur, and gives promise of furnishing a good coke. It is mined some five miles south and south-west of the mouth of Meeker's Run, and is reported as reaching a thickness of six feet. There is evidently a large area in this neighborhood, where it is undeveloped; and if, as its appearance indicates, it is sufficiently free from sulphur to make a good coke, its value can be hardly overestimated, supplementing as it does the other iron-making products, and there being no other material wanting for the cheap production of good iron. On the Cawthorne property, on Snow Fork, Ward township, this coal is reported to be three feet thick, and No. 6*a* is exposed from twenty-five to thirty feet above the Great Vein, where it is four feet thick. In the hills between Nelsonville and Straitsville, the outcrops of both of these coals may be seen, but no openings into them have been made. Search should be made for these upper coals on all the hills which reach their horizon; and wherever they are of workable thickness, they should be mined before or simultaneously with the mining of the Great Vein. It should be esteemed a crime to destroy the value of these upper coals by the too hasty mining of that below; and it is to be hoped that so much better results will be obtained in iron-making, by mingling the fuel obtained from the different horizons, that there will be no temptation to commit this error.

* This interval is doubtless correctly given, and the coal which Mr. Roy traces to this point as an offshoot of the Great Vein, should not be confounded with it. The latter is No. 6*a*, and its horizon can be traced throughout nearly all this territory.

IRON ORES.

The lowest iron ore of the series is on the horizon of the massive calcareous ore found north of old Straitsville, on the level of Monday Creek. Its outcrop may be traced near the base of the hills in the neighborhood of Haydenville, with a fire-clay and faint traces of coal smut below it. It is the horizon of Coal No. 3, which is ordinarily capped with a blue, cherty limestone, frequently ferriferous. Here it shows a thick band of blue, calcareous ore, not thick enough to be mined by drifting, or to warrant much stripping, but sufficient to justify further explorations on this level.

The ore above I have called the Haydenville drift ore, as it was extensively mined by drifting some sixteen years ago, for use in the old Hocking furnace at that place. It was reported to be a solid block-ore, ten inches thick. From the specimens seen, I should call it a brown oxide, of good quality.

The third ore I have seen opened only on the hill directly above the last. It is there fifty feet above the drift ore, and fifteen feet above a thick bed of fire-clay, which is mined for the Columbus potteries. The ore is from two to three feet thick, a blue, silicious carbonate, changed upon the outside of the layers to a yellow sesquioxide. It is not as rich as some of the other ores, but may prove of sufficient value to be profitably worked.

The fourth ore from the bottom is the equivalent of the "Baird ore," which is ordinarily just below the fire-clay of Coal No. 5, often resting on a drab, cherty limestone. This horizon carries two ores, only one of which I have found largely developed in the same locality, one directly above the coal, one below the fire-clay. And in all cases where there is a considerable body of the ore the coal is reduced to a mere carbonaceous shale. The thick bed of fire-clay is a characteristic indication of this horizon. On Mr. Peter Hayden's property, near Haydenville, this ore is from eighteen inches to two feet thick, and of good quality. On the Brooks property, section 29, Ward township, it is a good gray ore, and its presence is indicated in all the western part of this territory where the horizon of No. 5 is above drainage, and ranges from about twenty-five to thirty-five feet below the Great Vein. On Charles Robbins's land, south of Nelsonville, it is thirty feet below the Great Vein, is two and a half feet thick, a very rich brown oxide, changed on the outcrop to a soft yellow sesquioxide, of great excellence. On Lost Run of Monday Creek, in the roof of Coal No. 5, there is a silicious ore, much like the "Baird ore," two to two and a half feet thick, which is also found on

Sugar Run. This horizon will evidently furnish a very large amount of excellent ore.

The shales between No. 5 and the Great Vein may here, as at Straitsville and Shawnee, be regarded as ferriferous, carrying ores in places at nearly all elevations. On Meeker's Run these ores are very conspicuous, consisting of flat layers of very hard, compact blue carbonate, of good quality, so abundant that their fragments constitute a large part of the rock debris in the beds of the streams, from which many hundred tons could be gathered up. On the Brooks property, section 19, it is a compact blue carbonate, weathering to a brown oxide, and presenting an excellent appearance. A similar ore is also found in the shales directly above the Great Vein. No explorations have been made for either of them, so far as I have observed, but there are indications of a large amount of the ore, especially in the shales below the coal.

On Charles Robbins's land, section 23, York township, fifteen to twenty feet above the Great Vein, an opening is made into a bed of dark calcareous ore of good quality, in compact nodules, filling a space of four feet. This is just below Coal No. 6*a*, and as far as opened shows a nearly solid mass of ore.

On George W. Gill's land, section 16, York township, sixty feet above the Great Vein, is an outcrop, three feet thick, of compact non-fossiliferous drab limestone, which, on section 23, is seen forty feet above the coal.

On section 23, at about seventy feet above the Great Vein, is a compact blue carbonate, so far as opened, fifteen inches thick, and on section sixteen appears to be still thicker; the upper part only is exposed showing a rich, well-oxydized ore in large nodules, giving promise of a stratum two feet or more in thickness. This is the limestone ore of Shawnee, and the proper place of the limestone is just below it. On the Brooks property the upper part of the ore is a compact blue carbonate, and the lower part a calcareous ore. At Haydenville it is of a similar character and two feet thick. On the Akron Iron Company's property, near Bessemer, an opening had been made in the ore at the time of my visit, which exposed from six to ten inches of this ore—a mixture of red and yellow sesquioxide of good quality—the whole thickness of the stratum not determined, and the limestone below not uncovered. At the town site of Orbiston, on the Ogden Furnace property, four inches of good gray calcareous ore is uncovered, resting on eighteen inches of compact non-fossiliferous limestone, the roof rock not being reached. The nominal thickness of the limestone which is exposed at various places is here two feet. Near Haydenville it reaches a thickness of five feet. This is a very important horizon, carrying large quantities of excellent ore, the limestone being also ferriferous, making a desirable flux, and appearing to be quite persistent. It often seems to be wanting on its proper horizon, as it and most of the limestones here are quite soluble, and, at the outcrops, have often been dissolved out.

The Bessemer or Buchtel ore has a fine development on the Ogden Furnace property, showing in one place eighteen and in another thirty inches of ore of a great excellence. It is remarkably free from earthy matter, contains a large percentage of sesquioxide, and, according to an analysis made for the company in Detroit, the unroasted ore yields fifty per cent. of metallic iron. It extends through the hills to Bessemer and westward to Haydenville, where it ranges in thickness from two feet six inches to four feet six inches, according to reported measurements, which seem to be reliable. It is there, as well as on the Ogden Furnace property, ninety feet above the Great Vein.

On the Akron Iron Company's property (Bessemer) a drift has been carried into the hill far enough to disclose the full body of an ore which fills a space of six feet three inches, and at the face of the entry is equivalent to about five feet of solid ore. It is in large nodules bedded in clay, containing both calcareous and silicious matter, wasting more in roasting than the Iron Point ore, but leaving a rich, good-looking ore when calcined. Experimental drifts have been made at various places which indicate that a thick stratum of this ore extends through the whole hill. It is regarded here as the equivalent of the Shawnee ore, but it is apparently on a lower horizon and below the Bayley's Run coal.

Just before the great depression in the iron industries the Akron Iron Company erected at Akron, in Summit county, a fine furnace in close proximity to their rolling-mill, and purchased coal lands in this field with the intention of shipping coal, ore, and limestone to Akron for the smelting of pig-iron. This was to be prepared in their rolling-mill for their extensive manufactories of mowers and reapers at Akron and Canton, the stock in the different companies being owned largely by the same persons. Compelled to put their furnace out of blast soon after its erection, they have now purchased valuable lands at Bessemer, and are engaged in removing and re-erecting their furnace at that place, where, in place of the long transportation by railroads of all the raw material, which they originally contemplated, tramways from the drifts carried into this coal, ore, and limestone can be connected directly with the furnace, and all the raw material delivered at the stack without rehandling. The removal of the rolling-mill to this property will naturally follow the successful smelting of their iron ore, and it is quite probable that their mower and reaper manufacture will ultimately be transferred to the same locality.

It seems evident that a new era in manufacturing has already commenced, one of those revolutions in the productive industries of the county which the rapid development of our resources produces, resulting in losses in one locality and yet gains in others. Our railroads, by furnishing cheap fuel to the large cities where capital had accumulated, stimulated its employment in manufacturing, and built up industries that brought large returns both to capital and labor. The demand is now for still cheaper fuel, and the tendency is too strong to be overcome to locate manufacturing establishments where the combined cost of the raw material and the coal is the least. In the establishments for the manufacture and working of iron the law of natural selection and survival of the fittest will rule, and those who refuse to remove their works from the less to the more favored localities will have such a disadvantage in the struggle for existence that they can not long survive. Iron can not be made at from $18 to $20 per ton and compete with that which costs from $10 to $13 only, nor will the pig-metal be transformed into bars, castings, bolts, nails, etc., in the cities, with coal costing $3 to $4 per ton, when at the places where it is produced the fuel will cost only fifty to seventy-five cents per ton. The removal of the Newark and the Akron Iron Company's furnaces to this field, and the construction of new furnaces by those who have furnaces idle in other places, are illustrative of this new era in iron-making, and are examples which will be largely followed by others.

Near Carbon Hill the Iron Point ore has recently been thoroughly opened, and the thickness is reported to be seven feet. This is to be interpreted as meaning that the nodules extend through a vertical height of seven feet.

There is some difficulty in locating this ore on the north side of the Hocking River. Beds of ore are opened which resemble it, but they are from one hundred and twenty to one hundred and forty feet above the Great Vein, and it is my belief that this ore is to be sought for there at an elevation of from ninety to one hundred feet above that coal. At one hundred and twenty feet I found an outcrop of good ore which had not been explored, and it is possible that this is here the horizon of the Iron Point ore. At one hundred and forty feet above the coal there is a rich brown oxide measuring fifteen inches, and at an elevation of two hundred and thirty feet a very rich soft sesquioxide with limestone shells, the thickness of which has not been determined. The interval between these last two ores is mainly composed of soft ferruginous shales on the surface of which small fragments of rich ore are abundant, indicating that thorough exploration will be rewarded by the discovery of important ore deposits. Mr. Brooks reports a valuable ore on Section 19, Ward township, at from one hundred and seventy-five to two hundred feet above the Great Vein, and one on Section 29, York township, at an elevation of from one hundred and forty to one hundred and fifty feet above the Great Vein. The last is doubtless the same ore as the brown oxide mentioned above, the other an ore in the ferruginous shales below the upper ore of the section.

On Section 16, Ward township, an ore is reported about one hundred and eighty feet above the Great Vein, three to four feet thick, in large bowlders, on the outside a rich sesquioxide. New deposits and new openings are reported so often that it is impossible to personally inspect them all without delaying indefinitely the publication of this report.

The following analyses of the ores of this part of the field have been made for this report by Spencer B. Newberry, of Cleveland. Other analyses have been promised by the owners of different mining properties, and it was hoped that they would be obtained in time for insertion here:

	1.	2.	3.	4.	5.	6.	7.
Silica	39.31	35.71	8.22	53.62	9.39	8.70	10.19
Sulphur	0.22	0.36	0.21	0.09	0.05	0.16	0.06
Protoxide of iron	14.60	....	34.63	....	28.86	....	27.70
Sesquioxide of iron	25.50	44.83	18.58	27.20	21.20	47.20	18.48
Alumina	0.23	2.58	1.94	2.65	2.45	1.25	5.28
Oxide of manganese	1.64	2.82	2.81	1.72	2.19	11.32	2.01
Lime	3.50	2.83	4.45	8.48	6.53	12.69	6.46
Magnesia	1.80	1.26	1.42	1.87	3.11	2 98	2.91
Phosphorus	0.12	0.20	0.19	0.30	0.12	0.96	0.10
Water	0.55	8.10	2.35	2.45	1.45	8.25	1.30
Carbonic acid	13.05	0.60	25.45	2.24	25.05	7.35	25.20
Totals	100.52	99.29	100.25	100.52	99.40	100.86	99.75
Metallic iron	30.17	31.38	39.93	19.04	37.29	33.04	34.48

No. 1, Baird ore, Section 29, York township.

No. 2, Baird ore, Section 29, York township, oxydized.

No. 3, Limestone ore, Section 19, Ward township.

No. 4, Limestone ore, Section 19, Ward township, outcrop.

No. 5, below Great Vein, Section 19, Ward township.

No. 6, Orbiston, oxydized.

No. 7, below Great Vein, Section 29, York township.

LIMESTONES.

The limestones of this field have been only incidentally mentioned in the preceding pages, because a few lines of description will suffice for the whole. For iron making the supply is abundant, and it is found in so many different horizons that it will be difficult to find property on which there is not a full supply.

On the west, where the ravines cut the base of the Coal Measures, the Maxville limestone is accessible, which, at Webb's Station and Maxville, is eleven feet thick.

About one hundred and fifty feet below the Great Vein is the Blue limestone, sometimes cherty, but often of good quality, reaching a thickness of two and three feet. It is exposed at Shawnee, Straitsville, and in the valleys to the west and south.

Associated with the Baird ore, on the horizon of Coal No. 5, is a limestone which in other parts of the State sometimes reaches a thickness of six and ten feet, but seems generally thin in this field. It will probably be found here in places worth quarrying.

At about forty and seventy feet above the Great Vein are limestones in places five feet thick, frequently ferruginous, and carrying valuable ores. That at seventy feet is the limestone used as a flux in the furnaces at Shawnee, and is rarely wanting in any part of the field.

The Cambridge limestone is about one hundred and seventy feet above the Great Vein, from two to three feet thick, and of good quality.

The Ames limestone, two hundred and seventy to two hundred and eighty feet above the Great Vein, is two to three feet thick, and in places in Trimble township, Athens county, is reported by Professor Weethee as fifteen feet thick. Both of these limestones are very persistent, and each will doubtless make a good flux. In the eastern part of Trimble the limestones of the Pittsburgh coal are regularly developed, and are of good quality. Besides these there is a black limestone three feet thick, seen near Ewing, thirty-seven feet above the Bayley's Run coal, bowlders of which, fallen down from their proper horizon, are often seen throughout the whole territory. There is no doubt that the supply of limestone is ample for all the wants of the smelting furnaces.

The following table shows the composition of the limestones which have been analyzed:

No. 1, Shawnee limestone, by S. B. Newberry:

Silica	9.91
Lime	31.19
Magnesia	12.50
Alumina and protoxide of iron	3.57
Oxide of manganese	2.76
Sulphur	0.28
Phosphorus	0.05
Carbonic acid	39.35
Water	0.65

No. 2, Shawnee limestone, by Gregory.
No. 3, top layer Cambridge limestone, Moxahala, by Gregory.
No. 4, bottom layer Cambridge limestone, Moxahala, by Gregory.
No. 5, bottom layer Cambridge limestone, Moxahala, by Gregory.

	2.	3.	4.	5.
Silica	19.31	8.75	7.37	10.57
Oxide of iron	....	7.52	....	....
Carbonate of iron	5.42	....	3.31	20.45
Alumina and phosphoric acid	3.03	1.88	0.30	0.51
Carbonate of manganese	0.44	....	0.45	....
Oxide of manganese	....	0.44	....	3.40
Carbonate of magnesia	6.16	0.65	0.68	0.11
Carbonate of lime	62.38	80.76	86.86	65.06
Water and iron	3.23	....	....	....
Metallic iron	....	4.79	....	....

FIRE-CLAY.

Fire-clays of the ordinary character of the Coal Measure clays are abundant everywhere, forming the bed of the coals and of many of the ores. A specimen of excellent non-plastic fire-clay, similar to that at Mineral Point, Tuscarawas county, has been shown me, as obtained in the north-east part of Ward township, below the Great Vein. I was not able to find the locality.

But a non-plastic clay of good quality is mined at Logan, and used extensively in the manufacture of fire brick by the Wassall Fire Clay Company, of Columbus. It is three feet thick, and is much like the Mineral Point Clay.

BUILDING STONE.

None of the massive sandstones seem to be persistent over the whole field. That above No. 6, the Mahoning, is the most so, and in places is a fine quarry rock. It is often loosely cemented, and decomposes on exposure into sand. In many places, however, it affords good building stone. And on almost every hill-side, some where in the exposed section, strong and durable building stone crops out.

SALT.

A large number of wells have been bored for salt in the valley of Sunday Creek and other parts of this field, and a strong brine uniformly obtained at a depth of from four hundred and fifty to five hundred feet below the Great Vein Coal. The construction of canals and railroads compelled the abandonment of all works at a distance from these means of communication. The brine is evidently on the same horizon as that obtained in boring for oil in Coshocton and Knox counties, where the position of the salt bearing rocks is very accurately determined, their base resting upon the chocolate shales which I regard as the bottom of the Waverly. Salt is now successfully manufactured at Salina on the Hocking Canal, and at McCuneville on the Shawnee branch of the Baltimore and Ohio Railroad, at both places the coal being mined for the evaporation of the salt. The waste slack coal should be used for this purpose. It affords a power costing practically nothing with which to drill the wells, pump the brine and concentrate it; and when it is thus utilized, the cost of manufacture will be reduced to a minimum, and the production limited only by the amount of consumption within the territory to which it can be carried by the ordinary channels of communication.

GENERAL CONSIDERATIONS.

The larger tributaries of Sunday Creek, Snow Fork, and Monday Creek, are prominent streams affording a never failing supply of water for the use of smelting furnaces.

The Hocking Valley Railroad follows the Hocking River through the southern part of this territory, with a branch from Logan to Straitsville, and is in the control of men who will carry branches into all the villages occupied by mining or manufacturing establishments. Arrangements are already made for branches up the Sunday Creek and Snow Fork, and it is also proposed to construct another up the valley of Monday Creek. The Baltimore and Ohio Railroad Company has a branch from Newark to Shawnee, which it is proposed to continue further into the field. The Atlantic and Lake Erie road is projected from Pomeroy to Toledo, passing through the valley of Sunday Creek, on which much work is already done, and the road opened for business from New Lexington on the Muskingum Valley road to Moxahala. The Cleveland, Mt. Vernon and Columbus Railroad Company have made good progress toward the extension of their road from the south part of Holmes through Coshocton to connect with the Muskingum Valley road, and by a branch from the latter at Cluny Station, to extend it into the center of this coal field. These roads and their branches will bring all this territory into ready connection with all the great lines of railroads in the State.

All these advantages, coupled with the fact that these lands are in the center of a rich and populous agricultural territory, render the future prosperity of this region a certainty. There is no place in the United States, and probably not in any other country, where iron can be manufactured more cheaply than here, and very few where the manufactured products of the iron can be more cheaply distributed to the points of consumption. In addition to the four furnaces already in blast, which have been previously described, arrangements are already made for two more at Shawnee. One, the Vilas Furnace, between Shawnee and Iron Point, and one two miles north of Gore Station; the Ogden Furnace, at Orbiston, on Snow Fork; the Akron Iron Company's Furnace, at Bessemer; another by a Cleveland company, at Bessemer; Moss and Marshall's Furnace, at Straitsville, and the Moxahala Iron Company's Furnace, at Moxahala, while negotiations are pending for the purchase of several other sites. This active work in furnace building by experienced iron men, while a majority of the furnaces in all old iron districts are out of blast, is a happy augury of the future. Under the stimulus of the large profits of iron-making a few years ago, many furnaces were built at business centers, where capital had accumulated, and which were compelled to suspend operations as soon as the price of iron materially declined. It is evident that many of these will never be again put in blast, and iron will hereafter be manufactured on so small a margin that the cost of the transportation of the raw material must be made as small as possible. But competition can not close a furnace intelligently and economically managed, situated on property containing all the raw material necessary for the production of the iron, and of easy access to the points of consumption. If a mixture of Lake Superior ore shall be required, the amount needed will be small, and the competition for this freight on the coal flats returning from the Lake ports will make the expense small. But with the great variety of ores in this field it is probable that all grades of iron can be produced by a proper mixture. The Iron Point ore, which is the "Great Seam" of the whole region, produces, when used alone, an iron very similar to the Scotch pig. This is at the present writing quoted in the New York market at from $24.25 to $27.25 per ton, and is often the only foreign iron now quoted. It may be confidently anticipated that a brand of iron made from this ore at a cost of from $10 to $12 per ton, will soon be placed on the market in such abundance and of such a character as to entirely prevent the importation of this Scotch pig.

CHAPTER LXXXVI.

REPORT ON THE GEOLOGY OF JEFFERSON COUNTY.

BY J. S. NEWBERRY.

SURFACE FEATURES.

Jefferson county lies altogether outside of the Drift area, and its superficial deposits are therefore only such as are derived from the decomposition of the underlying rocks. These are shales, sandstones, limestones, beds of coal, fire-clay, and iron ore—the usual components of the Coal Measures—and these when disintegrated have produced a soil which is somewhat varied locally, but is generally light and loamy and well adapted to the cultivation of corn and the small grains. Here, as in many other of the counties lying within the coal field and beyond the influence of the Drift, the great irregularities of the surface have produced comparatively little effect upon the fertility of the soil, the hills, even though high and bold, being successfully cultivated to their summits; and the narrow alluvial bottoms yielding scarcely better crops of corn.

Before the advent of the whites all portions of Jefferson county were covered with a dense forest. This consisted of a mixed growth of timber, although oak was the predominant variety. In the lower grounds hickory, ash, black walnut, butternut, and maple prevailed, while sycamores and white maples bordered the streams.

The topography of Jefferson county is very greatly diversified. On the east it is bordered by the Ohio, which flows from four hundred to five hundred feet below the tops of the hills which border it, and from six hundred to seven hundred feet below the highlands of the interior of the county. A convenient base line for measuring altitudes in the county is the River Division of the Cleveland and Pittsburgh Railroad, which follows the course of the Ohio, generally from forty to fifty feet above low-water mark. The elevations of the different stations of the railroad above Lake Erie and the ocean are as follows:

	Above Lake Erie.		Above the ocean.
Hammondsville	115	(+ 575 =)	690
Yellow Creek	121		696
McCoy's	111		686
Sloan's	125		700
Steubenville	90		665
Portland	90		665

The altitudes of the stations on the P. C. & St. L. railroad above Lake Erie are as follows:

	FEET.
Steubenville, Washington street	155
Mingo Station	94
Gould's Station	106
Tunnel No. 1	260
Smithfield	200
Tunnel No. 2	370
Reed's Mill	233
Kelley's Station	268
Tunnel No. 3	490
Bloomfield Station	328
Unionport	373
County line	418

According to Blickensderfer's profile of the P. C. & St. L. Railroad, the highest land in Jefferson county is the summit of the hill one mile east of Bloomfield, eight hundred and sixty-one feet above Lake Erie.

The minor streams of the county are all tributaries of the Ohio, flowing from the west, and having their sources on the highlands near the county line. In their eastward flow the valleys are gradually deepened until, when they join the Ohio, they are brought down to its level. These streams are Yellow Creek, Island Creek, Wells Creek, Cross Creek, Salt Run, Rush Run, and Short Creek. The interlocking branches of these streams form a network of minor valleys which render all the surface rolling, and in some instances, where the declivities are abrupt, it may be called broken. There is, however, in the county little land that can not be profitably used for agricultural purposes.

A marked feature in the topography of the county is the erosion of the Ohio valley below the present stream. In many parts of this report the old buried channels which traverse the State and country are referred to, and the fact that the Ohio flows in a trough excavated from one hundred to one hundred and fifty feet below the bottom of the present river is mentioned in the report on Columbiana county and elsewhere.

The banks of the Ohio at Steubenville are bold and high, and are composed of horizontal strata which are seen to correspond closely on both sides; hence we may conclude that they were once continuous, and that the gorge that separates them has been excavated by the river. The reason why it is cut so far below the present stream is that at a certain period the continent was higher above the ocean level than now, the drainage was more free, and the Ohio and other tributaries of the Mississippi ran for ages with rapid currents until they had deeply excavated their channels. Subsequently a depression of the continent set back the water in these channels and caused the deposit in them of the material transported by the smaller tributaries. In this manner the valley of the Ohio was filled to the height of its highest terrace. Afterward the continent rose again, the drainage became freer, the work of excavation was resumed, and the present stream has cut so deeply into the material under which its old bed is buried as to leave portions of it standing in terraces of gravel, sand, etc., much above the highest points reached by its floods. Two distinct terraces mark the banks of the present river in numerous localities; one the flood-plain, covered in extreme high water; the other much higher, and marking the level of the old filling of the valley.

No tests have been made which determine with accuracy the depth of the old channel along the river front of Jefferson county, but from borings made for oil on the Beaver and other tributaries of the Ohio, we learn that they are in some instances cut down one hundred and fifty feet below the present water surface. We may therefore conclude that the bottom of the old channel at Steubenville, is at least one hundred and fifty feet below the river, and it may be, considerably lower. No rock was found, as I am informed, on which to place the piers of the railroad bridge, and they are built on cribs. It is also reported that the effort to drive galleries from the bottom of one of the coal shafts in Steubenville, under the river, was rendered abortive by the flood of water which poured in from above; this was probably caused by the approach of the gallery to the loose material that fills the old river bed.

GEOLOGICAL STRUCTURE.

Jefferson county lies wholly within the limits of the Allegheny coal field, and all the rocks exposed here belong to the Coal Measures. Of these strata a thickness of nearly one thousand feet are included in the sections obtained by an examination of the hills bordering the Ohio Valley, and by the shafts which have been sunk below the river. A very fair exposition of the geological structure of Jefferson county is given in charts Nos. 3 and 4, which accompany Vol. I of this report. These charts include a series of sections taken along the Ohio, from Smith's Ferry to Mound City; much the greater number of which are in Jefferson county. From them it will be seen that the general section of the rocks of the county include the following strata:

		FT.
1.	The Upper Coal Group with Pittsburgh coal (No. 8) at base	300
2.	The Lower Barren measures	450
3.	The Lower Coal Group	350

In the northern part of the county, the upper half of the hills is composed of the red and olive shales of the Barren Measures, with the Cronoidal Limestone—which lies about midway of that series—near the top; while the lower slopes of the valleys cover all the workable seams of the Lower Coal Group, that is, Coal No. 3 (the "Creek Vein"), No. 4 (the "Strip Vein"), No. 5 (the "Roger Vein"), No. 6 (the "Big Vein"), and No. 7 (the "Graff Vein.") Coal No. 3 generally lies above the bottom of the valleys, and there are one hundred and fifty feet or more of Coal Measure strata beneath it, which have been penetrated by numerous borings or shafts. These include two or three thin seams of coal but none of workable thickness. The section at Londale, on the opposite page, gives a very good view of the succession of strata in this part of the county, but it does not show the famous beds of fire-clay beneath Coal No. 3, which is so conspicuous and valuable an element in the mineral resources of this part of Ohio. In the lower part of the Yellow Creek Valley, and along the Ohio, this bed is well developed and largely worked.

In the central part of the county, about Steubenville, the hills are capped with the Pittsburgh Coal, with its associated limestones. Below these, to the level of the Ohio, succeeds the great mass of shale and sandstone which forms the Barren Measures. The first of the Lower Coal Group—Coal No. 7, which in the northern part of the county lies two hundred feet above the river, is carried down by the rapid southerly dip, and reaches the river level near the mouth of Wills Creek. At Steubenville it would be found some fifty feet below the river, but it apparently runs out here, and the first workable seam found in the shafts is No. 6—the second from the top of the Lower Group of coals.

In the southern part of the county, the dip has carried the Steubenville shaft (No. 6), nearly two hundred feet below the river, and the Pittsburgh Coal, (No. 8), has come down in the hills so as to underlie much of the surface, and is quite extensively mined. Still farther south Coal No. 6 passes beyond present reach, and Coal No. 8 is the chief source of the supply of coal. At the mouth of the Wegee this, too, passes beneath the river.

The following notes on the geological extent and character of the different groups of rocks which have been enumerated will suffice with what has gone before to give a clear idea of the general geological structure of the county.

THE UPPER COAL GROUP.

The Coal Measures of Ohio show more or less distinctly four divisions, corresponding to those which have been described by Prof. Rogers in his Report on the Geology of Pennsylvania, and named by him:

1st. The Upper Barren Measures.
2d. The Upper Coal Group.
3d. The Lower Barren Measures.
4th. The Lower Coal Group.

The Upper Barren Measures are hardly shown anywhere in Ohio except in Monroe county, where the deepest portion of the coal basin occurs. Here the highest hills are formed chiefly of a mass of shale containing no important coal seams, and which overlie the workable coals of this and the adjoining counties, and form the summit of the geological series in Ohio. Below the Upper Barren Measures is found a group of six or seven coal beds, distributed through about three hundred and fifty feet of shales, sandstones, limestones, etc., constituting the Upper Coal Group. Of these the lowest is the Pittsburgh seam, or Coal No. 8, of the Ohio series. Immediately above this there are sometimes two or three small coals, which have been numbered *8a*, *8b*, and *8c*. Following these are Coals Nos. 9, 10, 11, 12, and 13, which, with the exception of Coal No. 10 (a persistent and important seam south of the National Road), are generally thin, or of inferior quality, and have only local importance.

In the southern part of Jefferson county, back from the river, in the townships of Mt. Pleasant and Smithfield, the surface rises in some places nearly three hundred feet above the horizon of Coal No. 8, and the highlands contain Coals *8a*, *8b*, *8c*, and 10, 11, and 12. Coal No. 9 is generally absent, and Coal No. 12 present only in the hill tops.

This series of coals above No. 8 is here of little economic importance. They rarely exceed a foot to eighteen inches in thickness; and where reaching, as Coals Nos. 10 and 11 sometimes do, workable dimensions (two to three feet), they are of inferior quality. Hence it will be seen that the Upper Coal Group, with the exception of Coal No. 8, can contribute little to the mineral wealth of the county.

An interesting fact has been brought out by Prof. Stevenson in his study of the geology of Belmont, Harrison, and the southern townships of Jefferson, viz., that all the Upper Coal Group, with their associated limestones, diminish rapidly in thickness towards the north, the intervals between the different limestones and coal seams becoming less, and the limestone strata conspicuously thinning. This shows conclusively that the margin of the basin in which the members of the Upper Coal Group were deposited was not far from the northern line of Jefferson county.

Coal No. 8.—This, as has been stated, is the great Pittsburgh seam, which is, on the whole, the most extensive and economically important coal bed in the Allegheny coal field. Its chief development lies east of the Ohio. It is the main coal seam worked at Pittsburgh, on the Youghiogeny and Monongahela Rivers, at Connellsville, Wheeling, and many other places. In western Pennsylvania it attains a maximum thickness of fourteen feet, and is estimated to underlie six to seven thousand square miles. It is also a widespread and important coal seam in Ohio, where it occupies three thousand to four thousand square miles, and here maintains a thickness of from four to six feet. The basin throughout which the Pittsburgh coal was originally continuous is deeply cut by the Ohio River, the valley of which shows parallel lines of outcrop on the opposite sides from near the north line of Jefferson county to the southern border of Belmont, where, by its southward dip, the coal is carried below the river, and the two outcrops join to form an unbroken sheet. This descends beneath the overlying strata of the Upper Coal Group and the Upper Barren Measures that form the surface rocks in south-eastern Ohio. Rising towards the west, it comes out in the vicinity of Pomeroy, and is the coal so extensively mined in that vicinity.

The western line of outcrop of Coal No. 8 passes north-easterly through the eastern part of Gallia, Meigs, Athens, Morgan, Noble, Guernsey, and Harrison, to the southern part of Carroll, and the northern of Jefferson; thence it curves round into the valley of the Ohio, as has already been described. In the most northern localities, where it is found, it occupies the summits of the hills, and forms isolated patches separated by the valleys of the draining streams. It is here thinner than further south, as are also its associated limestones, and it is evident that we have reached nearly to the margin of the basin in which it originally accumulated. If it had not been removed by surface erosion in this region, it is probable we should find it running to a feather edge within a few miles of what is now its most northerly outcrop.

The quality and thickness of the Pittsburgh coal varies considerably in different parts of the county. In the hills about Knoxville and Richmond it is from thirty inches to four feet in thickness, has generally insufficient cover, and is consequently soft. South of the Pittsburgh, Cincinnati and St. Louis Railroad, it is usually from five to six feet in thickness in two or three benches. Prof. Stevenson mentions one locality in Warren township, in the mine of Mr. J. C. Pickens, where the coal is in four benches, as follows:

1.	Roof coal	2 feet to 2 feet 6 inches.
2.	Clay parting	2 "
3.	Coal	2 " 6 "
4.	Parting	2½ "
5.	Coal	1 " 2 "
6.	Parting	2 "
7.	Coal	1 " 6 "

And in Wells township, at the mine of Mr. Edwards, the proprietor reports the coal to consist of two benches, each five feet in thickness, separated by a clay parting of one feet.

In quality the coal of No. 8 is more uniform than in structure and thickness. It is everywhere a coking coal, and in many localities can hardly be distinguished from that mined at Pittsburgh. It varies, however, considerably in the quantity of sulphur it contains. In some places one of the benches is thickly set with balls or lenticular masses of pyrites, which if permitted to remain in the coal would very much impair its value. They are, however, easily separated in mining, and almost everywhere a good coking and steam coal may be produced from this seam. In a few places, also, it is pure enough to be used for the manufacture of gas.

The best exposures of Coal No. 8 in Jefferson county are along the Ohio River, near Tiltonville, and in the valleys of Short Creek and Rush Run. Here it is generally from four to six feet in thickness, and lies at a level about half way between the surface of the river and the summits of the hills in the interior. It therefore exhibits continuous lines of outcrop for several miles up those streams, and when they shall be traversed by railroads, coal can be mined and shipped here with great facility.

It has been remarked above that the limestones associated with No. 8 thin out toward the north. In Knox township, where the coal and limestones are last seen, the limestone beneath the coal is two and a half feet in thickness, the one above it entirely wanting. At Wintersville the overlying limestone is reported to be five feet in thickness, that below it six feet, the coal from four to four and a half feet thick. In Belmont county and about Wheeling the upper limestone is from thirty to seventy feet in thickness, the lower from four to thirty feet. The mines where Coal No. 8 is worked in Jefferson county will be enumerated and described further on.

THE LOWER BARREN MEASURES.

The Lower Barren Measures of western Pennsylvania have a typical representation in Jefferson county. The series is about 450 feet in thickness, and consists here chiefly of olive and red shales, with intercalated bands of red and yellow sandstone, two or more strata of limestone and two or three small seams of coal. About the middle of the Barren Measures occurs a limestone which is remarkably persistent in place and uniform in character. It varies somewhat in thickness, but is usually from three to five feet, is gray in color, and contains numerous and characteristic fossils; these are largely portions of crinoids, and hence we have called it the *Crinoidal limestone.* Perhaps the most abundant fossils contained in it are the spinous plates of *Zeacrinus macrospondylus.* It also contains many mollusks, such as *Spirifer cameratus, S. Kentuckensis, Retzia punctulifera, Productus longispinus, P. semireticulatus, P. Nebracensis, Hemipronites crassus,* and *Chonetes Smithii,* and numerous fish teeth of the genera *Cladodus, Petalodus,* and *Ctenoptychius.* In the northern part of the county the crinoidal limestone caps the hills bordering Yellow Creek, and the red and green shales which underlie it are conspicuously shown on the hillsides above Salineville and Irondale.

Passing southward from the valley of Yellow Creek, the first opportunity of measuring the distance between the Pittsburgh coal and the first of the lower group—the "Groff Vein," Coal No. 7—occurs near Knoxville. Here the distance between the Pittsburgh Coal and the crinoidal limestone, as measured by barometer, is about 165 feet. In the section taken from Richmond to Brown's Station, the interval between the Pittsburgh seam and the crinoidal limestone is 207 feet, and the distance from the Pittsburgh seam to Coal No. 7 at Fleming's mine is 423 feet. In the section from the highlands down to the mouth of Wills' Creek, the distance from the Pittsburgh seam to the coal beneath the crinoidal limestone—the limestone itself not being seen—is 230 feet, and to Coal No. 7 is 488 feet, to Coal No. 6 552 feet. At Steubenville Coal No. 7 is apparently wanting, and the interval between the Pittsburgh coal and Coal No. 6, the "Shaft coal," is at the rolling-mill shaft 506 feet. At Boreland's shaft it is 198 feet from the Pittsburgh coal to the crinoidal limestone, and 511 feet to the shaft coal.* At Mingo Station the dis-

* I am told by Mr. John Lowe that measurements carefully made by the county surveyor show that at Averick's shaft, which is 204 feet deep, the Pittsburgh coal lies 365 feet above the shaft mouth, making the distance between the two coals 569 feet. The same authority reports the distance between the Pittsburgh and shaft coals at Spaulding, Woodward & Co's shaft, to be 534 feet. The measurements given above and on our charts were from observations taken with the aneroid barometer, by several

tance from the Pittsburgh coal to the crinoidal limestone is 207 feet, and to the shaft coal is 511 feet. At LaGrange the interval is 540 to 550 feet. The interval between Coals No. 6 and No. 8 is 512 feet, as measured by barometer.

The hills which form the banks of the Ohio at Pittsburgh are geologically the same as those at Steubenville, and those who have noticed the great thickness of olive and gray shales which chiefly form them, with nothing of interest or value below the Pittsburgh coal and above the Ohio, will perceive the appropriateness of the term chosen by Prof. Rogers to designate them.

As has been stated, the coals of the Barren Measures are generally of little or no value, but on Wills Creek the coal under the crinoidal limestone, about two hundred and twenty-five feet below the Pittsburgh seam, is two and a half feet in thickness, and of very good quality. This is Coal No. 7*b* of our series, and is that worked at Harlem, in Carroll county. There are a few places in the northern part of Jefferson where it is worth working. South of the railroad it is generally but a few inches in thickness, and has no economic value.

THE LOWER COAL GROUP.

In all the northern part of the county five workable seams of the Lower Coal Group lie above drainage, and are opened and worked in many places. These are Coal No. 7, locally known as the "Groff Vein" and "Salineville Strip Vein;" Coal No. 6, the "Big Vein;" Coal No. 5, or the "Roger;" Coal No. 4, the "Hammondsville Strip," and Coal No. 3, the "Creek Vein." The latter lies about thirty feet above the Ohio, at the mouth of Yellow Creek, and runs along the river bank at about the same level to Sloan's Station. Here a rapid southerly dip begins, which soon carries all the lower coals beneath the surface.

Borings and shafts in the northern part of the county have revealed the presence of two, or, sometimes, three thin coal seams within a hundred and fifty feet of the "Creek Vein," but, so far as known, these are nowhere of workable thickness. Deeper borings, of which a large number have been made for salt and oil in the northern part of Jefferson

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members of the Geological Corps. Since it is impossible in this vicinity to obtain a vertical section, the outcrops of the Pittsburgh coal being west of the river, while the shafts are located on the river bank and down a south-easterly dip, the true distance between the two coals has been doubtless somewhat exaggerated. The sections at LaGrange and Rush Run are, however, so nearly vertical that there is no great liability of error from the cause cited above, and the distance as measured there between the Pittsburgh and shaft coals—a little over 500 feet—is probably about the average for this region.

county or in the adjacent townships of Columbiana, have shown that the Waverly Group is reached within two hundred feet of the "Creek Vein," and hence that the base of the Coal Measures is there passed, and that no more coal can be hoped for at a greater depth. Along the northern margin of the coal field the lowest coal seam in the series is in many localities of workable thickness and of superior quality. It is there known as the Briar Hill, or Massillon coal, and from its development in the Mahoning and Upper Tuscarawas Valleys, has proved to be one of the most important and valuable coals of the series. Much effort has been made to find it in the interior of the coal basin, but up to the present time it has been nowhere struck of workable thickness on the Ohio River.

Associated with the coals of the Lower Group are numerous beds of limestone, fire-clay, and iron ore, which have more or less economic value, and some of them will be referred to more specifically further on. The limestones have been generally taken as guides in the identification of the coal seams, but it unfortunately happens that they are somewhat local, and that in one place or another beds of limestone are found in the intervals that separate each two of the coal seams, hence they have proved as great a hindrance as a help in the study of the geology of the county. At Salineville a limestone is seen between Coals 7 and 6, another between 6 and 5, and still another beneath No. 5. At Irondale no limestone has been discovered under No. 7, while that under No. 6 is two feet in thickness; that under No. 5 (the "Roger Vein") three to five feet thick. No limestone has been detected at Irondale between Coals 3 and 4 (the "Strip" and "Creek"). At Collinwood limestones occur under Coals 7, 6, and 5, and none, so far as known, between 4 and 3. At Linton a limestone five feet thick is seen under Coal No. 7, on the west side of Block House Run; on the east side it has not been detected. No limestone has been found beneath the "Big Vein" at Linton, and Coal No. 5 and its limestone are either wanting or concealed, while a thin band of limestone occurs beneath the "Strip Vein"—Coal No. 4. Along the river a limestone is seen under Coal No. 5, at Elliotsville, Croxon's Run, and Sloan's Station, but no limestone has yet been discovered under the upper seams. In the vicinity of Brown's Station the hills contain six limestones, viz: (1) that under the Pittsburgh coal; (2) the crinoidal limestone; (3) a thin bastard or earthy limestone about sixty feet above Coal No. 7 (Fleming's); (4) a limestone under Coal No. 7; (5) an impure limestone over Coal No. 6; (6) a limestone immediately beneath Coal No. 6. At the mouth of Wills Creek, at Boreland's Shaft, and at Rush Run, a limestone occurs beneath the fire-clay of Coal No. 6.

Throughout Columbiana county a thick bed of limestone is found almost constantly beneath Coal No. 6, and we learn from Professor Rogers's reports, that the same is true over a large area in western Pennsylvania, where the coal is known as the *Upper Freeport* seam, and the limestone is called the *Freeport Limestone.*

It must not be inferred from the above facts, that the limestones of the Coal Measures are altogether without value for the identification of strata, for they are really more persistent and reliable than the shales and sandstones with which they are associated. It often happens, however, that in tracing a limestone it is found to become earthy and finally to pass into a calcareous shale or disappear altogether. In such cases it is evident that an unusual quantity of clay was washed into some parts of the basin where the limestone was accumulating by organic processes. This was sometimes only sufficient in quantity to render the calcareous sediment earthy and impure, but sometimes to replace it altogether.

Another source of error connected with the limestones is that they are soluble in atmospheric water, which contains carbonic acid, and hence have sometimes disappeared from the outcrops when their associated shales and sandstones remain.

The frequent references made in different parts of this Report to the Putnam Hill and Zoar limestones of the Tuscarawas Valley, the " White Limestone " of Columbiana county, and the crinoidal limestone of the Barren Measures, afford abundant evidence of the value of some of the limestones of the coal series as geological guides, and it is probable that further exploration will show that the limestones of Jefferson county are much more persistent than might be supposed from the observations yet made; for since they are generally thin and always readily dissolved, their out-crops are undoubtedly often concealed when the strata are present.

Coal No. 7.—This, as has been mentioned, is the highest workable seam of the Lower Group. Its geological position is distinctly marked by the red and green shales of the Barren Measures which are found above it, although sometimes at a considerable interval, and this is the first workable seam below them. The Harlem seam referred to on a preceding page, lies at least two hundred feet higher, is above the most highly colored shales of the Barren Measures and beneath the crinoidal imestone. Hence there is little danger of confounding these two coals. Coal No. 7 is at Salineville, from 3 to 3½ feet in thickness, a partially open, burning coal, with a moderate percentage of sulphur and ash. Passing down the creek from Salineville, Coal No. 7 is seen to thin out along the railroad below the station, and it has altogether disappeared at the point where the railroad crosses Yellow Creek. At the Empire Mine, it is apparently wanting, as the air shaft shows a limestone twenty feet above the coal mined (No. 6). This limestone is apparently the same as that seen at the railroad bridge, and as there without any coal above it. In a boring made at the Empire Mine, limestone four feet thick occurs immediately beneath the fire-clay of the coal, just as in the central and eastern portions of Columbiana county. At Irondale coal No. 7 is $2\frac{1}{2}$ feet thick; at Collinwood, from 3 to 4 feet; at Linton, where it is known as the "Groff Coal," from 3 to $4\frac{1}{2}$ feet. Along the river between Yellow Creek and Wills Creek, Coal No. 7 appears at various places—Elliotsville, Sloan's Station, Brown's Station, etc.—and varies from $2\frac{1}{2}$ to 4 feet in thickness. At Fleming's Mine, above Brown's Station, it is very well shown and 4 feet thick. At Wills Creek it has come down nearly to the level of the river, and is three feet in thickness. At Yocum's Well, just south of Wills Creek, it is reported to have been passed in boring, and to have been about 2 feet thick. At and below Steubenville, it is either wanting or too thin to be worked.

On the south side of the river, Coal No. 7 has apparently been identified at Tomlinson's Run, and at New Cumberland, and is there from 3 to 5 feet in thickness.

The interval between Coal No. 7 and the "Big Vein"—No 6, is at Salineville from 50 to 62 feet; at Irondale it is 50 feet; at Collinwood it is reported to be 35 feet only; at Linton 65 feet; at mouth of Wills Creek it is 62 feet.

Coal No. 6.—The "Big Vein" of the northern part of Jefferson county, the "Shaft coal" of Steubenville and Rush Run, is the thickest and most valuable coal found in this region. Its thickness at Salineville varies from three to six feet, at Kirk's salt well showing the latter, while at the Empire Mine the maximum thickness is five feet nine inches, average thickness about five feet. At Irondale it is five and a half feet, at Linton six to seven feet, at Steubenville it is four feet in thickness, at LaGrange five and a quarter feet, and at Rush Run six to nine. In all the northern part of the county the coal of seam No. 6 is highly cementing, and contains considerable sulphur. At Steubenville it is a very pure, partially open-burning coal, largely used, when coked, for the manufacture of iron. This seam is rarely homogeneous and almost always shows a parting of slate or bony coal at or below the middle.

Coal No. 5.—This is known on Yellow Creek as the "Roger Vein." It is there from two and a half to three and a half feet in thickness, of medium quality, and has been worked only for local use. The interval that separates No. 5 from No. 6 is quite variable, ranging from thirty-five to sixty feet. In the river hills Coal No. 5 has been apparently identified at Elliottsville, Croxon's Run, and at Sloan's Station. It is there about three feet in thickness, and rests upon fire-clay and limestone. At Croxon's Run the coal which has been regarded as the Roger is ninety feet above the "Strip Vein"—Coal No. 4—which makes it probable that it is No. 6, and that Coal No. 5 is there cut away and replaced by the very heavy bed of sandstone which overlies Coal No. 4. In the boring near the mouth of Wills Creek a coal is said to have been passed through forty-one feet below Coal No. 6, which is probably No. 5. In the "test well" bored by Mr. Blynn, at Steubenville, a coal is reported two and a half feet thick, fifty-four feet below No. 6, and in the Rolling-Mill shaft a coal seam four feet thick has been reached forty-four feet below the "shaft" seam. These are doubtless the same coal, and if the "shaft" coal is, as we suppose, No. 6, this is the "Roger." Further south no traces of it have been found.

Coal No. 4.—At an interval of from fifty to seventy feet below Coal No. 5 a coal seam occurs which is quite persistent in the valley of Yellow Creek, and in that of the Ohio between Linton and Sloan's Station. This is what is known as the "Strip Vein" in these localities, and is so named from the fact that it was like the "Strip Vein" of Salineville (Coal No. 7), first mined by stripping and quarrying in the bottom and along the sides of the valley. It is generally about two and a half feet in thickness, a hard and bright coal, containing little sulphur, although a large amount of ash. It has been most extensively mined at Hammondsville, where it has been coked successfully, and it has also been largely shipped for the manufacture of gas. Along the Ohio it is sometimes called the "Block Coal," from the fact that it comes out in cubical blocks with smooth faces. The "strip" of Hammondsville is probably, though not certainly, identical with the Leetonia and Hartford coals of Columbiana county.

Coal No. 3.—This is what is known as the "Creek Vein" in the lower valley of Yellow Creek, so named from the fact that it is generally found near, sometimes in, the creek bed. At Irondale the interval which separates Coals Nos. 3 and 4 is eighteen feet, at Linton it is twenty feet, at McCoy's Station thirty-six feet, at Elliotsville thirty-four feet, at Croxon's Run fifteen feet, and on Island Creek twenty-two feet. This interval is to a large degree filled with black shale, set with nodules of iron ore, and a similar shale is sometimes found above No. 4. The Creek Vein is usually from three to four feet in thickness, a soft, coking, sulphurous coal, not highly esteemed for any purpose. It was formerly called the "Salt Coal" in the valley of Yellow Creek, from the fact that it supplied much of the fuel used in the manufacture of salt, which was carried on there many years since.

Beneath Coal No. 3 is a heavy bed of fire-clay, which is used for the manufacture of fire-brick, pottery, terra-cotta, etc., at many places along the Ohio, in the counties of Columbiana and Jefferson. From its association with this important bed of clay, No. 3 is sometimes called the "Clay Coal."

As has been mentioned on a preceding page, thin seams of coal occur below Coal No. 3, in the northern part of Jefferson county. These have been reached by borings in many places, and according to the reports of the drillers, a bed of coal of workable thickness was reported to exist below the bed of the Ohio at McCoy's, Sloan's Station, and New Cumberland. Shafts were sunk to reach this at the latter two localities, when it was found to consist largely of black shale and to be practically worthless. Whether this is the representative of Coal No. 1—the Massillon seam—is not known, but if so, it has in this part of the State so degenerated in character as to have no value.

From the Pennsylvania line to Brown's station Coals No. 3 and 4 are found nearly at the same relative levels, and lying so near together and to the railroad, they constitute a marked horizon which may be followed without much difficulty. Their identification is also rendered more easy by the heavy beds of clay under Coal No. 3, and the black shales, with iron ore, which are associated with them. Neither seam is absolutely continuous throughout this interval, for one or the other is wanting in several localities, but the group of strata of which they form part can be recognized at all intermediate points, and found a convenient and reliable base from which the local sections can be studied. South of Brown's Station these coals go under the river, and have not been cer- inly identified further south. We may, infer, however, that the lowest coal met with in the McElroy and Yocum wells, at the mouth of Will's creek, at ninety-five and ninety-two feet below the "shaft coal," is one of these, probably No. 4. The coal found in the borings at Mingo, one hundred and thirty feet below the "shaft coal," and in the oil well one mile below Mingo, at one hundred and forty-seven feet below the "shaft coal," may be supposed to be Coal No. 3. In a boring made on Cross Creek, West Virginia, this same coal was struck at one hundred and twenty-nine feet below the Steubenville coal. In all these, and many other borings made in the central part of the county, no lower workable coal is found.

LOCAL GEOLOGY.

On the preceding pages a brief review has been given of the surface features, and the general geological structure of Jefferson county. The characteristics of certain subordinate districts of special interest with the local groupings of geological facts, as illustrated by mining or manufacturing enterprises, will now be described.

THE YELLOW CREEK VALLEY.

The greater part of the valley of the north fork of Yellow Creek lies in Columbiana county, and its geological features are given in the report of that county, but the stations of Irondale, Hammondsville, Collinwood, and Linton, are within the limits of Jefferson, as are the valleys of Brush Creek and the south fork of Yellow Creek (Big Yellow Creek). These latter streams have their sources in Carroll county, but drain the townships of Brush Creek, Springfield, Ross, Saline, and Knox. The summits of the hills in Brush Creek and Saline rise two hundred feet into the Barren Coal Measures, and are capped with the crinoidal limestone. Further south, in Knox, Ross, and Saline, the highest points contain the Pittsburgh coal and limestone, and hence all the upper portions of the valleys of the streams mentioned lie in the Barren Measures and contain no workable coal, except where the Harlem seam (*7b*), as it sometimes does, attains a thickness of two and a half feet, and is sparingly worked. The altitude of Robinson's point is about six hundred and eighty feet above Lake Erie, and the surface is one hundred and fifty feet above the crinoidal limestone. The highest rocks of this vicinity are in the upper portion of the Barren Measures, reaching to within about fifty feet of the Pittsburgh coal. They are mainly yellow friable sandstones above, and soft olive shales below to the crinoidal limestone. About ten feet above the limestone, a seam of coal from twelve to eighteen inches thick occurs. The crinoidal limestone is here from three to eight feet thick; the Harlem coal thirty inches.

At Hammondsville, Coals No. 3, 4, 5, 6, and 7 are exposed. Going towards Salineville, on the railroad, Coals No. 3 and 4 pass under the creek at New Salisbury, and No. 5 at the Big Cut. Coal No. 6 sinks below the bottom of the valley just below the village of Salineville, but comes out again at the station and rises rapidly towards the west and north, so that No. 5 is shown at the old salt well on the switch.

In following up the valley of Big Yellow Creek, almost precisely the same geological structure is observable. Between Hammondsville and the mouth of Brush Creek, Coals 3 and 4 pass beneath the surface, and are not again seen. Above the mouth of Brush Creek, Coals No. 5, 6, and 7 descend until No. 5 disappears, and No. 6 is just on the level of the Creek. At the Tunnel Mill the strata rise again, and Coals Nos. 5, 6, and 7 are all exposed. No. 6 is here about four feet thick, and some forty feet below it No. 5 appears. About ninety feet above a coal outcrop is seen, which probably indicates the place of No. 7. Still higher are the crinoidal limestone and the Harlem coal.

At Moretown three coal seams are seen, apparently the same as those exposed at the Tunnel Mill. At Dorrance's the lowest is three feet thick, with much sulphur, and bearing a strong resemblance to the Roger vein. The next seam is fifty feet higher, and four feet thick, netting over three feet of good coal. The loss is occasioned by a slaty band at the top, a feature this coal has in common with the "Big Vein" at Salineville, its probable equivalent. It contains, however, less sulphur here than is usually found in the "Big Vein." The upper seam, sixty feet above the one last mentioned, is said to be twenty-eight inches thick.

At Nebo, the lower of the three seams mentioned is seen near the level of the creek, and one mile west of this point it passes beneath it and disappears. The upper two of the thin coals exposed below apparently continue to the county line, but are shown only by outcrops. A bed of light gray limestone appears midway between the lowest and middle seam.

In the Barren Coal Measures which form the hills west of the county line, the crinoidal limestone is conspicuously shown, with its associated strata, giving the following section :

1.	Olive shales and sandstone	70 feet.
2.	*Coal* (7c)	18 inches.
3.	Fire-clay	20 "
4.	Green and red shales	15 to 20 feet.
5.	Crinoidal limestone	2 to 8 "
6.	*Coal* (Harlem Vein)	30 inches.
7.	Fire-clay	2 feet.
8.	Green shale and shaly sandstone	50 to 60 "
9.	*Coal* (7a)	1 "
10.	Olive shales.	

In the valley of Big Yellow Creek no Drift was found on the surface, but a few transported bowlders were seen at a farmer's house, and are said to have come from the bed of the creek. These were probably brought down by some tributary of this stream reaching to the margin of the Drift area.

A few observations on the directions of the joints in the coal of this region, made by Mr. G. K. Gilbert, give the following results : Two miles below Salineville the main cleavage planes are N. 60° E.; at New Salisbury and Irondale, N. and S.; on Big Yellow Creek, near Brush Creek, N. 50° E.

At the mouth of Brush Creek is an isolated hill of rock, separated from the adjacent highlands on one side by what is evidently an old channel of Brush Creek or Big Yellow Creek, a channel long since deserted by the stream which formed it.

The sandstone above Coal No. 6, on Big Yellow Creek, contains many quartz pebbles as large as peas, as it does in Columbiana on the east and Tuscarawas on the west. None of the sandstones below Coal No. 6 show this peculiarity.

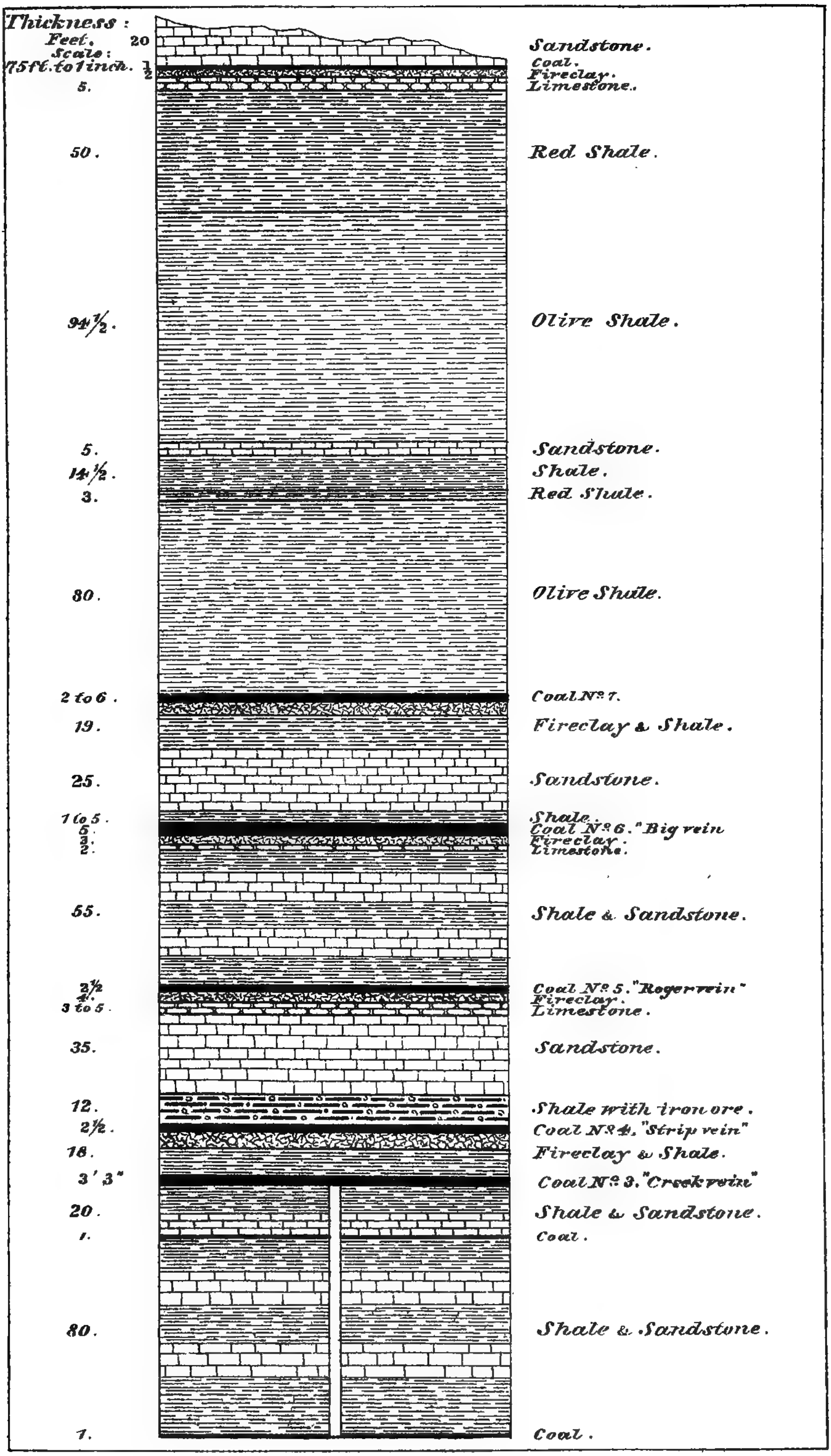
The limestones of this section are all inclined to be nodular, and those under coals Nos. 5, 6, and 7, and the black fossiliferous limestone, thirty feet above No. 7, on Tidball Run, below Salineville, often contain minute coiled shells—*Spirorbis carbonarius.* This is supposed to be the calcareous tube of an annelid somewhat like *Serpula*; it is frequently found adherent to the leaves of plants which had fallen into the water. It also covers in countless numbers some of the surfaces of the cannel coal beneath the "Big Vein" at Linton.

At several places on Yellow Creek a micaceous sandstone, some twenty feet below the "Roger Vein" (Coal No. 5), is saturated with lime, forming a "bastard limestone"—a peculiarly tough rock. It contains some iron, and the exposed surfaces are frequently brown, while the rock within is still blue or gray. Along its outcrop it weathers into rounded angles, showing its solubility.

Many reports are current of the discovery of galena on Big Yellow Creek, and much mystery is thrown around the subject, as if it were a matter of great importance. This is, however, not peculiar to that locality, as nearly every county in the State has its *lead man*, who claims to have found important deposits of this metal, and manufactures a certain degree of cheap notoriety by pretending to be the possessor of an important secret, which he carefully guards. With sincere regret for the necessity of robbing such persons of the capital which they employ with so much pleasure, if not profit, I am compelled to say that all these rumors of the discovery of valuable lead veins, or the allied legend of the manufacture of bullets by the Indians from lead obtained in certain secluded places are, for Ohio, either deliberate frauds or creations of the imagination; for not only has no valuable deposit of lead yet been found in the State, but enough has been learned of its geological structure to warrant the statement that no such thing exists here.

In the country about Big Yellow Creek there are many of the works of the Mound Builders. A son of Mr. James Dorrance reports having opened several mounds on the upland, and from these he has obtained a large number of wrought flints and other stone implements. A little

SECTION AT IRONDALE.



W. J. Morgan & Co. Photo Lith. Cleveland, O.

above Moretown a peninsular hill, commanding a detour of the valley, is said to be surmounted by an ancient fort, and what is apparently a similar monument is visible from the house of Mr. Dorrance. Looking up the valley, what seems to be a large artificial mound is set on the northern end of a low bend extending from the southern margin.

IRONDALE.

The section of the rocks at Irondale is given on another page. It is typical of the geology of all the northern part of the county. From this it will be seen that the upper half of the hill is composed of the Barren Coal Measures, chiefly red and green shales, with a sandstone at the very top. Below this is a coal six inches thick, with a thin band of fire-clay, under which is the crinoidal limestone and a mere trace of the Harlem coal. The "Salineville Strip Vein"—Coal No. 7—is here from two to three feet thick, and is not worked. About fifty feet below it is the "Big Vein," five and a half feet in thickness. This supplies the fuel for the rolling-mill. It has the general character and average quality of Coal No. 6 of this region. From sixteen to eighteen feet below Coal No. 6 is a coal seam two and a half feet in thickness, which is sometimes regarded as the "Roger Vein"—No. 5—but it seems probable that a thin coal, sixty feet below the "Big Vein," should rather be considered Coal No. 5. About fifty-five feet below the last mentioned coal is Coal No. 4—the "Strip Vein"—two and a half feet thick, and eighteen feet below this the "Creek Vein," three feet three inches in thickness.

A boring made by Mr. David Morgan, the managing partner of the Irondale Iron Works, to the depth of eighty feet below the "Creek Vein" passed through shale and sandstone containing a seam of coal about one foot thick and terminated in another of equal dimensions. This boring did not reach the bottom of the Coal Measures, which should lie from fifty to one hundred feet lower; but it is scarcely probable that any workable coal would have been found had the hole been carried lower. Coal No. 1 is *due* from one hundred and fifty to two hundred feet below the "Creek Vein," but it has not yet been found in Jefferson county.

The fuel used in the furnace at Irondale is three-fourths coke and one-fourth raw coal, both from Coal No. 4. A very elaborate coal-washing establishment has been erected here for the purpose of cleansing the Coal of No. 6 of its sulphide of iron, with a view to the manufacture of coke from it. So far the experiment has been only moderately successful, and the coke from the washed coal of No. 6 is inferior to that made from No. 4.

Analyses of Irondale coals will be found in the tables at the end of this chapter.

HAMMONDSVILLE.

The section here is essentially the same as at Irondale, but the hills are not so high and do not catch the Crinoidal limestone. The "Strip Vein," Coal No. 4, is the seam principally worked here. It is about two and one-half feet thick, very clear and bright, with only one fault—that it contains an unusual percentage of ash. It is comparatively free from sulphur; comes out in cubical blocks, and resembles the Pittsburgh coal in appearance. It yields an excellent coke, which is extensively manufactured here. The coal has also been largely used for gas.

The mines and coke ovens at Hammondsville are owned by H. W. Wallace, Esq., and the Hammondsville Coal and Coke Company.

For analysis of Hammondsville coal see tables at end.

COLLINWOOD.

The geological section of the hills at Collinwood is as follows:

		FT.	IN.
1.	Shale and sandstone	30	..
2.	Coal No. 7	3 to 4	..
3.	Fire-clay limestone, shale, and sandstone	35	..
4.	Coal No. 6	3	7
5.	Fire-clay and limestone	8	..
6.	Shale and sandstone	50	..
7.	Coal No. 5	2	6
8.	Fire-clay	4	..
9.	Yellow argillaceous limestone	3 to 7	..
10.	Sandy and clay shales	50	..
11.	Coal No. 4	2	6
12.	Fire-clay	3	..
13.	Sandstone	15	..
14.	Coal No. 3	3 to 4	..
15.	Fire-clay	5 to 6	..

Here, as elsewhere in the valley of Yellow Creek, numerous bands of kidney ore traverse the shales. Mr. E. K. Collins has had a series of the ores on his property analyzed by Prof. J. L. Cassells, with the results given below. None of these ores have as yet been mined, and it is impossible to say whether any of them can be profitably worked. Those numbered 1 and 2 are from below Coal No. 4; those numbered 3 and 4 are from between the "creek" and "strip" veins; the others above the "strip."

ANALYSES OF IRON ORES FROM COLLINWOOD. BY J. L. CASSELLS.

	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.
Specific gravity	3.251	3.138	3.261	3.476	3.421	3.480	......	3.095	3.360	3.568	2.751	3.034	3.272	3.022
Loss in roasting	14.80	16.	21.20	28.	29.60	27.60	21.20	24.40	28.	26.40	10.40	17.60	21.20	21.60
Moisture at 212°	2.45	2.60	2.10	1.95	1.60	2.25	1.80	1.75	1.85	1.50	1.20	1.00	.80	2.10
Oxyd of iron	40.	38.	50.20	59.40	57.60	78.00	56.00	......	64.75	62.30	25.00	37.40	61.25	48.00
Carbonate of iron	......	......	......	......	......	......	......	62.00	......	......	......	......	......	......
Carbonate of lime	.40	1.60	......	1 20	......	1.20	......	......	.85	1.20	21.20	29.60	6.00	7.60
Lime	......	......	1.20	......	3.60	......	......	......	......	......	......	......	......	......
Magnesia	1.46	1.45	Trace.	......	......	.73	......	2.19	.75	.60	2.20	......	1.20	2.98
Carbonate of magnesia	......	......	......	.40	1.27	......	......	......	......	......	......	5.86	......	......
Alumina	4.60	1.35	13.30	12.50	5.25	4.00	12.74	4.	17.40	17.25	7.20	3.20	15.55	17.20
Potash	.35	.55	.75	.46	.50	.50	.36	.35	.40	.40	.75	.25	.15	.52
Soda	.10	.20	.25	.29	.25	.12	.10	.16	.15	.10	.45	.90	.50	......
Carbonaceous matter	......	......	......	......	......	......	2.40	.80	......	......	......	......	......	......
Oxyd of manganese	5.44	4.25	3.80	4.20	2.60	......	......	.75	1.85	.65	1.80	1.40	2.00	1.00
Silica and insoluble matter	45.20	50.	28.46	19.60	27.23	13.20	26.60	25.20	10.	16.	40.20	21.20	13.20	20.60
Metallic iron	.28	26.60	35.14	41.58	40.32	54.60	39.20	40.29	45.32	43.61	17.50	26.18	42.87	33.60

LINTON.

The geology of the country immediately about the mouth of Yellow Creek has been frequently referred to in the pages of this report, and is described somewhat at length in the Report on the Geology of Columbiana County, which forms another chapter in this volume. The hills which border the Ohio here rise to the height of about five hundred feet above the river. Throughout the upper three-fifths of this height they are composed of the shales of the Barren Measures, while the two hundred feet of strata below include all the workable coals in this region. With some local variation, this section is parallel with that at Irondale, the fall of Yellow Creek keeping pace with the south-easterly dip of the strata.

Coal No. 7 is on the south side of Block House Run, one hundred and sixty-six feet above the railroad and Coal No. 4. On the north side, and near the station, it is one hundred and eighty feet; further back, at Groff's mine, it is one hundred and ninety-four feet above the railroad, which is in turn one hundred and fifteen feet above Lake Erie. This coal is from three to four and a half feet in thickness, and has long been worked at the mine of Mr. J. Groff, from which it has taken the name of the "Groff Coal." Its quality is good. On the west side of Block House Run it has been known to exist, but has not been opened. The section on the Diamond property is as follows:

		FT.
1.	Shales of the Barren Coal Measures	275
2.	*Coal No.* 7	3
3.	Fire-clay	4
4.	Shale	10
5.	Grey limestone	5
6.	Sandstone and shale	50
7.	*Coal No.* 6	7
8.	Fire-clay	5
9.	Interval. Mostly shale and sandstone; reported to contain Coal No. 5, with limestone under it	70
10.	Black shale, with iron ore	15
11.	*Coal No.* 4 ("Strip")	2
12.	Fire-clay and limestone	4
13.	Shale, with iron ore	20
14.	*Coal No.* 3 ("Creek")	4
15.	Fire-clay	5
16.	Shale and sandstone, with a thin coal to river	17

Coal No. 6, at Linton, is thicker than in any other locality in the northern part of the county. It usually runs from six to seven feet, but in some places is seven feet three inches. It is a highly coking coal, of average quality, containing considerable sulphur, and showing its usual parting. The mine opened in this seam on the Diamond Coal Company's property is of special scientific interest, as it has yielded a remarkably interesting group of fossils. These are the remains of fishes and aquatic salamanders, about twenty species of the former, and nearly twice as many of the latter, having been already described. All these are found in a stratum of cannel four to six inches in thickness, which underlies the cubical coal. This cannel layer is not found in any other locality where Coal No. 6 has been opened in the region, and it probably has but a limited extent. As it has been shown in the general review of the mode of formation of coal, in Vol. II, all cannel coals are deposited from water, and this view is confirmed by the fact that all the remains found in the Linton cannel are those of aquatic animals.

The mode of formation of this interesting deposit was apparently this: Coal No. 6 occupied a depression of the surface as a peat bog, but the lowest portion of this depression was for a time a lagoon, perhaps land-locked, perhaps connecting with the sea. In this lagoon fishes and swimming salamanders, much like our *Menopoma* and *Menobranchus*, lived and died for ages. In process of time this lagoon was "grown up" by the vegetation that lined its shores, just as so many lakelets are now being converted into peat bogs in the northern part of our State.

To the palæontologist there are few places in the world more interesting than the Diamond Mine, at Linton, since we here get such a view of the life of the Carboniferous age as is afforded almost nowhere else, and of the great number of species found there, not more than three or four have ever been met with elsewhere. It is also true that the mine is by no means exhausted of its novelties, and a large part of the amphibian remains obtained there are so fragmentary that very important portions of their structure yet remain unknown. Hence it is to be hoped that those who have the opportunity will make an effort to secure, from a deposit which is destined soon to be worked out, as large a portion as possible of the scientific riches it contains.

The "Rogers coal" (No. 5) is not certainly known to be present at Linton. The interval between Coals No. 4 and 6, on the Diamond property, is covered, and no outcrops of it are seen. It is reported that a boring or shaft, sunk in the Diamond Mine, cut Coal No. 5 some sixteen feet below the "Big Vein;" but this statement wants confirmation, both as regards the discovery of such a coal seam and its identification as the "Roger Vein."

On the east side of Block House Run a heavy sandstone is seen to occur about on the horizon of Coal No. 5, and only a streak of coal is left to represent that seam. The "Strip Vein" lies just along the grade of the railroad at Linton. It is from two to two and a half feet in thickness, furnishing an excellent coal, like that at Hammondsville. The "Creek Vein" (Coal No. 3) lies about twenty feet below the grade of the railroad. It has been opened near the hotel at the east end of the bridge which crosses Yellow Creek. It is, at the outcrop, about three and a half feet in thickness. It is of fairly good quality, but contains, as usual, much sulphur. It was mined here for many years by the salt boilers. The old entry is now closed, but the coal is said to have run out in the hills—whether from a "horseback" or a slip can not now be determined—and hence it was known as the "Lost Vein."

It is reported that a coal seam from four to six feet in thickness was once opened a few feet above No. 3, but it proved to be only local. It was very soft, and seems rather to have been an accumulation of coaly matter torn up from its original position and washed into some depression by the water from which the associated shales and sandstones were deposited. The "Creek Vein," as mentioned above, was "cut out" in the mine opened in this locality, and it is quite possible that the local deposit referred to above was formed from its *debris.*

A good example of the manner in which shales and coals were eroded before the deposition of sandstones which rest on them, may be seen alongside the railroad track between the Diamond Mine and the station. Here the black shale over Coal No. 4 has been very irregularly furrowed by currents which brought in and deposited sand upon it. The shale having been here removed in building the railroad, shows the wavy and irregular under-surface of the sandstone very distinctly. To fully comprehend such exhibitions it is necessary to realize that sandstones are always deposits from water in rapid motion, while shales are the product of deposition in quiet water, and coal was formed at the surface as peat accumulates at the present day. Hence where we find coal covered with fine laminated shale, once a clay, we know that a peat bog was quietly submerged and covered with more or less turbid water, from which the clay was thrown down as a sediment. Where sandstones and conglomerates irregularly replace shales over coal, we know that the quiet of the first period of submergence was followed by a stormy one, where waves and currents swept over what had been the bottom of still water, carrying away more or less of the soft material, and bringing in sand and gravel to take its place.

On the south side of Yellow Creek, at its mouth, the exposures of the rocks are very imperfect. In the hill below the post-office a coal seam occurs fifty feet above the railroad. It is reported to be thirty inches thick, and is probably Coal No. 5. The place of Coals Nos. 3 and 4 should be beneath the railroad. A massive sandstone occurs below grade at this point, and this may cut out the lower coals; the exposures are too imperfect to decide this question.

PORT HOMER.

At Port Homer the following section was obtained on the farm of Mr. Desellems:

1.	Shale and sandstone	50 feet.
2.	Crinoidal limestone	4½ feet.
3.	Olive and red shales, with some sandstone	158 feet.
4.	*Coal*	6 inches.
5.	Shale	40 feet.
6.	*Coal No.* 7	18 inches to 3 feet 8 inches.
7.	Sandstone, clay, and shale	40 feet.
8.	Non-plastic fire-clay, with plastic clay	1½ to 3 feet.
9.	Shale and sandstone	47 feet.
10.	*Coal No.* 5	20 inches.
11.	Fire-clay	1 foot.
12.	Concealed	75 feet.
13.	Gray shale, with nodular iron	15 feet.
14.	*Coal No.* 3—"clay seam"—3 inches of cannel at bottom	3½ to 4 feet.
15.	Fire clay	8 feet.
	Cleveland and Pittsburgh Railroad 45 feet above river.	

Port Homer is the first point below the mouth of Yellow Creek where the "Clay coal" ("Creek Vein," or Coal No. 3) has been identified. It is here worked for household purposes, but is a very inferior coal. A trace of No. 4 is found twenty to thirty feet above it, but it is not well seen here, and is probably thin. A twenty inch seam ninety feet above Coal No. 3 is probably Coal No. 5, although the exposures are insufficient to determine this. The seam ninety feet above that last mentioned, is apparently Coal No. 7, the place of No. 6 being half way between the visible coals. No traces of it were discovered, and it may be wanting. The interval is too incompletely shown to decide the question.

M'COY'S STATION.

From Port Homer the strata are nearly horizontal to McCoy's. They slightly rise towards the south, indeed, as the fire-clay under No. 3, on the grade at Port Homer, is at McCoy's five or six feet above the railroad.

As shown in the section made at Port Homer, a hard non-plastic fire-clay, similar to the Mineral Point and Mt. Savage clays, occurs about one hundred and fifty feet above the railroad. It is associated with plastic clay and recurs in many of the sections taken in this vicinity. Its thickness is variable, reported from eighteen inches to ten feet, but no good exposures of it were seen, and it has been but little used. No definite report can therefore be made in regard to its economic value.

A strong dip to the west and south begins at McCoy's Station. This is strikingly shown by comparing the sections taken at McCoy's, and New Cumberland, West Virginia.

The fire-clay of Coal No. 3 affords a convenient datum line, as it is a strongly marked stratum, and is worked at many localities in this region. At McCoy's this is forty-five feet above the river, while at New Cumberland it is one hundred feet above the same level.

The following very incomplete section was taken by following up the run from McCoy's to Taggart's farm, two miles west:

		FT.	IN.
1.	Hill tops with many fragments of buff limestone about 650 feet above the Ohio River.		
2.	Concealed	81	..
3.	*Coal* outcrop.		
4.	Concealed	45	..
5.	*Coal* outcrop—strong.		
6.	Concealed	99	..
7.	*Coal,* old opening	2	10
8.	Interval, chiefly sandstone and shale	234	..
9.	*Coal,* Taggart's (No. 5?) poor	2	6
10.	Fire-clay resting on nodules of ferruginous limestone	5	..
11.	Interval consisting of heavy masses of sandstone where exposed.	95	..
12.	*Coal* reported thin.		
13.	Slate with nodules of iron ore	36	..
14.	*Coal No.* 3	2	6
15.	Fire-clay	8 to 9 ft.	

Coal No 3 at McCoy's averages about thirty inches in thickness, and is of the usual rather inferior quality. Its underlying clay supplies material to a manufactory of drain pipe and tiles. Immediately over the coal is a bed of shale containing balls of kidney ore, such as is usually found between Coals No. 3 and No. 4, in the valley of Yellow Creek, below its mouth, and on the north side of the Ohio. On the Virginia side of the river this shale bed is replaced by a heavy mass of sandstone, which cuts out Coal No. 4 just as at Smith's Ferry, and it is quite possible that those two exposures are parts of the same sandstone belt, marking the line of some current of water which swept the surface of this region after the formation of Coal No. 4. All the coals in the vicinity of McCoy's Station, so far as explored, are either thin or of poor quality. The "Strip Vein," No. 4, is either thin or wanting, and the three higher seams of the lower coal group show a marked degeneration as compared with their development at the mouth of Yellow Creek, about five miles further north. Between the "Clay Coal" and that marked No. 5 (?) in the section, no seam of workable thickness has been developed.

The coal called No. 5 has been opened in several places, but is reported to be slaty and inferior. Between two hundred and twenty-five and two hundred and forty-three feet above this, a coal was formerly worked on Mr. Taggart's farm, but the mine was abandoned long since on account of the inferior quality of the coal. Near the tops of the hills are two coal outcrops with fragments of an overlying buff limestone probably belonging to the Pittsburgh series, although the coals have not been opened. Two and a half miles south-west of McCoy's a coal is worked on the farm of Mr. John Winns. It is reported to be four feet in thickness, and is apparently the same mined at Knoxville, which is Coal No. 8.

The difference in level between the corresponding members of the section at McCoy's and New Cumberland has already been referred to. The distance between the two points of observation is scarcely a mile, but by comparing the levels of Coal No. 3, the "Clay Seam," and Coal No. 7, the "Prentiss Coal," it is seen that the dip is westerly about fifty feet.

The section at New Cumberland is as follows:

1.	Slope concealed	60 feet.
2.	*Coal No* 7—"Prentiss" or "Groff" coal	4 to 5 "
3.	Fire-clay with ferruginous limestone	8 "
4.	Interval showing in places massive sandstone	208 "
5.	*Coal No.* 3—poor	3 "
6.	Fire-clay	7 "
7.	Sandy fire-clay	10 "
8.	Hard blue limestone	3 "
9.	Sandy and micaceous shales	55 "
10.	Slope to river	25 "

Several deep wells have been bored at New Cumberland. One of these was begun about twenty-five feet above the river, and carried to the depth of one thousand and one hundred feet. According to the report of the drillers the register of this well was briefly as follows:

		FT.	IN.
1.	Earth	12	--
2.	Coal	1	--
3.	Sandstone	7	--
4.	Shale	5	--
5.	"Blue rock" (sandstone)	7	--
6.	Black shale	4	--
7.	Coal	1	1
8.	Shale	29	--
9.	White sandstone	4	--
10.	"Blue rock"	3	6

		FT.	IN.
11.	Iron ore	..	6
12.	Soft blue shale	..	7
13.	Coal	5	6

14. "Conglomerate rock" followed by alternations of shale and sandstone to bottom.

A shaft was subsequently sunk to the lower coal and it was found to be largely composed of slate and worthless. This stratum has been found in wells bored at McCoy's Station, and it was supposed to be Coal No. 1. Whether it is really the representative of the Massillon coal cannot be determined, although this seems probable from the fact that it holds about the proper position for that seam, and no coal whatever was found below it. If, as reported by the drillers, the well passed through a conglomerate immediately below the coal, this would lend additional probability to this theory. The nearest point to New Cumberland, where the Briar Hill coal has been struck, is at Limaville, forty-five miles north-west. The difference in level between the lower coals of the two localities is about 400 feet; the coal at Limaville being 409 feet above Lake Erie, while that at New Cumberland is just about the lake level.

The limestone found beneath the "clay coal," at New Cumberland, is apparently identical with that which holds nearly the same position at Wellsville. It has not been met with in other sections in this region, and would seem to be a local deposit like several of those higher up in the series in different parts of Jefferson county. By Professor I. A. White, of the Pennsylvania Geological Survey, this is thought to be identical with the "Ferriferous Limestone" of Rogers. If this is true, there is a great thickening of the Lower Coal Measures toward the east, for here this limestone is only about 125 feet above the lowest trace of coal found, and what is, for this region, the base of the series, whereas the Ferriferous Limestone is in Pennsylvania some 300 feet above the Conglomerate. There is very little doubt that the "Creek" and "Strip" veins of southern Columbiana county—which may be traced along the Ohio continuously from Liverpool to Sloan's Station—are identical with Coals Nos. 3 and 4 of the vicinity of New Lisbon, the first two workable coals above the Block coal—(No. 1) at Limaville and vicinity, and with the furnace coal and the next seam below it at Leetonia. That they are identical with Coals Nos. 3 and 4, of the Tuscarawas Valley, cannot be demonstrated, as they have not been, and cannot be traced through the divide, but they hold the same relative position to the Barren Measures, and Coals Nos. 6 and 7 above, and to the base of the Coal Measures below.

The flow of gas from the New Cumberland well has always been large, and it was for a time turned to account for the manufacture of lamp-black. Burning jets of gas were made to impinge on slabs of soap stone, and the accumulated carbon was automatically removed by a scraper. The lamp-black was of excellent quality, and was used for the manufacture of printer's ink, etc. The works have recently been burned, and the gas is about to be utilized in Porter Smith & Co.'s fire-brick factory.

ELLIOTSVILLE.

Between McCoy's and Elliotsville, a distance of $1\frac{3}{4}$ miles, the "clay seam"—Coal No. 3—is well exposed, running nearly parallel with the railroad, and from 3 to 4 feet above its grade. The clay is worked at several places, viz.: at the establishment of Messrs. Porter & Miner, where it is manufactured into fire-brick of good quality; by Messrs. Garlick & Sizer, and Mr. Jno. Freeman in their pipe works, and at the "Excelsior Works" (Conner Bros.)

At Porter and Miner's a good coal 3 feet in thickness is found about 30 feet above the "clay seam." This is coal No. 4—the "Block" or "Strip" Vein. A well bored here is reported to have passed through $5\frac{1}{2}$ feet of coal 80 feet below the "clay seam," but the distance is probably greater and the coal the same as that found at New Cumberland, and proved by trial to be worthless. About a quarter of a mile above Elliotsville, at Freeman's terra cotta and drain-pipe works, the following section was observed:

		FT.	IN.
1.	Sandstone massive	40	..
2.	Gray shale	5	..
3.	*Coal No.* 5	3	2
4.	Fire-clay	1	..
5.	Limestone	3	..
6.	Shale and sandstone	46	..
7.	Coal	2	6
8.	Interval—partly covered	52	6
9.	Coal reported thin—No. 4.		
10.	Shales with nodules of iron ore	25	..
11.	*Coal No.* 3, very sulphurous	$2\frac{1}{2}$ to 3	..
12.	Fire-clay—used in the pottery	8	..
13.	Slope to river	20	..

The openings in the upper coal, No. 7, are now all abandoned, and the coal here called No. 5 is regarded by the residents of Elliotsville as the Roger Seam of Yellow Creek. This was at first supposed to be impossible, as its distance above the "clay coal" is so great—130 feet—and there is an intervening coal, No. 7, of the above section, which corresponds better in position to the Roger Vein, but a comparison of the sections at Freeman Bros., Elliotsville, Croxon's Run and Sloan Station, indicate that the limestone coal of Elliotsville is No. 5, here widely separated from the underlying coals, and a local coal seam coming in to occupy the middle of the interval. Possibly further observations will prove this conclusion wrong, but it is the only logical inference from the facts now before us. If we were to suppose the limestone coal at Elliotsville to be No 6, we should then have another difficulty in the interval of 100 feet, which separates that from Coal No. 7, which is nearly twice the average distance in this region. Another fact that argues in favor of the coal in question being No. 5, is that 30 feet above it is a hard, non-plastic fire-clay, which is found in most of the sections along the river. At Smith's Ferry it is *below* Coal No. 6, and at Sloan's Station it lies above the "Limestone Coal" which is here only 62 feet from No. 4, and midway between that and Coal No. 7. The intervals are there all diminished as will be seen when the notes on that locality are reached. At Elliotsville the local geology has been quite carefully studied by Dr. Wilmot Garlick, and the members of the Geological Corps have at different times received much assistance and many courtesies from him, and his father, Dr. T. Garlick.

The following section was taken at Elliotsville:

1.	Shaly sandstones reported to contain near top a coal 3 to 4 feet in thickness	150 feet.
2.	*Coal*, thin.	
3.	Fire-clay and shale, used for pottery	3 feet.
4.	*Coal*, thin	3 inches.
5.	Fire-clay and shale	35 feet.
6.	*Coal No.* 7, hard and clean	3 feet 8 inches.
7.	Shale sandstone and covered	66 feet.
8.	Hard clay, changing gradually into shale above and below, reported	8 feet.
9.	Shales and shaly sandstones	26 feet.
10.	*Coal No.* 5, soft and smutty	3 feet 2 inches.
11.	Fire-clay	6 inches.
12.	Limestone	3 feet.
13.	Sandstone and shales, with a line of springs near the middle	85 feet.
14.	*Coal No.* 4	18 inches.
15.	Fire-clay and gray shales, with nodules of iron	25 feet.
16.	*Coal No.* 3	$2\frac{1}{2}$ to 3 feet.
17.	Fire-clay, used in pottery	8 feet.
18.	Hard, blue, argillaceous sandstone, with mica, to river.	

The exposures of the strata between the coals is not very good, but all the coal seams enumerated above have been opened by Dr. Garlick.

The clay and argillaceous shales associated with the two thin coals (2 and 4 of section) are used as a mixture in the manufacture of sewer pipe. The principal supply of clay comes, however, from below Coal No. 3.

Dr. Garlick has an extensive terra cotta and drain-pipe factory, for which the raw material is obtained from the fire-clay of the "Clay seam," and he has now the largest stock of such things as he manufactures to be found on the river. The principal articles made here are drain-pipe of all sizes from two inches to thirty-three inches in diameter, terra cotta chimney tops, vases, etc.

The upper coal (No. 7) is clean and bright, mines in blocks, and is of better quality than the seam next below it. It is now not much used, as it costs more than the other. Coal No. 5 is very black and smutty, contains considerable sulphur, and has some "bony" coal in the lower bench. It costs two cents per bushel delivered at the works. The coal found beneath the "Roger seam," at Freeman's, has not been detected here. Its position is, however, indicated by a line of springs. Coal No. 4 has been opened, but, being only eighteen inches thick, is not worked. The coal taken from this seam is very hard, and burns well, but leaves a red and rather copious ash. Coal No. 3 has its usual sulphurous character, and is not mined. Analyses of the coals and clays of Elliotsville will be found in the tables given at the end of this chapter.

At the Excelsior Works, Coal No. 3 lies just above the railroad; at Garlick & Sizer's, seven hundred and twenty-eight feet south, it is from seven to ten feet below—showing a southerly dip of about one foot in a hundred.

CROXON'S RUN.

At Croxon's Run are extensive factories which formerly produced fire-brick of good quality, but they are not now in operation. The following is a section of strata found in the hills here:

SECTION AT CROXON'S RUN.

1.	Slope, with black shale at base.	
2.	*Coal No* 7, quality good	$3\frac{1}{2}$ feet.
3.	Interval, showing shaly sandstone where rock is exposed	77 feet.
4.	Black shale	18 feet.
5.	*Coal No.* 5, good quality	34 inches.
6.	Fire-clay, thin.	
7.	Limestone	2 feet.
8.	Sandstone	80 feet.
9.	Gray shale	6 to 8 feet.
10.	*Coal No.* 4	28 to 30 inches.
11.	Argillaceous shale	15 feet.
12.	*Coal No.* 3	36 inches.
13.	Clay, used for fire-brick	7 feet.
14.	Sandstone to Croxon's Run.	

The strata have a rapid dip to the south and west from Croxon's Run, and local dips were reported as high as eighty feet in two hundred yards.

SLOAN'S STATION.

About a quarter of a mile above Sloan's Station are the fire-brick works of John Francy. Coal No. 3 here lies about twenty-three feet below the railroad. It is from thirty to forty inches in thickness, and of somewhat better quality than where mined further up the river. It is overlain by a stratum of micaceous sandstone twelve to fifteen feet in thickness, which forms a remarkably smooth and firm roof throughout most of the mine. Below the coal is soft, plastic fire-clay, thirteen feet in thickness, which supplies the material for the factory. Under this is a hard, silicious clay, of unknown thickness, not worked. In one part of the excavation made to remove the fire-clay, it was found to assume locally the hard, non-plastic character of the Mineral Point and Mt. Savage clays. This phase of our fire-clays is much less uncommon than is generally supposed, as most of them exhibit some local manifestation of it, and although most characteristic of the clay under Coal No. 5, in Tuscarawas county, is only local there, and can not be trusted as a means for identifying clay seams at distant points. Mr. Francy's works are among the most extensive on this side of the river, producing about two million bricks annually.

The section of the strata in the hills above Sloan's Station is as follows:

		FT.	IN.
1.	Slope concealed	80	..
2.	*Coal* out-crop, reported to be	..	6
3.	Interval, where exposed heavy masses of gray, with bands of red shale	184	..
4.	*Coal* out-crop, reported	..	6
5.	Clay and shale	18	..
6.	*Coal*, reported	1	6
7.	Olive shale	27	..
8.	*Coal No* 7	$3\frac{1}{2}$ to 4	..
9.	Fire-clay, reported	6 to 7	..
10.	Interval, principally sandstone, with non-plastic clay, reported 16 to 18 feet near middle	75	..
11.	Gray shale	5	..
12.	*Coal No.* 5, good qualily	3	..
13.	Limestone	2	..
14.	Interval concealed	58	..
15.	*Coal No.* 4, good	2	6
16.	Clay and shale	14	..
17.	Black shale	3	..
18.	Fire-clay	8	..

The section of the strata below the surface at Sloan's Station has been revealed by a boring and shaft made for Messrs. Carlisle & Co., to reach a thick seam of coal reported by several drillers to be something like a hundred feet below the river. This was found to be mostly a mass of shale, and of no economic value.

The section of the shaft and boring is, according to Mr. W. W. Rogers, as follows:

		FT.	IN.
1.	Earth and gravel	53	..
2.	Fire-clay	3	..
3.	Blue shale	23	..
4.	Coal No. 3	3	4
5.	Fire-clay	9	..
6.	Hard blue sandstone	9	6
7.	Shale	8	..
8.	Sandstone	5	6
9.	Blue shale	23	..
10.	Shale	31	..
11.	Black shale	3	..
12.	Sand-rock to bottom.		

A somewhat different section of the strata at Sloan's Station was furnished, I think, by Mr. Carlisle, from borings made previous to the sinking of the shaft. It was copied on chart 3, published with Vol. I of this report, and was as follows:

		FT.	IN.
1.	Earth and gravel	55	..
2.	*Coal No.* 4	2	6
3.	Fire-clay	4	..
4.	Dark shale	22	..
5.	*Coal No.* 3	3	9
6.	Fire-clay	9	..
7.	Sandstone	22	..
8.	Shaly sandstone	20	..
9.	Soft, greenish clay	7	..
10.	Flaggy sandstone	21	..
11.	Dark shale	21	..
12.	Black shale—with gas	6 to 7	..
13.	Very hard sandstone	37	..

Coal No. 3, at Sloan's Station, as shown by these analyses given at the end of this chapter, is of unusually good quality. The fire-clay below it is worked by Messrs. Connelly, Hood & Co., successors to Messrs. McFadden & Carlisle, for the manufacture of drain-pipe, etc. It is reached by a slope at a perpendicular depth of about 60 feet. The upper coals at Sloan's Station have not been thoroughly developed; that called Coal No. 5, in the section above, is known in many places as the "Limestone Coal" or "Mud Vein," because of its proximity to a limestone which underlies it, and of its containing a seam of shale or clay. A hard non-plastic clay is again found here above Coal No. 5, but its value has not been fully tested. A fire-clay 6 feet in thickness, lying 25 feet above Coal No. 3, was at one time worked by McFadden & Carlisle, and was shown to be for some purposes of superior quality. For the manufacture of drain-pipe it was, however, found to be less desirable than the clay under Coal No. 3, and this was therefore used in preference.

The following section was taken from Knoxville due south to Island Creek.

		FT.	IN.
1.	Hill-top at Knoxville, 630 feet above railroad, at Sloan's Station.		
2.	Slope with outcrop of buff limestone	76	..
3.	*Coal* outcrop, reported	1	6
4.	Interval, where exposed, yellow and greenish shales	108	..
5.	*Coal No.* 8, Pittsburgh seam	4	..
6.	Fire-clay	4	8
7.	Buff limestone	2	6
8.	Interval—shales and limestone where observed	142	..
9.	Hard blue limestone	3	..
10.	Shale	10	..
11.	Crinoidal limestone	2	..
12.	Sandstone and shale to creek	153	..

The clay works at Sloan's Station are the last now in operation on the Ohio side in descending the river. The rocks here dip rapidly southward, and Coal No. 3 and its clay are said to disappear below the Ohio at the northern extremity of Brown's Island. At King's Creek, on the Virginia side, however, they are seen at about the same level as at Sloan's Station, and the clay is there used for the manufacture of fire-brick.

Between Sloan's Station and Brown's no coal has been found of workable thickness and good quality, although the explorations in search of it have been quite extensive.

Near Jeddo, half a mile from Sloan's, a coal seam has been opened on the farm of Mr. Campbell, which is apparently the same as that worked by Mr. Thos. Wells, and also with that marked Coal No. 5 in the section at Brown's Station. At Mr. Well's mine the section is as follows:

1.	Gray shale.	
2.	Coal No. 5 (?) containing much sulphur	2½ feet.
3.	Shale	6 to 10 "
4.	*Coal*	3 to 4 inches.
5.	Black shale	1 foot.
6.	Massive sandstone to the Ohio, and forming bed of river	45 feet.

A little further south, on the same property, the workable coal of the preceding section is shown in its relative position with three seams above it. The section is as follows:

1.	Gray shale.	
2.	*Coal*	15 inches.
3.	Clay shale	18 feet.
4.	*Coal*	12 inches.
5.	Sandstone and shale	18 feet.
6.	*Coal No.* 7 (?)	2½ to 3 feet.
7.	Interval concealed	54 feet.
8.	*Coal No.* 6 (?) or grade of railroad	2½ "
9.	Fire-clay and sandstone to river	45 "

By reference to the section at Sloan's Station it will be seen that the upper workable coal has two thin coals above it, just as here; and as these lie at the base of the Barren Measures, we may consider the upper workable coal of the section, next below the two little seams, as Coal No. 7.

At Sloan's Station, the distance between Coal No. 7 and the "limestone coal" (No. 5) is eighty-five feet; between Coal No. 7 and the next coal below it, in the Wells property, the distance is only fifty-four feet. Hence, if the coals are the same in both sections, they have approached each other thirty-one feet in three miles. This is no unusual thing for coal seams to do, but it is quite possible that the lower seam at Wells's is not the same as the "limestone coal" at Sloan's Station. There is apparently no limestone below it, and if we are right in our enumeration of the coals at Sloan's, Coal No. 6 belongs in the blank interval where the hard clay is at Sloan's, and it is quite possible that it has made its appearance at Wells's mine. Unfortunately, the heavy bed of sandstone which forms the immediate bank and bed of the river has obliterated the record below, so that, without further exploration, it is impossible to settle this question.

From Jeddo to Brown's Station the Cumberland (or No. 7) coal has been much sought for, but without success.

On Island Creek, however, it has been found and worked in several places. It is here known as the "Finley Coal." It is worked on the Moreland farm, but is reported as running down to two feet, and even disappearing altogether. The following is a section from the summit of the hills to Moreland's mine, and thence to Island Creek:

1.	Slope covered	70 feet.
2.	Crinoidal limestone	5 "
3.	Slope mostly covered, olive shales and sandstones near base	220 "

4.	Shale with iron nodules	18 feet.
5.	*Coal No.* 7, inferior in quality	4 "
6.	Fire-clay reported	7 "
7.	Shale	5 to 10 "
8.	Limestone	3 "
9.	Shale and sandstone	45 "
10.	Gray and black shale	10 to 15 "
11.	*Coal*	20 inches to 2 "
12.	Fire-clay reported	5 "
13.	Massive sandstone to Island Creek.	

In the above section the coals are apparently the same with those opened at Wells's mine, the distance between them being here seventy-two feet, and fifty-four feet there. The lower coal in the above section has not been worked to any extent. It is reported poor. The "Finley Coal," or No. 7, at Moreland's, has the following composition:

1.	Black shale.	
2.	Slaty coal	18 inches.
3.	Coal	30 "
4.	Slate parting	1½ "
5.	Coal	18 "
6.	Fire-clay.	

Nearly a mile further up Island Creek, this coal has been opened on the farm of Mr. H. F. Fleming, three and a half to four feet thick, and of good quality, though, as shown by analyses, inferior to the Steubenville coal.

In the highlands back of the river the Pittsburgh seam is found in many localities from Knoxville south. It is quite largely worked for home use, but it lies at a distance from the railroad, and the coal it furnishes is of fair but not superior quality. It cannot, therefore, be profitably shipped.

Knoxville is built upon a higher hill than any in the neighborhood. Several seams of buff limestone occur on the hill, and the Pittsburgh coal lies one hundred and eighty-five feet from the top. It is here four feet thick, and is mined on the farm of Mr. T. S. Mills.

Coal No. 8 also occurs in some of the high hills between Knoxville and McCoy's Station, and towards the south and west it is found on all the land which is high enough to catch it. It is mined in many places near Pekin and Richmond.

The following section was taken from Knoxville south to Island Creek. The heights were measured by barometer in bad weather, and are therefore not to be relied upon. For example: the distance between Coal No. 8 and the crinoidal limestone, which is elsewhere in this region about two hundred feet, as shown by the barometer, is, according to the series of observations, only one hundred and sixty-two feet:

		FT.	IN.
1.	Olive and red shales, with bands of buff limestone	76	..
2.	*Coal* reported	1	6
3.	Olive shales	108	..
4.	*Coal* reported	2	6
5.	Olive shales	30	..
6.	*Coal No.* 8	4	..
7.	Fire-clay	..	8
8.	Buff limestone	2	6
9.	Shale and sandstone of Barren Measures	149 (?)	..
10.	Hard blue limestone	3	..
11.	Shale	10	..
12.	Crinoidal limestone	2	..
13.	Shale and sandstone of Barren Measures to creek	153	..

A more complete and satisfactory section was obtained from the top of the hills near Richmond to H. F. Fleming's mine, and thence to the mouth of Island Creek.

SECTION FROM RICHMOND TO MOUTH OF ISLAND CREEK.

[Hill top. Jos. Moses' farm, 623 feet above Ohio River.]

		FT.	IN.
1.	Shale, with bands of limestone and thin coal near middle	67	..
2.	*Coal No.* 8	2	6
3.	Fire-clay and black shale	..	6
4.	Buff limestone	3	..
5.	Interval, mostly olive shales	203	..
6.	Crinoidal limestone	6	..
7.	*Coal*	..	1
8.	Interval, mostly olive and red shales	108	..
9.	Dark argillaceous shale	6	..
10.	*Coal*	1	6
11.	Fire-clay	3	..
12.	Blue bastard limestone	2	6
13.	Gray shale	12	..
14.	*Coal*	..	1
15.	Fire-clay	6	..
16.	Gray and greenish shale	40	..
17.	*Coal No.* 7, H. F. Fleming's	4	..
18.	Fire-clay, reported to be	7	..
19.	Shale	13	..
20.	Limestone, used for lime, reported	3	..
21.	Shale	40	..
22.	Hard blue bastard limestone	2	..
23.	Sandstone, shale, and thin limestone	4	..
24.	*Coal*, reported to be	1	..
25.	Ferruginous limestone	3	..
26.	Gray shale	4 to 5	..
27.	White micaceous sandstone	2 to 3	..
28.	Gray and black shale	10 to 15	..
29.	Fire-clay, reported to be	5	..
30.	Massive sandstone to river	49	..

In the lower part of the above section we have a repetition of the section at Sloan's Station with some important differences. The upper workable coal seam (No. 7) is easily identified as also are the two small coals above it. The coal 88 feet below the Fleming seam is apparently the same with that 80 feet below it at Sloan's Station, but between the two, 21 feet above the lower seam, a thin coal has come in with limestone below it. This is perhaps the beginning of the reappearance of Coal No. 6, which has been wanting in the sections above.

West of Brown's Station a somewhat remarkable development of cannel coal is found in the upper part of the Barren Measures below the Pittsburgh Coal. In Taylor's Hill, half a mile south of Brown's, two seams of cannel are opened and mined for domestic use; they are about 90 feet apart, and are respectively 385 and 295 feet above the railroad. The lower seam at Taylor's mine is 3 to 3½ feet thick; at Dobb's, 3 feet 10 inches. The upper seam is 3 feet 4 inches and has supplied some fuel for household use.

Three or four miles west of Taylor's, on Ford's and Hunt's farms, a much thicker seam of cannel coal is found, which, perhaps, corresponds to the upper one in Taylor's Hill. On Ford's farm it is reported to be 5 feet 8 inches in thickness, and another seam of cannel is reported some 75 feet below. On the farm of Mr. Hunt the following interesting section is shown:

		FT.	IN.
1.	*Coal No.* 8 with limestone above and below, struck in well	4	..
2.	Sandstone and shale partly concealed	49	..
3.	*Cannel Coal*	9	3
4.	Sandstone	17	..
5.	Sandy shale with seams of coal	3	..
6.	*Coal*	..	8
7.	Fire-clay and concealed	10	..
8.	Limestone	2	..
9.	Sandstone	23	..
10.	Olive shale	45	..

All the cannel from these beds contains much earthy matter, and yet serves an excellent purpose for local fuel, and it is possible that in some localities a sufficiently pure coal can be found to be worth exportation. (See analysis at end of chapter.)

We have in this local development of beds of cannel a good illustration of the mode of formation of this variety of coal. They are without the under clays which are always associated with strata of cubical coal, and the carbonaceous matter which chiefly composes them has evidently been transported from its place of origin and deposited in some lagoon, or lake of quiet water, just as we see inky looking streams carrying off the most perfectly macerated vegetable matter from our modern swamps. In the general discussion of the formation of coal contained in Chapter XXXI, p. 125, the origin of cannel is so fully treated that no further reference to it is required here.

From Brown's Station to the mouth of Wills Creek there are no exposures which can serve to maintain the geological connection, and no explorations have been made by boring or otherwise that can help us in the correlation of the Steubenville coals, and those of Island Creek, and the upper river. This blank is greatly to be regretted, as, until it shall be filled, it will be perhaps impossible to definitely settle the mooted question of the proper numbering of the Steubenville "Shaft Coal."

WILLS CREEK.

The valley of Wills Creek lies altogether in the Lower Barren Measures. At its mouth the base of this series is reached, and the tributaries of the stream have their sources in hills which rise above the Pittsburgh Coal.

The following section gives the succession of the strata from the house of Deacon Robertson—situated on the hills which overlook the valley of Wills Creek on the north side—to the mouth of the creek. From this level it is continued downward from the register of the well bored by Mr. J. McElroy, half a mile from the Cleveland & Pittsburgh Railroad, and commencing about twenty-five feet above it.

Section on Valley of Wills Creek.

		FT.	IN.
1.	Slope concealed	38	..
2.	Limestone	2	..
3.	Coal	1	6
4.	Slope concealed	28	..
5.	Limestone—reported	5	..
6.	Shale	1	..
7.	Coal No. 8, Pittsburgh seam	4	..
8.	Fire-clay	1	..
9.	Limestone	2	..
10.	Slope concealed	140	..
11.	Limestone reported	8	..
12.	Sandstone	30	..
13.	Shaly sandstone	42	..
14.	Blue shale (limestone on opposite side of valley)	5	..
15.	Coal, good—Harlem seam (?)	2	6
16.	Fire-clay (reported)	9	..
17.	Concealed	80	..
18.	Limestone (reported)	4	..
19.	Concealed	75	..

		FT.	IN.
20.	Sandstone	25	..
21.	Concealed	20	..
22.	Coal (on opposite side of valley)	1	..
23.	Shale " "	20	..
24.	Coal	..	8
25.	Olive shale (to creek)	10	..
26.	Shale, concretionary (to well head)	6	..
27.	"Fire-clay" and shale in well	10	6
28.	Coal No. 7 (?) "	3	..
29.	Fire-clay "	5	..
30.	Shale "	7	6
31.	Sandstone "	29	..
32.	"Flint-rock" "	1	..
33.	Sandstone "	18	..
34.	"Black slate" "	2	..
35.	Coal "	4	..
36.	"Blue clay" "	2	..
37.	Limestone "	1	..
38.	Gray shale "	15	..
39.	Black shale "	23	..
40.	"Coal, cannel" (?) "	4	..
41.	Blue shale "	4	..
42.	Sandstone "	28	..
43.	"Blue flint" "	1	6
44.	Sandstone "	7	6
45.	Black shale "	10	..
46.	Coal "	5	6
47.	Blue shale "	43	6

In the above section the coal midway of the Barren Measures is probably the Harlem seam, or 7*b*. It will be noticed that there are two thin coals below this a few feet above the creek, then a seam three feet thick near the creek level. Sixty-two and a half feet below this is another coal four feet thick, with a foot of limestone just beneath the fire-clay. Forty-one feet below this again is a coal reported to be cannel, four feet thick, and fifty-seven feet below the "cannel coal" another seam five and one-half feet thick is said to have been passed through. When we compare this Wills Creek section with those afforded by the shafts and "test well" at Steubenville, we find the task of co-ordinating them quite easy. The limestone coal (No. 35 of the Wills Creek section) is plainly the Shaft Coal of Steubenville. It is exposed in the bed of the Ohio, just above the mouth of Wills Creek; is reached at the depth of 75 feet in the shaft of Cable & Co.; at 80 feet in the Busted Shaft; at 172 feet in the boring in Stony Hollow; at 188 feet in the Rolling Mill Shaft; 204 feet in Averick's Shaft; at 221 feet in Boreland's Shaft, and at 234 feet at the Mingo Shaft. At Mingo, Boreland's, and the Busted Shaft a band of nodular limestone was found just below the fire-clay, as in the Wills Creek boring. The coal below this shaft seam (No. 40 of the section) was found in the "test well" 54 feet below the main coal, and in the Rolling Mill Shaft at 44 feet below. In the boring at Mingo it is apparently represented by a thin coal 52 feet below the Shaft Coal. The coal seam, which lies sixty-two and one-half feet above the Shaft Coal (No. 28 of the section) was passed in the Yocum well one-fourth of a mile south of Wills Creek. It is there two feet thick, and is sixty-one and one half feet above the main coal. South from this point it apparently runs out, or is replaced by heavy beds of sandstone, deposited by agencies which cut it away.

The second coal, below the main seam at Wills Creek, (No. 46 of section, 98 feet below the Shaft Coal, and said to be 5½ feet thick,) was passed in the Yocum Well 92 feet below the Shaft Coal—the seam between not appearing in the record—and is perhaps the lowest seam found in the "test well," 80 feet below the Shaft Coal.

The registers of McElroy's and Yocum's borings are essentially alike, except that the first coal under the main seam is apparently wanting in the latter, and a limestone is indicated at about its place. The coal was perhaps passed through but was too thin to be noticed.

When we attempt to co-ordinate the coals of Wills Creek and Steubenville with those of the northern part of the county, we find that the observations yet made are not sufficient to rid the subject of all doubt, and any conclusion reached must be regarded as provisional, until some farther explorations shall be made between Island Creek and Wills Creek. The chief and indeed only important question to be settled is in regard to the equivalency of the Shaft Coal at Steubenville, *i. e.*, which of the coals of the northern part of the county does this represent. In the open-burning character of the coal it furnishes, the Shaft Seam has most resemblance to Coal No. 7—the Salineville "Strip Vein," the Groff and Cumberland Coals, and like these it has at Steubenville no workable coal above it. Still the evidence has seemed to me stronger that it is Coal No. 6, the equivalent of the "Big Vein" of Linton and Salineville. This evidence is briefly as follows:—

1st. The intervals which separate the Pittsburgh Coal and the Crinoidal limestone from the Steubenville Seam, are greater than are anywhere else known to occur between these strata and Coal No. 7, the distance between the Steubenville Shaft Coal and Coal No. 8 being nowhere less than 500 feet, (502 to 560.)

2d. On Indian Creek a coal is worked which is there known as

"Fleming's" or "Finley's Coal." It is of good quality, and $3\frac{1}{2}$ to 4 feet in thickness. This has been generally and doubtless accurately identified with the Groff and Prentice Coals, and with the upper seam of Nebo and Salineville (Coal No. 7.) In all these places it is, like the shaft coal of Steubenville, the uppermost of the Lower Coal Group, *i. e.*, it is the next highest workable seam to the Pittsburgh Coal, but Fleming's Coal is 50 or 60 feet nearer the Crinoidal limestone than the shaft coal is, and it will be noticed that there are two little coals not far above it, the same that appear at Sloan's Station, and Wills Mine. Coming down across the blank space to Wills Creek, we find at the base of the Barren Measures, two small coals holding the same relation to a seam three feet thick there found near the creek level, and *sixty two feet above* the Shaft Coal. Going towards Steubenville, this 3 feet coal is found in the Yocum Well but 2 feet thick, and in the "test well" it has disappeared.

3d. The chemical composition of the Steubenville Shaft Coal is quite unlike that of No. 7, as that appears on Indian Creek, and Wills Creek, and Elliottsville—as will be seen from the tables of analyses given at the end of the chapter. The Shaft Coal contains only about one-fourth as much ash and sulphur as are found in No. 7. Hence, as mentioned above with our present knowledge of the subject it seems safer to consider the upper workable coal of Wills Creek as No. 7, and the Shaft Coal 60 or 70 feet below as Coal No. 6.

STEUBENVILLE.

At Steubenville, numerous shafts have been sunk to Coal No. 6, and it is extensively worked, both for home consumption and for exportation. Several furnaces and rolling mills have been erected here, and these, with the other manufactories, attracted by the abundance and excellence of the coal, have made Steubenville the industrial center of the county, as well as the center of population.

As has been stated the main coal passes beneath the river, just above the mouth of Wills Creek, and it is reached in the series of shafts that have been sunk to it along the river bank at a depth which rapidly increases southward in consequence of the southerly dip of the strata. At Cable & Co's. Shaft, above the mouth of Wills Creek, coal is reached at 75 feet from the surface. This is now abandoned, the quality of the coal being inferior. Between Wills Creek and the railroad bridge, is the shaft of the Jefferson Coal Co., called the Bastard Shaft, which is 80 feet deep. The coal is here 4 feet in thickness, but is said to be friable and sulphurous, and inferior in quality to the coal mined at Steubenville.

In the hill above the shaft a quarry has been opened in a stratum 32 feet in thickness of a light colored sandstone. This is of excellent quality and has been largely worked. In the "Stony Hollow" Shaft sunk for the Steubenville Coal and Mining Co., coal was reached at the depth of 187½ feet—109 feet below the railroad. The coal is 4½ feet in thickness and of good quality.

Fifty-four feet below the main seam is another coal 2½ feet in thickness, (Coal No. 5). The Market Street Shaft of the Steubenville Coal and Mining Co., is 225 feet deep, and the coal lies 23 feet lower than in the "Stony Hollow" Shaft. It is here 4 feet to 4 feet 8 inches in thickness, with a parting 14 inches above the bottom. The roof is gray slate, and it is underlain by fire-clay, said to be 9 feet in thickness, but containing much iron and of inferior quality. At the time the survey was made sixty miners were employed by the Steubenville Coal and Mining Co.; a considerable portion of the product of the mine was coked, though the greater part was sold in the city or to the railroad company; some of it was also shipped for use in rolling mills and gas works. The coke ovens used here are circular, 11 feet in diameter, and 5 feet high in the clear, arched from the bottom; the charge is 100 bushels of coal, and it is left in the oven 72 hours. To Mr. Jas. Blynn, former superintendent of all the works of the company, and to Mr. Wm. Smurthwaite, mining captain, we are indebted for much valuable assistance and information. In the mine which now connects the "Stony Hollow" and Market Street Shaft a thin coal is seen above the main seam. In the "Stony Hollow" Shaft it lies near to the main coal, and in the workings of the mine it has been found in contact and blending with it; going towards the Market Street Shaft, the seams diverge until they are 18 feet apart. In this mine a coal seam 4 feet thick has been found 44 feet below the main coal. It is probably the same as that found next below the main coal in the Wills Creek boring, and "Stony Hollow" shaft and the equivalent of the "Roger Vein" of the Yellow Creek Valley.

The shaft of the Steubenville Furnace & Iron Co., known as the Gravel Shaft, is 92 feet deep; the coal is 3 feet 10 inches thick, and of superior quality. It is coked for use in the new furnace of the company, and an analysis of the coke, made by Otto Wirth, of Pittsburgh, gave the following for its composition:

Water and hydrogen	0.72
Fixed carbon	90.63
Sulphur	.27
Ash	8.38
Total	100.00

This indicates a quality superior to that of the Connellsville coke, in which there is usually 1 per cent. of sulphur, and 10 to 14 per cent. of ash.

Eight or ten inches above the top of the coal, in this mine, is a band of impure coal six inches thick, containing roots of stigmaria. At a distance of twelve hundred feet from the shaft it joins the main seam, but separates from it again thirty feet further on.

At the Jefferson Iron Works (Spaulding, Woodward & Co.), the shaft is said by Mr. C. R. Thomson, superintendent of the mine, to be one hundred and eighty-seven feet seven inches to the coal. The coal is three feet eight inches in thickness, with a parting eight to nine inches from the bottom. At the time the examination was made, ninety-five hands, miners and putters, were employed inside the mine. Most of the coal raised was consumed in the extensive iron works of the proprietors. The fuel used in the furnaces is coke, one hundred and twenty ovens being in operation to produce it. These are circulars ten and a half feet in diameter, with thirty-six-inch spring of arch above wall, five and a half feet deep in clear under the ring. Charge: seventy-five bushels of coal, drawn after forty-eight hours burning, and yielding ninety-five bushels of coke. In the furnaces ninety bushels of coke are consumed to manufacture a ton of iron.

In the mine of the Jefferson Iron Company an effort has been made to drive galleries under the Ohio to reach coal lands on the other side. This has not been fully accomplished, but, in the judgment of the proprietors, all difficulties have been overcome, and no obstacles oppose the extension of their works as far eastward as may be deemed advisable. It should be said, however, that until the low lands on the east side of the river shall have been passed, it will not be demonstrated that no old channel exists deep enough to cut out the coal. It has been supposed that the old channel was here not less than one hundred and fifty feet deep, since the channels of some of the tributaries of the Ohio at points above Steubenville have been found cut to about that depth below the present streams; but the surface where these deep channels are known to occur is very much higher than at Steubenville, and consequently free drainage would be afforded to the tributaries above, even if the buried channel of the Ohio was not more than one hundred feet deep. At and below Cincinnati, borings have shown that the old channel is at least one hundred feet deep. This, taken in connection with the borings made on the Upper Allegheny and Beaver, have led to the inference that the old channel was from one hundred to one hundred and fifty feet deep at Steubenville, but the facts presented by the mine of the Jefferson Iron Company, if correctly reported, render it probable that the old channel is not much, if any, over one hundred feet in depth. The bottom of the Rolling Mill Shaft is about one hundred and twenty feet below low water mark in the Ohio. From this point parallel galleries eight yards apart have been driven two thousand two hundred and seventy feet in an easterly direction. For the first sixteen hundred feet the dip was found to be easterly, amounting at the bottom of the basin to twenty-two feet; thence the coal rises five or six feet to the end of the galleries. The deepest point in the workings is therefore about one hundred and forty feet below low water in the Ohio. The coal at the eastern end of the workings is four feet six inches thick. The exact position of the end at the galleries, with reference to the surface, was not determined, for they are now filled with water; but Mr. C. R. Thompson, to whose courtesy we owe the information given above, states that it is beyond the water surface of the present river. Should no deeper channel or excavation be met with, it will be easy to work from the Steubenville side the coal lying under the opposite highlands. As it has been proved by borings that the Steubenville shaft coal extends with undiminished thickness to the western border of the county, and as far south as Rush Run with greatly increased dimensions, it may be said to be demonstrated that a very large area, throughout which the shaft coal is continuous, is laid open and made accessible through the line of shafts now open along the Ohio.

Near the shaft of the Jefferson Iron Company are two others which present essentially the same features. These are the shafts of the Pennsylvania and Ohio Coal Company (Averick's), and that of the Cincinnati Coal and Coke Company (Swift's). Averick's shaft is two hundred and four feet deep, the coal four feet in thickness. Part of the product of the mine is coked. The ovens are of the prevailing fashion in this vicinity, are charged with one hundred bushels of coal, and burned seventy-two hours. The coke weighs forty pounds to the bushel.

Swift's shaft is two hundred and twenty-one feet to the coal, which is three feet nine inches to four feet in thickness, and of the same excellent quality with that in the neighboring mines. There is a parting of one inch of clay one foot from the bottom. The coal is mostly sent to Newport, Kentucky, and some of it is coked here and at Cincinnati.

At Mingo Junction the shaft is two hundred and thirty-four feet to the top of the coal. In the vicinity of the shaft the coal is twenty-eight inches in thickness, but the extension of the mine north-westward has shown the coal to increase to three feet, and there is little doubt that it will be found, at no great distance, to reach a thickness of four feet or more. The coal lies here a little higher than at Swift's, but it dips rapidly south again, and is some forty feet lower at Rush Run.

At Mingo the coal is chiefly used in the furnace, and is coked on the spot. Deep borings made at Mingo by J. C. Crane, Esq., show a workable coal seam three feet nine inches thick at the depth of one hundred and thirty-nine feet below the Shaft Coal. This is doubtless the same with that struck in boring on Cross Run, one hundred and forty-seven feet below the seam which is the equivalent of the Steubenville shaft coal. Just which of the Yellow Creek coals this lower one is cannot be certainly determined. It is more likely, however, to be the representative of Coals No. 3 or No. 4 than of No. 5, as has been suggested.

The coal is probably thinner at Mingo, because it originally accumulated on higher ground. We find in all our coal mines that the coal is thickest in the "swamps," and thin or wanting on the ridges. This means that it accumulated as peat in a bog, of which the bottom was irregular, and from which, in many cases, islands projected. Over these islands no coal was formed, but on their sides it reached up to the water line, perhaps fifty feet or more above the deepest portion of the marsh. When buried under clay and sand, and greatly compressed, the coal, into which the peat was converted, occupies perhaps not more than one-tenth of the space that the spongy peat did, but it will be found reaching from the bottom of the basin where the peat was, and the coal is now thickest over the shallows in diminished thickness, and up the slopes of islands or shores to the original water-line, where it terminates in a feather edge.

LA GRANGE.

At La Grange the La Grange Coal Co., of which Mr. John Lowe is manager, have sunk a shaft to the Coal No. 6. The shaft is 261 feet deep, beginning 87.56 feet above low water in the Ohio, or 43.58 feet above the grade of the Cleveland and Pittsburgh Railroad. By barometric measurement Coal No. 8 lies 333 feet above the railroad at La Grange, which would give for the distance between Coals Nos. 6 and 8, 550.42 feet. I am informed by Mr. Lowe that he had the distance measured by level some time since, and that it was found to be about 540 feet. The coal at La Grange is five feet three inches thick, divided into three benches by two slate partings of one inch each, respectively seven and twenty-eight inches above the bottom. The shaft at La Grange was sunk under the direction of Mr. Lowe, who was the pioneer in this mining enterprise, and one of the principal stockholders in the company. He is one of the best informed men in the county in regard to its geology, and we are indebted to him for much valuable information and assistance in the prosecution of the survey.

In sinking the La Grange shaft three thin seams of coal were cut. Of these two are twenty-two feet above the shaft seam, respectively seven and fifteen inches thick, separated by two feet of sandstone. These are regarded by Mr. Andrew Roy, State Inspector of Mines (report for 1876, p. 172) as the equivalent of the Mingo and Steubenville shaft coals, and as Coal No. 7, while the shaft coal of La Grange and Rush Run he considers the representative of the coal found forty-four feet below the main seam in the rolling-mill shaft at Steubenville, and this as Coal No. 6. For reasons given elsewhere, I am compelled to dissent from this opinion. In my judgment Coal No. 7 runs out just above Steubenville. The Shaft Coal at Steubenville, Mingo, and Rush Run is all the same seam, and Coal No. 6. The lowest coal in the Rolling Mill Shaft is probably Coal No. 5.*

The Pittsburgh seam, at La Grange, is about five feet thick, with a parting of slate, sometimes two, near middle. The coal works in large cubical blocks, resembling that mined at Pittsburgh in appearance and character, though containing a little more sulphur. An analysis of it will be found in the table at the end of the chapter.

RUSH RUN.

At Rush Run the Steubenville Shaft Coal has attained extraordinary dimensions, in some places being nine feet in thickness. It is, however, generally less, being but two feet thick in the highest part of the mine, and the average thickness would not be greater than seven to eight feet. The coal is divided by partings, and is less uniform in quality than the Steubenville coal. Some portions of the seam, however, closely resemble it, and there can be no reasonable doubt that they are geologically the same. We have reason to believe, also, that the Rush Run coal is the same with the Great Vein of the Hocking Valley region. This cannot be demonstrated because throughout all the interval between these two localities all the lower coal group are deeply-buried, but the Rush Run and Hocking Valley coals hold the same relative position to the Pittsburgh coal and the crinoidal limestone, which may be and have been traced through. The shaft by which the Rush Run coal is reached is 255 feet deep to the coal. It is owned by Messrs. Peck & Ramsay, who have now for several years carried on extensive and successful coal business.

* I am informed by Mr. Lowe that in a boring on Panther Run, about three miles south-east of La Grange, on the West Virginia side of the Ohio, the shaft coal was struck at a depth of 347 feet from the surface, and that 29 feet above high-water mark in the Ohio. The coal is there six feet ten inches in thickness. Two small seams were passed above it, one 160, the other 210 feet from the surface.

The Pittsburgh seam comes within easy reach of the river at La Grange, and thence southward is worked in a great number of localities, but generally only for local use. It is regarded as inferior to the Shaft coal being more cementing in character and containing more sulphur. It varies, however, considerably in quality, and in the valleys of Short Creek and other tributaries of the Ohio shows extended lines of outcrop, which, when the railroads traverse these valleys, will supply an unlimited quantity of excellent coal at very low rates.

TILTONVILLE.

At Tiltonville, two and a half miles south of Portland, the Pittsburgh coal is first mined commercially on the river. It is here five and a half feet thick, with a "rider" or roof of coal some two feet in thickness, separated from the lower bench by from six inches to one foot of clay shale. The roof coal is not mined. The quality of the Tiltonville coal is excellent. It has been coked at the Martinsville Blast Furnace, and the coke produced from it was very compact and silvery. No coke has, however, yet been manufactured from the Tiltonville coal except by way of experiment. The Pittsburgh seam at Tiltonville lies 185 feet above the railroad, and a well has been sunk to reach the Steubenville coal. This is said to have been found at the depth of 400 feet, and to have been only one foot in thickness.

The general geological structure of the western portion of the county has already been briefly sketched, but there are some facts of local interest in this section that remain to be noticed. In the highlands of the county the Pittsburgh coal is the only element in the geology that has any considerable economic value. This, as has been mentioned, is found in the hills about Knoxville, its extreme northern outcrop. It also occurs in detached areas in the southern part of Ross and the western sections of Island Creek townships. It is more generally present in Salem township, and is worked at Springfield, Richmond, etc. The coal is here very near the surface, having for cover only a little shale and earth. Half a mile east of Richmond, on the road to Steubenville, the outcrop of the Pittsburgh seam is visible, covered by the full thickness of its limestone; over this is shale, and forty-five feet above is seen the outcrop of a thin coal corresponding to that over the Pittsburgh seam, at Wintersville. In the vicinity of Salem the valleys are cut deeper, and the hills are composed of the Barren Measures. These contain two, and sometimes three seams of coal, which are always thin, but the lower one is locally and sparingly worked. This lies under the Crinoidal limestone, and is the

'Harlem seam" of Carroll county. Its best development is at Salem, where it is worked by Mr. J. S. A. Carter. It is only two feet in thickness, but of good quality. The section at Carter's mine is as follows:

		FT.	IN.
1.	Shale	40	..
2.	*Coal*, thin.		
3.	Shale	30	..
4.	Sandstone	2	.
5.	Crinoidal limestone	3	..
6.	*Coal*	..	6
7.	Shale	6	..
8.	*Coal 7b*	2	..
9.	Fire-clay	5	..

The dip is here one foot in one hundred toward the south-east.

At Wintersville the hill rises fifty to sixty feet above the Pittsburgh coal, which is reached in a shaft. The section here is as follows:

		FT.
1.	Earth	10
2.	Shale	20
3.	*Coal*	1
4.	Olive shale	24
5.	Hard purple limestone	15
6.	*Coal No.* 8, with its partings	7
7.	Fire-clay	1
8.	Limestone	2

The detailed section of the coal seam is—

1.	Roof coal	1 foot.
2.	Shale	1 foot six inches.
3.	Coal—top bench, best	2 feet 1 inch.
4.	"Bearing-in seam"	3 inches.
5.	"Brick coal"	1 foot.
6.	Bottom coal—poorest	14 inches to 18 inches.

Along the line of the Pittsburgh, Cincinnati & St. Louis Railroad the Pittsburgh coal is found in the hills all the way from Unionport to Alexandria road. At Unionport it makes its first appearance on the east side of the anticlinal, which passes northward through Harrison county. The section here is briefly as follows:

		FT.
1.	Concealed	20
2.	*Coal No.* 8, reported to be	5
3.	Slope imperfectly exposed	220
4.	Crinoidal limestone	3
5.	Shale and sandstone to railroad	70

At Bloomfield there are exposed—

		FT.	IN.
1.	Sandstone	40	..
2.	*Coal No. 7b*	1	3
3.	Sandstone to track	4	..

Near Bloomfield several borings have been made for oil, but no records have been kept. Many persons agree, however, in the statement that a coal seam two and one-half feet thick was passed through at a depth of about 180 feet, and another five feet thick at a depth of 260 feet. If the statement is true, these coals are doubtless Coals No. 7 and 6; the latter the Steubenville shaft coal.

At Southfield Station the Pittsburgh coal does not appear immediately on the railroad, but is seen about one mile north, where we have the following section.

		FT.
1.	Sandstone	35
2.	*Coal* No. 8.	
3.	Slope concealed	300

In the railroad cut, near Shelley's, are seen—

1.	Sandstone	20 feet.
2.	*Coal*	5 inches.
3.	Shale	8 feet.
4.	Impure limestone	2 to 3 feet.

One mile east of the station and half a mile north of the road, on the farm of Mr. Davis, a coal seam two and one-half feet thick is opened. This lies above the sandstone seen at Shelley's, and is probably Coal 7*b*.

Half a mile west of Gould's Station Coal No. 8 outcrops, and has been worked 332 feet above the railroad. Another opening nearer the station is 315 feet above the track.

At Mingo Junction a coal seam twenty inches in thickness is seen about twenty feet above the top of the shaft. This is one of the small coals, 7*a* or 7*b*, which lie about midway of the Barren Measures.

The following notes on the geology of the southern and western portions of the county have been furnished me by Prof. J. J. Stevenson:

Warren Township.—In this township *Coal No.* 8 is available in the hillsides on both Big and Little Short Creek, but owing to its altitude is opened at few localities. Near the junction of the two streams, it is two hundred and seventy-five feet above Short Creek, and at Portland it is nearly three hundred. The elevation above the stream diminishes toward the western line of the township to about two hundred and ten feet The hills are very steep, and the difficulty of constructing roads up their sides is so great that most persons prefer to obtain their coal from the few banks already in operation. At Mr. J. C. Pickens's opening we find it somewhat more than two hundred and sixty feet above the creek, and showing the following section:

1.	Roof *Coal*	2 feet to 2 feet 6 inches.
2.	Clay	2 feet.
3.	*Coal*	2 feet 6 inches.
4.	Parting	2½ inches.
5.	*Coal*	1 foot 2 inches.
6.	Parting	2 inches.
7.	*Coal*	1 foot 6 inches.
8.	Fire-clay	1 foot.
9.	Limestone	5 feet.

The coal is of very fair quality, and for the most part quite clean, but in No. 5, the "brick coal," nodules of pyrites occur, which weigh from twenty to fifty pounds. These are surrounded by soft coal, and are easily detached.

The same coal was worked at one time near the still-house on Little Short Creek, but the openings have long been deserted. The thickness is said to be not far from five feet. The limestone overlying the coal is about forty feet thick, and is sufficiently good in portions to be used as a flux. For this purpose it is quarried near Portland, and shipped thence to the furnaces at Steubenville and in the vicinity of Wheeling.

The strata above Coal No. 8 are not fully exposed at any locality within the township. On the ridge road from Portland to Mt. Pleasant, the following imperfect section was observed:

		FT.
1.	Shales, etc	50
2.	Coal No. 11	3
3.	Sandstones and shales, with some flaggy limestones	130
4.	Limestone, very imperfectly exposed	50
5.	*Coal No.* 8c—blossom only.	
6.	Sandstone, somewhat shaly	25
7.	Limestone—exposure imperfect	40
8.	*Coal No.* 8—blossom only	5

Below the coal the rocks are for the most part uninteresting. The section is as follows:

		FT.
1.	Coal No. 8.	
2.	Fire clay	3
3.	Limestone	3
4.	Shales and sandstones	50
5.	Limestone, somewhat conglomerate	4
6.	Shales and sandstone	160
7.	Crinoidal limestone	5
8.	Shales and sandstone to creek	50

The *limestone* (No. 5) is exposed in the roads along the hillsides. It is rudely conglomerate, bluish, and yields a good lime even when roughly burned. A limestone occupying this position is seen in the bank of Little Short Creek, not far from the Belmont county line. There it is imbeded in a mass of clay shale, not laminated, and occurs in three layers, fourteen, five, and four inches thick respectively, and separated by one to three feet of the shale. Below these about six feet is a thin, irregular layer of nodular ferruginous limestone, extending less than one hundred yards, and describing many odd curves.

The *shale* immediately overlying the Crinoidal limestone are black, and from seventy to eighty feet thick. Near the base they contain many impressions of *Neuropteris* and *Calamites*. At one locality a sandstone ten feet thick is seen twelve feet above the limestone, gray to reddish brown in color, of concretionary structure, and containing vast numbers of imperfect vegetable impressions. The *Crinoidal limestone* is occasionally seen in the hillsides along Short Creek, and many fragments are seen in the stream; but the bed does not reach the creek level until near the western side of the township. On Little Short Creek it is a prominent feature in the hills for a mile or more above the junction of the two streams, and finally passes under the creek near some ruined mills, between three and four miles from Portland. It is in three layers. The lowest, two feet thick, is quite compact, and crowded with plates, stems, and spines of crinoids, most of which belong to *Zeacrinus mucrospinus*, or to a closely allied species, together with many specimens of *Spirifer cameratus*, *Productus semireticulatus*, *P Nebrascensis*, *P. longispinus*, and *Chonetes Smithii*. This portion of the bed is very hard, and the fossils can not be separated. The upper layers are coarsely granular, and yield readily to the weather. They are blue, while the other is gray. On top, *Retzia punctulfera* and *Hemipronites* occur in fragments. The rock is too silicious to yield a good lime.

Mt. Pleasant Township.—Except in the immediate vicinity of Short Creek, the surface of this township is so elevated that Coal No. 8 is barely available. Upon the tributaries of that stream, however, it is readily accessible. The coal area, which the greater portion of the township, will be quite valuable in case an outlet for the coal should be afforded, for back from the creek to the southern line of the county there is hardly a ravine of sufficient depth to reach No. 8. Large plots, therefore, can be obtained almost entirely free from unsound coal, and with excellent opportunity for easy working.

In the south-eastern corner of the township, the old Wheeling plank road crosses Little Short Creek not far above where Coal No. 8 disappears under the stream. Along this road the following section was observed, which is very imperfect above, but fully exposed below:

		FT.
1.	Shales and sandstones, badly exposed	110
2.	*Coal*, blossom.	
3.	Sandstones, with some limestone	100
4.	Limestone and calcareous shale	60
5.	*Coal No.* 8*c*—shale, 2 feet; coal, 2 feet	4
6.	Sandstone	20
7.	Limestone	15
8.	*Coal No.* 8*a*	1
9.	Limestone and calcareous shale	30
10.	Shale	5
11.	*Coal No.* 8.	

In the little stream running by the plank road, Coal No. 8*c* has been taken out. The available thickness is about fourteen inches, and the coal is of moderately good quality, though much injured by numerous thin, slaty partings. The faces are covered by thin films of carbonate of lime.

Going north-west from Mt. Pleasant, on the Cadiz pike, we find the following section, which presents some interesting variations from the last:

		FT.
1.	Arenaceous shale	15
2.	*Coal No.* 12, blossom.	
3.	Arenaceous shale	50
4.	*Coal No.* 11, blossom	2(?)
5.	Concealed in part, but most sandstone, with occasional layers of flaggy limestone	115
6.	Limestone and calcareous shale	40
7.	Argillaceous shale	3
8.	*Coal No.* 8*c*, blossom	1
9.	Thinly laminated arenaceous shale	18
10.	Limestone, gray, ferruginous—weathers yellow	15
11.	*Coal No.* 8*a*, blossom	8
12.	Limestone and shale	18
13.	*Coal No.* 8	5

In these sections, Coal No. 8*b*, of the Belmont county section, which should overlie No. 7 of the first and No. 9 of the second, is absent, as is also Coal No. 9, which should rest on No. 4 and No. 6 of the two sections. It is well worthy of note that the limestone under Coal No. 9 has lost twenty feet of its thickness within three miles, while the interval between 8 and 8*c* has lessened about thirteen feet.

On Long Run, where the base of the last section is reached, Coal No. 8 has been mined quite extensively, but many of the openings have been deserted, or are now lying idle. In the banks of Messrs. Grubbs, Kithcart, and McKey, the main coal varies from five feet to five feet six inches, the clay from six inches to one foot, while the roof coal is said, at times, to reach three feet. The bank operated by Mr. Robert Dutton is regarded as yielding the best coal. It shows the following section:

1.	*Roof Coal*	6 inches to 1 foot.
2.	Clay	10 inches to 1 foot 3 inches.
3.	Slate	2 inches.
4.	Coal	2 feet 9 inches.
5.	Parting	½ inch.
6.	*Coal*	1 foot 2 inches.
7.	Parting	2 inches.
8.	*Coal*	1 foot.
9.	Fire-clay	3 feet 6 inches.
10.	Limestone	4 feet.

The roof coal is said to be very good. The upper pyrites band, so characteristic of the bed, is not persistent here, and occurs only occasionally four to eight inches from the top. Nodules of pyrites are common in the upper portion of No. 4, as well as in No. 8, where, also, a pyrites band, nearly one-half inch thick, is constant. Some portions of the bed are exceedingly rich in bitumen, there being layers several inches thick, which seem to consist of little else. Broken across the grain the fracture is clean and conchoidal, but when split with the grain, the surface is irregular. In the middle portion, the coal is rather open-burning, comes out beautifully in blocks, and contains many laminæ of vegetable charcoal. In the lower portion, films of carbonate of lime frequently occur on the faces. This is one of the prettiest coals in the county, and appears to be comparatively free from sulphur.

On the Smithfield road, there are several openings near Short Creek. In these the main coal is five feet to five feet four inches thick, and the roof coal is from six to twelve inches. The coal is not inferior to that obtained on Long Run. The bed is one hundred and sixty feet above the creek, and the section below is—

1.	*Coal No. 8.*	
2.	Fire-clay	3 feet.
3.	Limestone	3 "
4.	Shale	35 "
5.	Limestone	1 "
6.	Shales and sandstone to creek.	

Smithfield Township.—As in Mt. Pleasant, the surface here is elevated, the village of Smithfield being not far from six hundred feet above the Ohio River. Owing, however, to the regular rise of the strata northwestward, Coal No. 8 is available in a large portion of the township, being worked along the tributaries of Short Creek on the south and west sides, as well as on McIntyre's Creek on the north. Towards the western line the surface is lower than elsewhere, and the coal, though more easily accessible, is hardly so valuable as in the eastern portion, as the ravines cut down to the coal and break it into comparatively small areas.

The sections of the rocks overlying *Coal No.* 8, as seen in this township, are quite as interesting as those obtained in Mt. Pleasant. On the road leading from Short Creek to Smithfield the exposure is imperfect, except near the base. We find there—

1.	*Coal*, blossom.	
2.	Concealed	200 feet.
3.	*Coal No.* 8*c*, blossom.	
4.	Shaly sandstone	20 "
5.	Limestone	8 "
6.	*Coal No.* 8*a*, blossom.	
7.	Limestone	4 "
8.	Shale	6 "
9.	*Coal No.* 8, blossom	5 "

Here the interval between 8 and 8*c* again shows a marked diminution, having, in only three miles, decreased fourteen feet.

About two-thirds of a mile north from Smithfield, on the road to Steubenville, the following section is seen, its base being about four miles from the base of the last:

		FT.	IN.
1.	Arenaceous shale	15	..
2.	*Coal No.* 12, blossom.		
3.	Sandstone	50	..
4.	*Coal No.* 11	1	..
5.	Shales	20	..
6.	Limestone	5	..
7.	Shaly sandstone	20	..
8.	Limestone	8	..
9.	Shaly sandstone	25	..
10.	Limestone	6	..
11.	Shale	15	..
12.	*Coal No.* 10		..
13.	Shale and sandstone	60	..
14.	Limestone	6	..
15.	*Coal No.* 8*c*	1	..
16.	Shaly sandstone	8	..
17.	*Coal No.* 8*a*	..	6
18.	Limestone	4	..
19.	Shale	2	..
20.	*Coal No.* 8	5	..
21.	Fire-clay	3	..
22.	Limestone	1	..

In this important section, two things are worthy of note: First, that the interval between 8 and 8*c* has diminished, within four miles, from thirty-eight feet to less than fourteen, a difference of twenty-four feet; and, second, that the limestone above 8, the same which, in Belmont and Harrison counties, underlies *Coal No.* 9, is rapidly thinning out, having thus far decreased from sixty feet on Little Short Creek, to barely six feet at the locality of this section. If, now, we go to the western portion of the township, we find, about one-half mile north from York, the following section exposed in the road:

		FT.	IN.
1.	*Coal No.* 11, blossom.		
2.	Shaly sandstone and small slabs of limestone	60	..
3.	*Coal No.* 10, shaly and worthless	3	..
4.	Sandstone and shale	85	..
5.	*Coal*	1	6
6.	Shale	10	..
7.	*Coal No.* 8	4	6

Here all the limestones have disappeared, and the interval between *Coal No.* 8 and the sandstone under *Coal No.* 10 has been reduced to *ten feet*, while the sandstone under 10 has thickened from sixty feet in the previous section to eighty-five in this. It is somewhat difficult to assign the thin coal properly, but it seems to be *Coal No.* 9, as that coal occupies about that horizon in the adjoining portion of Harrison county.

Near Smithfield, *Coal No.* 8 is worked by Mr. Cope, at whose bank the bed is as follows:

		FT.	IN.
1.	Roof coal	1	..
2.	Clay	..	8
3.	Coal	4	7

The pyrites band is one foot from the top, and only one-fifth of an inch thick. There are no well-defined partings. The coal is very good. Near Wood's Mills, we find Mr. N. R. Wood's opening, which shows—

		FT.	IN.
1.	Roof coal	1	..
2.	Clay	1	..
3.	Coal	4	7

The roof coal is not very good, being more or less rotten. The main coal shows a parting two inches thick, nearly midway. Toward the bottom it contains large lenticular nodules of pyrites. The coal is very soft. Mr. J. Sutherland mines the same bed near the village, and delivers his coal on the Steubenville road by means of a whim. At his bank we find—

1.	Roof coal	1 foot.
2.	Clay	6 inches to 1 foot 3 inches.
3.	Coal	4 feet 8 inches to 5 feet 4 inches.

The partings are all present, and the pyrites band near the top is from one-third to two-thirds of an inch thick. Nodules of pyrites are not of frequent occurrence. The coal is of excellent quality, and this bank supplies most of the fuel used in the vicinity.

In the southern portion of the township, *Coal No.* 8 lies about one hundred and sixty feet above Short Creek, the fall of the creek being little more than that of the coal. Openings are few, and are worked only late in autumn to supply the wants of the owners. The bed averages about four feet nine inches. In the western portion, near York, we find—

1.	Coal	1 foot to 1 foot 2 inches.
2.	Clay	1 foot.
3.	Coal	4 feet 6 inches.

The coal is apparently of fair quality, but the openings are quite insignificant. At Mr. John Scott's bank, nearly two miles north from York, the coal is five feet thick, and Coal No. 9 (?) is only nine feet above it. No limestone is found in the interval.

At Adena the Crinoidal limestone is found in the bed af Short Creek. The section below the coal in this vicinity is—

		FT.	IN.
1.	Coal (No. 8)	4	6
2.	Limestone	2	..
3.	Shales and sandstone	110	..
4.	Limestone	2	..
5.	Shaly sandstone	35	..
6.	Crinoidal limestone	6	..

The Crinoidal limestone here is light gray and not very compact. It contains many fossils, which weather readily from the rock. The most common species are *Productus longispinus*, *Retzia punctilifera*, *Camarophoria Osagensis*, *Hemipronites crassus*, *Chonetes Smithii*, and fragments of *Zeacrinus mucrospinus*.

Wells Township.—Along the river in this township Coal No. 8 lies high up in the hills at from 260 to 340 feet above the grade of the Cleveland and Pittsburgh Railroad, and openings are seen on the several streams emptying into the river. On Rush Run it has been opened by several persons, all of whom mine it irregularly, and only to supply their own wants. At an opening belonging to Mr. Edwards, the bed shows the following:

Roof coal	5 feet.
Clay	1 "
Coal	5 "

The bank had fallen in near the mouth when visited, and preparation for winter work had not yet begun, so that detailed measurement could not be made. The thickness of the roof coal is given on the authority of Mr. Edwards, as at the bank only four feet could be seen. This expansion is extraordinary, no more than three feet having been observed at any other locality. The coal from both portions of the bed is said to be of very fair quality. In the same neighborhood the coal is worked by Messrs. Cusick & Caminski, and is about five feet thick, but the roof coal is much thinner than at Mr. Edwards' bank.

Two miles above these openings, No. *8a* is seen in the road, barely one foot thick. Near by is an old opening upon No. *8c*, which shows almost three and one-half feet of very fair coal.

In the extreme north-western portion of the township *Coal No.* 8 is mined by several persons residing on McIntyre's Creek. At Mr. Shackleford's bank the bed shows—

	FT.	IN.
1. Coal	1	..
2. Clay	1	..
3. Coal	4	6

This bank had partially fallen in, and no exact measurement could be made. The coal is much harder than in banks further up the stream. The "brick coal" contains many large nodules of pyrites, which, being in the "bearing-in bench," render the coal hard to dig. There appears to be a great deal of pyrites throughout the bed, as the coal slacks quite readily upon exposure. In Mr. J. Southerland's bank, near by, we find—

	FT.	IN.
1. Coal	1	..
2. Clay	2	..
3. Coal	4	6

The roof coal is quite good, and the clay is very regular, showing little variation in thickness. Lenticular masses of pyrites are not uncommon in the "brick coal," and weigh from one to thirty pounds. The pyrites band near the top is quite distinct. The coal is soft and easily mined. At Mr. Ezra Fell's opening the bed is—

	FT.	IN.
1. Roof coal	1	6
2. Clay	6	..
3. Coal	4	6

Lenticular nodules of pyrites occur here weighing from one to fifty pounds. The pyrites band is persistent, and the coal is easily mined.

The rocks between *Coal No.* 8 and the railroad level show little of interest. The Crinoidal Limestone was seen at several localities along the creeks emptying into the Ohio, and seems to hold a regular horizon about two hundred and twenty-five feet below No. 8. On McIntyre's Creek, a thin coal about six inches thick occurs nearly one hundred feet below that bed.

Near the mouth of Rush Run, Messrs. Peck & Rumsey mine *Coal No.* 6, by means of a shaft two hundred and sixty-eight feet deep. The coal is seven feet thick, including a roof coal of two feet, which is very poor and full of pyrites. Followed north-westward in the mine, this roof thins out and leaves five feet of good coal. Pyrites occurs throughout the bed in nodules, but is irregularly distributed. The lower bench is much softer than the upper. This coal yields a brilliant gas, but owing to the large percentage of sulphur, cannot be used profitably in gas manufacture. The slack makes a handsome but not compact coke. Fire-damp accumulates in the abandoned portions of this mine, but does not prove troublesome.

Wayne Township.—Here *Coal No.* 8 lies far up in the hills, while the general surface is rather lower than in Smithfield township. The average altitude of the coal above the Pan-Handle Railroad is probably not far from two hundred and sixty feet. It is worked near Bloomfield at various points along the road leading from Unionport to York. At Bloomfield the main coal is from four feet six inches to four feet nine inches, and the roof coal is about one foot thick.

About half a mile south from Unionport this coal is mined by Mr. J. Ferguson and Mr. S. Cannan. At a short distance from these openings, which are two hundred and ninety feet above Unionport, the following section is seen in the road:

1.	Partially exposed, chiefly sandstone with two layers of limestone	100 feet.	
2.	*Coal No.* 10, slaty and worthless	2 "	
3.	Arenaceous shale	69 "	
4.	*Coal No.* 8	4 "	3 inches.
5.	Fire-clay	1 "	
6.	Ferruginous limestone	1 "	

Here, then, the interval between 8 and 10 has been reduced to sixty feet, and the strata intervening between *Coal No.* 8 and the sandstone under *Coal No.* 10, have entirely disappeared, viz.: one hundred and fifteen feet of limestone, twenty-five of sandstone, and the included Coals No. 8*a* and 8*c*, all of which occur in Mt. Pleasant township.

In the section just given, *Coal No.* 8 appears to have no roof coal. At

Mr. Ferguson's opening, near Unionport, the main coal is from four feet two inches to four feet nine inches thick, roofed by one foot of clay shale, no roof coal being seen. The intimate structure of the bed is as follows:

		FT.	IN.
1.	*Coal*	1	2
2.	Parting	..	$\frac{3}{8}$
3.	*Coal*	6	..
4.	Parting	..	$\frac{1}{2}$
5.	*Coal*	..	$9\frac{1}{2}$
6.	Parting	..	$1\frac{1}{2}$
7.	*Coal*	1	1
8.	Parting	..	$\frac{1}{2}$
9.	Coal	2	..

The upper pyrites band is occasionally present at about ten inches from the roof, but it is not persistent. Nodules of pyrites are very common, and at times are very large. They are surrounded by soft coal and are easily separated. The coal is said to be of very good quality for domestic use. Southward, along the road to York, roof coal makes its appearance, and is covered by nine or ten feet of shale on which rests a thin coal, most probably *Coal No.* 9. At Mr. Voorhis's bank the main coal is five feet six inches, and the roof coal, eight to twelve inches thick. At Mr. Parker's opening the bed is—

1.	Roof coal	1 foot 6 inches.
2.	Clay	10 inches.
3.	Coal	5 feet 2 inches to 5 feet 6 inches.

The coal is good but pyrites is apt to be troublesome, as nodules occur five to eight inches in diameter.

Underlying the coal there are no rocks of interest until we reach the Crinoidal Limestone, which, in the northern portion of the township, is seen about two hundred feet below *Coal No.* 8. It may be seen cropping out at various localities along the railroad, but is best exposed, near Unionport on the road leading north from that station. It is about five feet thick, and contains great numbers of *Lophophyllum proliferum*, *Chonetes*, *Productus longispinus* and other species, all of them poorly preserved. From this locality two imperfect specimens of *Petalodus* were obtained. On the same road the blossom of a thin coal was observed two or three feet from the limestone. At several places along the railroad the blossoms of a very thin coal was seen, nearly three hundred feet below *Coal No.* 8. Near Bloomfield Station, some borings were made but no record was preserved. It is reported that two coals were cut, eighty feet apart, the upper two and one-half feet and the lower four feet thick. From their relations to each other, and to *Coal No.* 8 above, it is most probable that these are *Coals Nos.* 6 and 7.

Cross Creek Township.—In the greater portion of this township, *Coal No.*

8 is so high up in the hills that it is found usually in patches of from fifty to one hundred acres, only in a few instances much larger than the latter. North from the railroad the surface is elevated and broadly rolling, so that, excepting near the eastern portion of the township, the distance which one must pass through inferior or "crop" coal is so great that the expense deters many from opening banks. This cost of running a long adit could easily be saved in many instances, by sinking a shaft fifty or one hundred feet, as the case may be, from the outcrop, and thus reaching sound coal at once. In the great majority of cases the depth of such a shaft would not exceed fifteen feet, and the amount of water would be so small, that the increased cost of mining would be very slight. The area in which the coal is available does not extend far north from the road leading through the middle of the township from Smithfield Station to Steubenville. The exact limit cannot well be determined owing to the general character of the surface which is buried under debris, but there is reason to believe that only widely separated patches are found as far north as the road from Cross Creek Station to Steubenville. Along the other road the coal is usually seen at about sixty feet below the tops of the higher hills, there being only two instances of deeper covering. The section along this road is very clear, and can be verified at several localities, especially near the brick church and school house. Near the latter, where the highest ground is reached the section is as follows:

		FT.	IN.
1.	Shaly limestone with some flaggy limestone	40	..
2.	*Coal No.* 10, worthless	1	6
3.	Sandstone and arenaceous shale	60	..
4.	*Coal No.* 8	5	..
5.	Shale argillaceous, variegated	35	..
6.	Limestone, conglomerate	2	..

The distance between 8 and 10 is the same as that near Unionport. The limestone immediately underlying 8 elsewhere toward the south, is missing here, and at every other exposure along this line to Steubenville.

In this portion of the township there are many deserted banks, nearly all of which seem to have been abandoned because of the difficulty of drainage. The only one in operation is that belonging to the England heirs, which is situated very near the eastern line of the township. The full section of the coal here is—

1.	Roof coal	1 foot 2 inches.
2.	Clay	8 to 12 inches.
3.	*Coal*	1 foot 6 inches.
4.	Parting	$\frac{1}{8}$ inch.
5.	*Coal*	10 feet.

6.	Parting	½ inch.
7.	*Coal*	4 feet.
8.	Parting	½ inch.
9.	*Coal*	1 foot 4 inches.
10.	Parting	⅛ inch.
11.	*Coal*	1 foot.

This section is interesting in that it is one of the few obtained in this county presenting all the peculiar features of this bed as observed in other counties. The little "bearing-in bench," No. 7, is not ordinarily distinguishable in Jefferson county, though very characteristic elsewhere. At this opening, the pyrites band is quite persistent at from two to eight inches below the clay, and No. 10 is not infrequently composed of pyrites, in which case it is somewhat thicker than is given above. Nodules of pyrites are common in Nos. 3 and 11, and cannot always be separated easily. Horsebacks of fire-clay frequently come up from below, and sometimes cut out No. 11 wholly. The main clay parting, No. 2, thickens at the expense of No. 3, and sometimes contains streaks of coal. This bank is an important one, and is worked extensively to supply the neighborhood for several miles around. On McIntyre's Creek, near the southern line of the township, this coal is mined by Mr. Amos Hoagland, where the bed is—

1.	Roof coal	1 foot to 1 foot 6 inches.
2.	Clay	6 to 10 inches.
3.	Coal	4 feet 6 inches.

The coal is of good quality, but the "brick coal" contains many lenticular nodules of pyrites, some of them quite large. The pyrites band in the upper portion is not persistent, but a similar one, one-half inch thick, is constant at from eight to ten inches from the bottom. Along the line of the P. C. & St. L. Railway, this coal lies about three hundred feet above the track. The sharpness of the hills renders the work of constructing roads quite difficult, and no openings seem to have been made.

The limestone, thirty-five feet below the coal, is somewhat fossiliferous, and portions of it are crowded with minute univalves. It is sufficiently pure to be burned, and yields a good lime, even under careless treatment. The Crinoidal Limestone was seen only at one locality, and that almost directly on the eastern line. It is about two hundred and fifteen feet below *Coal No.* 8, and is gray and compact. It is too impure to yield lime. At nearly three hundred feet below *Coal No.* 8, blossom of coal was seen at two localities.

Steubenville Township.—Here, as in Cross Creek, *Coal No.* 8 is found only in the highest hills. These are quite abrupt, and the coal is difficult of access. Fortunately, near Steubenville, quite a large body of it has escaped erosion, so that a number of banks have been opened near each other to supply the city. The northern limit of the coal is on the south side of the pike, leading directly westward from the city. The full section obtained here, beginning at the coal banks, two miles from the Court House, and descending to the creek, is—

1.	Shales, including flaggy limestone	50 feet.
2.	*Coal No.* 10	1 "
3.	Shale and sandstone	60 "
4.	*Coal No.* 8	5 "
5.	Clay and shale	25 "
6.	Limestone	2 to 4 feet.
7.	Shales and flaggy sandstone	190 feet.
8.	Crinoidal limestone	4 to 6 feet.
9.	Shale	25 feet.
10.	*Coal*	1 foot to 1 foot 3 inches.
11.	Shale—argillaceous above, arenceous below	70 feet.
12.	Sandstone to level of creek	15 "

At Mingo, nearly five miles south from Steubenville, five feet of limestone were seen above *Coal No.* 8, but no limestone was seen at that horizon elsewhere.

At Mr. McCune's bank, the coal gives the following section:

		FT.	IN.
1.	Roof *coal*	3	..
2.	Clay	0 to 2	..
3.	*Coal*	2	6
4.	Parting	..	½
5.	*Coal*	..	3
6.	Parting	..	½
7.	*Coal*	1	3
8.	Parting		⅛
9.	Coal	1	2

The thickness of the roof coal is given on authority of Mr. McCune. It was not seen. Though not mined, it is said to be a good coal, but to leave a bulky white ash. No. 7 is a beautiful coal, burning very freely, with but little tendency to cake. For about one foot above the parting, No. 3 is equal to No. 7. No. 5 is very good, but soft, and is the "bearing-in bench." No. 9 is a fair coal, but is much inferior to other parts of the bed. It cakes readily, and its faces are coated with films of carbonate of lime. The upper pyrites band is persistent at twelve inches from the top, and No. 8 frequently carries pyrites. At Mr. Nelson's bank, which is not more than one hundred and fifty yards from the last, the bed shows—

		FT.	IN.
1.	Roof coal	..	6
2.	Clay	0 to 1	6
3.	Coal	5	..

This presents little difference from the other. Pyrites, as well as carbonate of lime, sometimes occurs in films upon the faces in the lower coal. These two openings are typical in character of those in this vicinity. The coal is a good gas coal and an excellent fuel, but for all purposes is regarded as inferior to that obtained from *Coal No.* 6, in the Steubenville shaft. The slack makes good coke in ovens, but burns too freely to coke in heaps. In several instances slack-heaps caught fire, and instead of coking were reduced to ashes. As there is too much sulphur in the coke to admit of its use in the manufacture of iron, the slack is not utilized. The coal is quite soft, and is mined by wedging. One man can take down and put out sixty-five bushels per day. At Mingo this bed is but four feet thick.

The limestone, twenty-five feet below the coal, is quite fossiliferous, containing many imperfect lamellibranchiates along with almost innumerable gasteropods. It is extensively used in the manufacture of lime. Attempts have been made to employ the Crinoidal Limestone for this purpose, but they have always been unsuccessful. The rock is very compact, and contains the characteristic grouping of species.

About twenty-five feet below the Crinoidal Limestone is a small coal, varying from twelve to fifteen inches in thickness. It is fully exposed on the road leading from Mr. Nelson's bank. Many years ago it was opened by Mr. Nelson's father, who found the coal very pure. It was much prized by blacksmiths in the vicinity, not only because it gave a quick, hot fire, but also because it was so remarkably clean. It is seen in several of the adjacent ravines, and shows little variation in thickness. It occupies the relative position belonging to *Coal No. 7b*, which is found in Harrison and Carroll counties, but was not seen elsewhere in Jefferson county.

The sandstone at the base of our section is quarried near Steubenville, and proves to be a very pretty, though rather soft, building stone.

Analyses of Coals of Jefferson County. By Prof. T. G. Wormley.

	Specific gravity.	Moisture.	Ash.	Volatile combustible matter.	Fixed carbon.	Sulphur.	Sulphur left in coke.	Sulphur forming of coke.	Fixed gas, cubic feet per lb.	Color of ash.	Coke.	Carbon.	Hydrogen.
Coal No. 3, Sloan's Station, bottom	1.283	2.00	5.75	34.20	58.05	5.71	2.22	......	3.63	Gray.	Comp.	......	......
" " middle	1.302	1.55	5.85	36.45	56.15	1.97	1.14	......	3.07	Dull white.	Comp.	......	......
" " top	1.328	1.25	9.45	32.25	57.05	1.93	.49	......	3.54	Dull white.	Comp.	......	......
Coal No. 4, Strip Vein, Irondale	1.320	1.20	12.20	31.60	55.00	2.36	1.20	1.78	3.24	Dull white.	Comp.	......	......
" " Hammondsville	1.333	.90	13.00	30.70	55.40	2.03	1.18	1.72	2.91	Gray.	Comp.	......	......
Coal No. 5, "Mud Vein," Croxon's Run	1.294	1.40	8.10	32.60	57.90	2.50	1.26	1.91	2.99	Dull white.	Comp.	......	......
" "Roger Vein," Elliotsville	1.300	1.00	7.00	31.60	60.40	2.60	1.37	2.01	3.15	Gray.	Comp.	......	......
Coal No. 6, Lower bench, Rush Run	1.373	1.90	4.60	31.30	62.20	2.06	.96	1.48	2.90	Gray.	Metal.	......	......
" Upper " "	1.315	1.40	4.80	32.20	60.60	2.08	1.12	1.72	3.40	Gray.	Metal.	......	......
" Lower " Linton, Big Vein	1.283	1.50	3.90	32.30	62.30	1.23	.69	1.03	3.64	Dull white.	Comp.	......	......
" Upper " " "	1.283	1.00	3.70	35.60	59.70	2.29	1.13	1.79	3.73	Gray.	Comp.	......	......
" Steubenville, Shaft coal	1.308	1.40	1.80	30.90	65.90	.98	.38	.56	3.26	Gray.	Comp.	......	......
" Lower bench, Lagrange*	1.284	1.81	3.76	39.21	53.96	1.26	......	......	3.90	White.	Metal.	......	......
" Upper " " *	1.284	1.77	1.65	38.73	57.21	.64	......	......	3.85	White.	Metal.	......	......
" Mingo Junction	......	2.00	4.80	34.60	38 60	2.20	......	......	......	......	......	......	......
Coal No. 7, Sloan's Station	1.323	1.70	6.70	32.30	59.30	3.90	2.08	3.16	......	Fawn.	Comp.	......	......
" H. F. Flemming's, Island Creek	1.363	1.50	7.50	31.90	59.10	5.35	3.40	5.11	3.24	Fawn.	Comp.	......	......
" New Cumberland Vein, Elliottsville	1.323	.90	7.20	31.10	60.80	5.49	2.60	3.82	3.15	Gray.	Comp.	......	......
Coal No. 8, Pittsburgh seam, Lagrange, Lower bench	1.301	1.50	4.00	37.10	57.40	2.99	1.10	1.73	3.15	Dull white.	Comp.	......	......
" " " Upper "	1.305	1.40	4.50	35.60	58.50	2.44	1.36	2.34	3.48	Gray.	Comp.	......	......
" " Winterville, Lower "	1.373	1.90	8.40	32.50	57.20	4.42	1.86	2.84	2.07	Gray.	Comp.	......	......
" " " Middle "	1.357	1.40	8.70	32.60	57.30	2.32	1.14	1.72	3.00	Gray.	Comp.	......	......
" " " Upper "	1.338	1.60	6.40	34.60	57.40	3.35	1.75	2.75	3.24	Gray.	Comp.	......	......
" " Richmond, Lower "	1.409	1.30	14.70	30.30	53.70	3.95	2.08	3.05	3.24	Gray.	Comp.	......	......
" " " Upper	1.342	1.60	6.10	33.80	58.50	4.06	2.06	3.19	3.07	Light br'n.	Comp.	......	......
Coal No. 7, ? 20 ft. shaft, Island Creek Township	1.282	2.85	7.80	30.35	59.00	4.31	2.67	3.85	3.29	Fawn.	Comp.	......	......
Cannel Coal, Upper seam, Taylor's bank, Brown's Station	......	3.50	26.90	27.30	42.30	......	......	......	......	......	......	......	......
" " Dobb's bank	......	3.20	44.20	21.40	31.20	......	......	......	......	......	......	......	......
Coke No. 4 Coal, Strip Vein, Irondale	......	......	12.00	......	......	1.56	......	......	......	......	......	85.97	.30
" No. 6 Coal, Big Vein, Collinwood	......	......	25.00	......	......	7.41	......	......	......	......	......	67.58	.23
No. 6, Shaft Coal, Mingo Junction	......	.04	7.38	......	......	1.97	......	......	......	......	......	91.28	1.30
" " Steubenville Iron Works	......	......	8.38	......	......	.27	......	......	......	......	......	90.63	.72

* Analysis by W. A. Hooker.

ANALYSES OF IRON ORES, LIMESTONES, AND FIRE-CLAYS OF JEFFERSON COUNTY. BY PROF. T. G. WORMLEY.

	Water.	Silicic acid.	Silicious matter.	Iron.	Iron sesquioxyd.	Iron carbonate.	Alumina.	Manganese.	Lime.	Lime phosphate.	Lime carbonate.	Magnesia.	Magnesia carbonate.	Fixed alkalies.	Sulphur.	Alumina and iron.	Metallic iron.	Phosphoric acid.	Specific gravity.
Iron ore—Oolitic ore, under Creek Vein, Irondale	6.69		28.96		19.20	36.96	trace	trace		1.10	2.83		2.95		1.00		31.20	.51	3.321
" " from clay of Coal No. 3, Newburgh	8.68		35.60		24.22	21.30	trace	trace		1.34	4.67		4.54		.17		27.24	.63	3.143
" Nodular, Barren Measures, Steubenv'e	2.40	15.84			75.27		2.00	.90			1.80		1.80				62.69	trace	3.423
" " below gray limestone, "			22.28								50.60						11.03		
" Vincent's, Sloan Station	7.40		76.56		7.00		4.10	.20		2.42	1.86		.22		.08		4.90	1.13	2.634
" Ferruginous limestone under Pittsb'gh Coal, Lagrange			18.20		34.06		7.74				28.60		11.05				23.85		
" Ferruginous limestone, under Coal No. 7, Island Creek			14.50		29.89		11.15				32.80		6.90				20.96		
Limestone—Under Rogers' Vein, Elliotsville			10.10								83.80		2.12			3.00			
" " Coal No. 8, near Pekin			6.60								89.30		1.59			2.40			
" Brecciated, under Coal No. 6, ? Steubenville			40.20								45.70		3.12			10.40			
" Over Pittsburgh Coal, used as flux, Steubenville			9.10								88		1.22			1.60			
Fire-clay—McFadden's Drift, under Coal No. 3, Sloan's	5.30	70.00		2.22			19.38		.15			.34		2.90					
McFadden & Carlisle, under Coal No. 3, Sloan's	9.35	57.25		1.94			28.66		.15			.24		2.55					
" Rock "No. 4," under Coal No. 3, Elliotsville	4.10	77.65			3.32		12.78		.55			.45		1.30					
" Rock "No. 5," under Coal No. 3, Elliotsville	8.55	59.20			2.70		26.10		1.05			.75		1.53					
" Silica clay, 8 ft., ? Elliotsville	5.40	66.75			4.25		19.35		.65			1.00		2.05					
" Clay No. 13, 50 ft. above New Cumberland Coal, Elliotsville	12.70	44.75			6.30		16.62		11.65			3.87		3.17					
" Bottom part under Coal No. 3, Sloan's Station	6.40	62.90			trace		25.90		.55			.53		3.50					
" Top part under Coal No. 3, Sloan's Station	8.60	56.60			trace		29 00		.95			.78		3 67					
" Under Coal No. 3, McCoy's Station	4.50	65.40			2.00		24.20		.80			.54		2.30					
" Between Coals 6 and 7, Elliotsville	6.70	63.80			.80		26.60		.80			.36		.60					
" Under Coal No. 3, Croxon's Run	8.70	58.10			1.20		29.60		.40			.54		1.75					

CHAPTER LXXXVII.

REPORT ON THE GEOLOGY OF MAHONING COUNTY.

BY J. S. NEWBERRY.

SURFACE FEATURES.

Viewed as a whole, the surface of Mahoning county may be regarded as an undulating plain, sloping gently to the north, its southern line running on or near the divide between the waters of the Mahoning on the north and the Little Beaver on the south, and having an altitude of from three to five hundred feet above the valleys of the north border. Topographically, the county forms a portion of the highland of the southern rim of the lake basin, but since this rim is cut through by the deep gorge of the Mahoning, the drainage, though locally northward, is all carried through that channel into the Ohio. But little of the surface is even locally level, but consists of an alternation of broad valleys of excavation, separated by rounded hills and tablelands, with gentle slopes. It is all varied and picturesque, while at the same time it is well adapted to agricultural purposes, and is now very generally in a high state of cultivation. The soil is in some places derived from the decomposition of the underlying rocks; but it, for the most part, rests upon a sheet of Drift material, for the county lies within the Drift area, though reaching its margin on the south. The general slope of the surface, and part of the local erosion, seem to have been produced by the southern extension of a tongue or lobe of the great glacier, which, moving from the north, excavated the low country that lies between the highlands of Geauga and Portage on the west, and those of Pennsylvania on the east. By this agent the northern outcrops of the rocks which underlie the country have been ground away, and a large amount of material transported southward from its place of origin. As the eroded rocks were largely sandstone and Conglomerate, much of the transported material is gravel and sand; while a part, produced by the erosion of the shales of the Waverly and Erie in Trumbull and Ashtabula, is clay. On the whole, the soil, from the causes mentioned, is much lighter than that of the two counties named, and the sheet of Drift material is thinner and less regular in its distribution.

Glacial marks are seen on the exposed surfaces of the harder rocks in nearly all parts of the county, and they are specially noticeable on the sandstone ledges on the south-east side of the Mahoning, in Youngstown and Poland, and on the higher strata of the same character in the southern part of Canfield and Ellsworth. The direction of the glacial scratches is nearly north and south; but they are sometimes deflected by local impediments a few degrees either east or west.

One of the most interesting features in the surface geology of Mahoning county, is the deep erosion of the valley of the Mahoning. In Trumbull county the river flows through a gently undulating country, and its banks are so low that it can hardly be said to have a well-defined valley. This is due to the general prevalence of soft, shaly rocks which have been broadly and evenly eroded. Soon after entering Mahoning county the river encounters the Conglomerate and the heavy-bedded sandstones that overlie the lowest coal. These form bold bluffs which gradually approach, until at Lowell the valley is quite narrow, and about three hundred feet deep. It has at one time, however, been still deeper, for the search for oil, which has been made at numerous points between Youngstown and Newcastle, has shown that in this interval the river is now running considerably above its ancient bed. At the State line it was found necessary to sink through eighty feet of sand and gravel in the old channel before solid rock was reached; and in some wells, near the junction of the Mahoning and Chenango, pipe was driven one hundred and forty feet to the rock. These facts were among the first observed of those which led to the discovery that our principal rivers were once flowing at a lower level, when the continent was higher than now; a subject which is treated at length in the chapter on Surface Geology, which forms the introduction to Vol. II of this report. The valley of the Mahoning, which is evidently excavated from the solid rock, must have been cut out when the drainage southward was much freer than at present, and this seems to have been one of the channels through which the lake basin, filled to a much higher level than now with water, communicated with the Ohio, and thus with the Gulf. The fact that rock is frequently seen in the bottom of the river does not conflict with the statements made above, for the stream does not follow the line of its ancient bed; but when the old channel was filled, and the work of excavation began again, the course of the river often crossed projections from the sides of the valley, and in these places has a rock bottom. The borings to which reference has been made prove that there is a continuous, deeply-excavated trough running beneath the bottom lands of the valley.

GEOLOGICAL STRUCTURE.

The rocks which underlie Mahoning county all belong to the Carboniferous System. They include exposures of the Waverly at base, the Conglomerate, and all the lower group of coal seams, except the uppermost, No. 7, with their associated sandstones, shales, limestones, fireclays, and iron ore. The dip of all the strata is toward the south-east, from ten to twenty feet to the mile; and, as a consequence, the outcrops of the different members of the series form irregular belts conforming to the topography, but having a general east and west direction, the outcrops of the rocks, which are lowest geographically, being lowest topo graphically, and found on the northern margin of the county, while the highest cap the hills along the southern boundary.

WAVERLY GROUP.

This consist of a series of shales and sandstones of which the entire thickness is from four to five hundred feet. In the counties futher north where better exposed, this formation is seen to be composed of a number of sub-divisions which have received distinct names, viz., the Cuyahoga shale, the Berea grit, the Bedford shale, and the Cleveland shale; the latter resting upon the Erie shale, which form the lake shore and underlie the surface throughout a large part of Ashtabula county. The only portion of the Waverly Group exposed in Mahoning county is the Cuyahoga shale, which is excavated to form the bed of the Mahoning River from Niles to the State Line. Not more than fifty or sixty feet of the formation is any where shown. This consists of yellow or olive argillaceous shales with beds of laminated sandstone. It contains few fossils here, and is rarely hard enough to serve as a building stone. As a consequence it has no interest or value except as it forms the "bottom rock" reached in many of the borings for coal, and therefore serves an important purpose in limiting the search, as it is well known that no coal can be found below or in it.

The extensive explorations for coal made in Mahoning county show that the Waverly rocks for a long time formed the surface, and were extensively eroded before the deposition of the next succeeding rock, the Conglomerate. Hence its upper surface is very irregular, showing hills and valleys over which the Conglomerate and Coal Measures were deposited; sometimes in local depressions with Waverly borders, so that both are found at a lower level than adjacent outcrops of Waverly rock.

This has produced much confusion in the search for coal; but all the drillers have noticed that the surface of the Waverly is reached at various depths, and that hills of "bottom rock" cut out the coal. In such cases the coal was never formed on these hills, but accumlated in lower ground surrounding them as a bed of peat that reach to a limited distance up their side. When subsequently covered by clay, sand, and gravel, the peat was compressed to perhaps one-fourth part of its original thickness, and formed a bed of coal five or six feet thick in the bottom of the basin, and running to a thin edge at the original water level. These irregularities in the surface of the Waverly have been sometimes attributed to disturbances and upheavals, but if they were folds in the strata the coal would be carried up with the Waverly; but since we find the Waverly hills composed of undisturbed and nearly horizontal layers, and the coal not reaching the tops of the higher ones, we must conclude that they are the result of erosion, and that before the deposition of the coal the surface was worn into hills and valleys much as now.

CONGLOMERATE.

Probably but little of the area of Mahoning county is underlain by the Conglomerate. Patches of it are found in the northwestern corner, and these may extend for a long distance southward; but the great sheet of Conglomerate which occupies Geauga and the northern part of Portage county, thins out rapidly toward the east, and between Niles and the State line it either does not exist, or is represented by a thin bed of sandstone without pebbles.

COAL NO. 1.

This is the seam which furnishes the famous Briar Hill or Mahoning coal, so extensively used for iron smelting, and widely distributed through the markets of the northwest. It is the same seam that is so largely worked in western Pennsylvania, at Sharon, Greenfield, etc., and shipped to Erie under the name of the Ormsby coal. The true position of this coal seam is from twenty to fifty feet above the Conglomerate, the interval being filled with shale, sandstone, and fire-clay. In Summit and Stark counties, where the same strata are exposed as those which form the banks of Mahoning at and below Youngstown, and were the Conglomerate is generally from fifty to one hundred feet in thickness, the position of Coal No. 1 is clearly shown and is always seen to be that described above. In Mahoning county where the Conglomerate is often absent form the series, and the Waverly rocks were extensively eroded before the formation of the coal, the succession is less apparent and has been sometimes misunderstood. The true reading of the geology of this region is, however, briefly stated in the notes already given on the Waverly.

As is now generally known, Coal No. 1 occupies a series of limited and sometimes disconnected basins which are separated by intervals of barren territory. The absence of coal from these latter areas seems to be due to two causes; first, its accumulation in narrow basins and channels; and second, its partial removal by surface erosion. The first of these causes is probably the chief one, as it is plain that the carbonaceous material which now forms the coal seam was once peat which accumulated in certain local depressions of the surface. These doubtless resembled the peat swamps of the present day, and all who have examined them know that they are sometimes broad basins many miles in extent, and sometimes they fill long and narrow valleys traversed by sluggish streams. At the time when the lowest coal seam in northern Ohio was formed, the surface had been for some time exposed to sub-aerial erosion, and in Mahoning and Trumbull counties was quite irregular. Subsequently the drainage which excavated the valleys seems to have been checked, and the lower portions of the surface became marshes. Here peat formed in some instances to the depth of fifty or sixty feet, and covering the minor irregularities of the surface below the water line with a sheet of spongy carbonaceous matter varying in thickness with the depth. The highlands between the marshes and any points or islands which rose above the highest water line were not covered by it. After the lapse of many centuries, during which the conditions of the surface remained as described, this region subsided and was overflowed with water. The inundation was at first quiet, and comparatively still water covered all the peat marshes, destroying the vegetation which grew there and formed the coal, and depositing over all the submerged area a fine clay sediment, which, compressed and consolidated, we now call shale. Naturally the weight of this sediment compressed the spongy peat, and caused a marked subsidence of the material over it in the deepest parts of the basin. Hence we find the strata of coal and shale dipping from all sides downward toward these points, and the coal terminating in a feather edge along the old water line. At a later date, strong currents of water swept over the surface, locally cutting away both clay and peat, and depositing over all a thick bed of sand, now sandstone. In a few places gravel was mingled with the sand, and the sandstone becomes locally a conglomerate, which has sometimes been mistaken for the true conglomerate below.

The quality of the Mahoning Valley Coal is so excellent, and th coal field lies so near the great lake market, that it has become the basis of an extensive commerce, and the mainspring of the most important iron industry of the west. Hence the land which holds the coal has acquired great value, and workable deposits have been sought with avidity through many years. From the fact that the basins which holds the coal are so narrow and few, much of the exploration made has resulted in disappointment; but such explorations have borne this fruit, that they have made the details of the local geology of Mahoning Valley better known than that of any other district in the State, and they have enabled us to trace the outlines of the productive coal areas and the barren intervals, with a degree of accuracy which would otherwise have been impossible. Since most of the coal basins are completely buried, and show no lines of outcrop, the search for coal has for the most part been conducted by boring. By this means the northern part of the county has been, not thoroughly, but generally explored. Though much yet remains to be learned in regard to the connections between the different coal basins, they seem to lie somewhat in belts which have a general direction a little east of north and west of south. For example, the Mineral Ridge belt of mines extends from Warner & Co's. slope in Weathersfield, to the southern part of Austintown, and includes the mines of the Cambria Coal Co., Todd & Wells Coal Co., Baldwin Bros. Harris, Maury & Co., and the Harroff Coal Co. A similar belt of mines extends from Vienna through Liberty township, Trumbull county, and in Youngstown includes the Brier Hill mines and those of the Powers Coal Co., the Mahoning Coal Co., the Foster Coal Co., the Kyle Coal Co., etc. There is another line of mines along the west side of Youngstown township, reaching into Coitsville. This includes the slopes and shafts of Andrews & Hitchcock, Arms, Powers & Co., the Holland Coal Co., and the Andrews and Powers mines south of the Mahoning. Between these belts there is much territory, which, up to the present time, has seemed barren, but it is possible that future explorations will prove the existence of valuable coal basins in the districts that are now regarded as unproductive; and will also show that the linear arrangement of the mines which has been referred to is merely accidental.

Within the limits of the productive territory the coal basins have been shown by the explorations and workings to form comparatively narrow, irregular and often branching channels, such as would be produced by the growth of peat in the excavated valleys of streams, if such streams were dammed up, and their waters made to form marshes. How far the basins now known are connected remains to be shown by future exploration, but there is little doubt that most of them form parts of continuous drainage lines, though these may have been partly filled up, and their connections obliterated before the peat was formed that subsequently became coal. The connecting links may also have been in places removed by the erosion to which the surface was subjected, subsequen to the formation of the coal bed, and when the overlying sandstone was deposited. The future working of the mines in the Mahoning Valley, will doubtless throw much light upon this subject. Maps have been procured of most of the basins which have been worked, and these with such others as may be hereafter obtained, will be laid down on the general map of the Mahoning Valley coal field which is to accompany a report that will form part of the volume on Economic Geology.

The peculiar valley-like character of some of the basins is well illustrated by that in which the Foster and Kyle shafts are located in the southern part of Youngstown. This has all the characters of some of the peat-filled valleys which may be seen in the northern counties of Ohio at the present time; and in this basin the drainage would seem to have been westward, as the coal lies lower, and in a broader trough at the shaft of the Foster Coal Co. than at the Kyle shaft.

It is hardly necessary to say that the old valleys, if such they are, which now hold the coal, have no relation to the present surface, since they were buried under many hundred feet of strata of various kinds, and the present surface is altogether the result of modern erosion. Hence, the only methods of explorations of untested territory are by boring, and by following the "swamps" wherever they may lead in the basins that are worked. It is also true that no surface indications have any value as guides, for the discovery of unknown basins below, and from the narrowness of many of the coal deposits no territory can be regarded as fairly tested until it has been pierced with numerous holes. This gives encouragement to hope that in the large area within the country which *may* hold Coal No. 1, many valuable coal basins will yet be found; and the experience of the past, as well as the general knowledge we have of the circumstances which have affected the distribution of the coal, point to the inference that new basins will, from time to time, be discovered through many years; and that the exhaustion of the coal deposits of the Mahoning Valley, which has been so often predicted, is not likely to occur at any near period.

The question of the extension southward of the series of coal basins which underlie the northern townships of the county, is one of great practical importance, and one in regard to which there is considerable diversity of opinion. It is held by some who have given considerable attention to the subject that all the important deposits of Coal No. 1

are confined to the northern margin of the great Allegheny coal-field; and in support of this view the fact has been cited, that no coal of workable thickness has been found in many borings that have been made for oil or coal in the counties that lie south and east of those where Coal No. 1 is mined; but no facts yet known can justify any very positive assertion on this subject. It is true that a great number of borings have been made in the interior of the coal-field which have passed below the horizon of Coal No. 1, without striking any workable coal; but it is also true that coal of good thickness has been reached at a few points far south of the outcrops of Coal No. 1, and that at depths which make it almost certain that this was the seam struck. For example, Dr. J. A. Dales reached a workable seam of coal at Limaville, just south of the line of Portage county, at the depth of about one hundred and seventy feet from the surface. This coal is said to have a thickness of four feet, and analyses made of the borings, preserved by Dr. Dales, show the coal to have the peculiar chemical and physical characters of that of the Mahoning Valley. If the facts in reference to this exploration are correctly reported, they afford almost demonstrative evidence of the existence in that region of a basin of Coal No. 1.

A boring made by Mr. Sheets, of Palestine, on Bull Creek, near Achor, is stated by him to have passed through a coal seam of workable thickness 166 feet below the bottom of the valley. Here again, if the facts are as stated, we have evidence of the presence of Coal No. 1, in a workable bed far south of any mine yet opened on it. In the valley of the Little Beaver, below New Lisbon, Mr. H. C. Bowman had borings made which passed through a thin coal seam about the place of Coal No 1; and a workable coal is reported as passed through one hundred and forty feet below the surface of the Ohio, in some of the oil wells at Smith's Ferry. On the other hand, a very large number of borings made for oil or gas in the valley of the Ohio, south of Mahoning county, have given no evidence of the presence of a workable coal seam below drainage. Hence we must conclude that Coal No. 1, is at least often absent from its proper place in the interior of the coal-field; but no facts yet known afford proof that there are no valuable basins of it much farther south than any yet worked. The borings made for oil, which would seem to have tested so perfectly some portions of the territory, rarely afford any reliable information in regard to the details of the strata passed through. They are generally bored with a rope drill, and with a special and single object in view, viz, to strike oil; and every thing else is usually neglected. Again, if the borings made in the interior of the coal-field, had been carefully conducted, they are too few in number to settle this important question. It is probably not an exaggeration to say that of the drillings made for coal in Mahoning county, not more than one in ten has passed through coal of workable thickness, and yet it is certain that here are valuable basins of the block coal, for many of them are known and worked; and it is highly probable that in the districts most thoroughly explored, there still remain important deposits of coal to be discovered. Hence we may conclude that many years must elapse before the important question of the southward extension of the coal basins of the Mahoning Valley can be satisfactorily answered. There is now a general feeling of doubt as to the presence of the Briar Hill Coal under the central and southern portions of Mahoning county, and as the borings made to reach the coal must go deeper and deeper as they are carried southward, and even if the coal area were extensive here as farther north, a large majority of the holes bored must prove unsuccessful, the work of exploring this region must necessarily be slow and expensive. It is, however, highly probable that ultimately some valuable deposits of block coal will be found south of any yet known; at least the probability seems sufficient to encourage those who have machinery in position or other facilities for boring cheaply to make farther explorations in search of the Lower Coal under the southern half of the county. Such efforts with the careful tracing southward of the basins that are now known, or may hereafter be discovered, will gradually and surely work out the solution of the problem.

The quality of the coal obtained from the lower seam in the Mahoning Valley has now been so fully demonstrated and understood that words would be wasted in its praise. It has been shown by a great number of analyses, and by long and varied trials, to be one of the purest and most valuable coals known in the world. Its open-burning character, its comparative freedom from sulphur, and the small amount of ash it contains, especially fit it for the smelting of iron, of which, if properly managed, it gives a product scarcely inferior in quality to that obtained with the use of charcoal. Bessemer pig and car-wheel iron are constantly made with it, which can hardly be said of any other coal. It has also been largely used for forge and mill purposes, but this has been to a degree a sacrifice, since cheaper coals would have served these purposes nearly as well. The interests of the iron manufacturers of the Mahoning Valley would probably have been best served in the past, as they will be in the future, by using the block coal only for smelting.

Coal No. 1 is found in all the northern tier of townships, but is not worked in Milton and Jackson. South of this line of townships little exploration has been made that can be regarded as reliable. A well bored for oil many years since, on Indian Creek, nearly east of the center of Canfield, is said to have passed through a workable coal seam, one hundred and sixty feet below the surface. It is also reported that on the Kirkpatrick farm, in the northern part of Ellsworth, a boring was made through the Blue Limestone and Coal No. 3 one hundred and fifty feet to the block coal, there three feet two inches in thickness. Two borings have recently been made in the northwestern corner of Beaver township, expressly for the Lower Coal, in one of which it was found eighteen inches thick, and in the other, some two hundred yards distant, it was wanting. Some other holes have been drilled in the southern part of the county, but it has not been possible to obtain any reliable information in regard to them. Considering the number of unsuccessful efforts made to find the coal in the townships where the most important basins are now known to exist, it cannot be said that any considerable portion of the southern half of the county has been tested for the Lower Coal; indeed, for anything yet known to the contrary, there may be as many and as valuable coal basins in the southern as in the northern portion of the county.

BLACKBAND IRON ORE.

Over a considerable area in the southern part of Weathersfield, in Trumbull county, and the north-western part of Austintown, in Mahoning—the Mineral Ridge belt—Coal No. 1 is accompanied with a stratum of blackband iron ore of good quality, which has been worked for many years, and has proved an important element in the economic resources of the Mahoning Valley. This iron ore is the upper part of a stratum of bituminous shale, highly charged with iron, and is clearly the carbonaceous mud that was deposited in a lake or body of open water which occupied a considerable portion of the area of one of the most important coal basins of this region. Usually the iron ore forms a continuous sheet from six to ten inches in thickness, capping a band of black shale two feet thick, both of which divide the coal seam into two benches. The lower bench, usually from one to two feet thick, is typical block coal of excellent quality; the upper bench, from two and a half to three feet thick, is considerably unlike most of the Mahoning Valley coal, breaking with more irregular fracture, having a pitchy luster and containing considerable more bitumen. These differences led to the impression that the Mineral Ridge coal was a different seam from that mined in the Mahoning Valley; and it was for a long time known as the "Blackband coal." Abundant evidence has, however, been gained that they are essentially the same, though it is quite possible that the lower bench in the Mineral Ridge coal is the only representative of the block coal, while the upper bench, accumulated a little later, and only in the district where it is found. That the blackband ore and its associated black shale were deposited in a lagoon or lake in the coal marsh, is proved by the great numbers of bivalve crustaceans, (*Estheria*) found in it. Similar fossils usually accompany blackband ore and and are regarded as quite decisive as to its mode of formation.

The history of the deposit of the Mineral Ridge coal seems to have been something as follows: A broad and shallow basin was for a time occupied by a sheet of vegetation from which a stratum of peat of limited thickness was formed. This, from the nature of the vegetation, or the prevalent physical conditions, produced an open-burning or block coal. When the growth of peat was sufficient to produce from one to two feet of coal, the basin was flooded with water, and at least a part of it became a lake. In this lake a carbonaceous mud was slowly deposited, and when two feet in thickness, iron began to be precipitated with it in considerable quantity. This formed the stratum of blackband ore. Subsequently the lagoon was invaded and occupied by vegetation, and a thicker bed of peat than the first was accumulated over its surface; this second peat bed—probably from its more constant saturation or submersion in water—produced a more homogeneous and bituminous coal, the thicker upper bench. The causes which operated to produce the deposit of iron in this lagoon, were probably the shallowing of the water, its more complete evaporation, and thus the deposition of the iron which before flowed away in solution as a part of the freer drainage. In a similar manner we find the limestones of the Coal Measures, which were certainly deposited in open bodies of water, generally capped with a stratum of iron ore; and we can plainly see that this was the last deposit in each of the water basins as it was disappearing. The accumulation of iron in our lakes and bogs at the present day is apparently produced in a similar way, although this is usually precipitated in the condition of limonite, the hydrated sesquioxide, because of the absence of carbonaceous matter.

BOWLDERS IN BLACKBAND AND COAL.

Some years since I found in the blackband at the Weathersfield shaft an irregular, angular fragment of talcose slate. This had evidently been dropped into the carbonaceous mud, and, I have conjectured, from the roots of a floating tree where it had been entangled. No rock of this kind is found in place in Ohio, and the specimen is not rounded like a Drift pebble, it therefore seems probable that it was floated from the

Canadian highlands where such rock occurs, down the current of some stream which drained into the marshes of what is now the north end of the great Allegheny coal-field.

A rounded bowlder of quartzite about five inches in diameter, was found buried in the block coal at the Foster shaft. Half of this has been presented to me by Mr. C. H. Andrews, of Youngstown. The material is a reddish, fine-grained congolmerate, metamorphosed into a dense quartzite. It was once smoothly rounded by attrition, and is evidently a bowlder from some stream bed or sea beach. No similar rock has up to the present time been found among the pebbles of the Drift or the Carboniferous conglomerate, and it has apparantly been derived from a different source. It resembles some of the metamorphic conglomerates of the Huronian in Canada and Lower Silurian of the Allegheny Belt. It is quite possible that it came from some parts of the Blue Ridge, which, as we know, formed a line of shore east of the Allegheny coal-field, before the more modern folds of the Alleghenies were raised. A careful comparison of this specimen with the metamorphosed conglomerates of Canada and the Allegheny Belt will perhaps enable us to determine its place of origin. In the general submergence which resulted in the deposition of the sediments which overlie the coal, the transportation of a block of foreign rock would seem to be a not improbable event, but as a matter of fact no such bowlders have yet been found in the shales or sandstones, and their occurence in the coal would lead to the conclusion that they were brought by the streams that drained the country while the coal was still forming. A larger bowlder of *gray* quartzite was found resting upon, partially imbedded in Coal No. 6, at Zaleski, and is referred to on page seventy-eight of our Report of Progress for 1870.

The chemical composition of Coal No. 1 may be seen by reference to the table of analyses at the close of this chapter. Its remarkable purity is only one of the good qualities which adapt it to the manufacture of iron. Its open-burning nature, which permits its use in the raw state, is another and no less important excellence which it possesses. This latter quality is quite independent of its chemical composition, and seems to be due to its physical structure. Many coals which have a larger percentage of carbon and less bitumen—such as the Cumberland and Blossburg coals—are still conspicuously caking in character. The chief reason why the Brier Hill coal holds its form in the furnace is, as its seems to me, its laminated structure, layers of non-caking, cannel-like coal alternating with others which are bituminous and pitchy. Hence, its bitumen may be said to lie in cells, so that the mass does not melt down together, but splits along the planes of deposition, and burns like wood. The laminated structure, visible in most coals, and especially conspicuous in this, seems due to alternations of greater and less quantities of water in the coal marshes. This would give somewhat different character to the sheets of carbonaceous matter which accumulated in the different intervals. This banding has perhaps been subsequently much increased by great vertical pressure, which has reduced the zones, once an inch or two in thickness, to mere sheets. In confirmation of this view, it may be said said that all our open-burning bituminous coals—the Brier Hill, the Brazil, and the Hocking Valley furnace coals—show a distinctly laminated structure, and hackly fracture; while the more bituminous varieties of Coal No. 1, the Mineral Ridge, and Massillon coals show broader, smoother, and more lustrous surface of fracture, and the highly caking coals exhibit this feature in a still higher degree.

The stratum immediately overlying Coal No. 1. is gray or black shale, usually the latter. Above the shale is sandstone; sometimes in a single bed of great thickness; sometimes divided, which I have called the Massillon sandstone. It is seen in many places on the sides of the Mahoning Valley, where it furnishes most of the building stone used. Its greatest known development is at the Foster shaft, where it has a thickness of one hundred and forty-six feet. At Wick and Wells' shaft, on the east line of Austintown, it is also very thick, one hundred and twenty feet; but its local and irregular nature is well shown by its variableness in the vicinity of these mines; for example, at the Kyle shaft, about a mile east of the Foster, it is said to be only eleven feet thick, and at Andrews & Co's shaft, less than a mile south-east from this point, it has again thickened up to eighty feet. In the Mineral Ridge belt the sandstone is generally from fifteen to fifty feet thick, and in the most southerly mine of this belt, the Harroff Slope, it is said to be wanting. In the western counties of Pennsylvania this rock becomes a Conglomerate that has been often mistaken for the true Conglomerate, which lies below the coal. The color of the Massillon sandstone is generally yellowish brown, but it is often either generally tinged or mottled with pink. It is rather coarse-grained, but frequently supplies a very handsome and durable building stone, as is shown in the new court-house at Youngstown.

Coal No. 2.

Where the Massillon sandstone has not cut out other strata, the interval of two hundred feet above Coal No. 1 consists of a number of alternations of gray and black shale and sandstone, in which a thin coal seam is frequently found from fifty to eighty feet above Coal No. 1. This is nowhere of workable thickness in Mahoning county, but is a geological feature recognized by all the drillers. Not unfrequently a band of iron ore is found near the same horizon. A stratum of iron ore, which I suppose to be this ore, was formerly mined near the Old Mill Creek Furnace. In the shales which hold the nodules are great numbers of very beautifully preserved fossil plants, several of which have not yet been found elsewhere, making this the most important and interesting locality of fossils yet known in the county.

Coal No. 3.

At a distance varying from one hundred to one hundred and fifty feet above Coal No. 1, a coal-seam is found which has a bed of limestone over it, sometimes resting on it. The coal varies from one to three and one half feet in thickness, and is also quite variable in quality. It is generally known through the county as Coal No. 2, because it is really the second workable seam from the bottom. This coal is well exposed in the gorge on the south side of the river at Lowell. It is here half cannel, and of fairly good quality. This seam is more extensively worked at the Wick and McDowell mine, in the northwest part of Canfield. The coal here lies about forty feet below the railroad, and is from two and one half to three feet in thickness, rather slaty, but much esteemed for household use, and has been quite largely shipped to the Lake market. The limestone here lies from twelve to fifteen feet above it.

Coal No. 3 is the seam formerly worked at the mine of Frank Henry, in the southwest corner of Austintown. It is of good thickness, but very slaty. The limestone is seen over it here, and is, as so often elsewhere, capped with iron ore. This coal is opened, though not worked, near the farm of Curtis Beardsley, in the western part of Canfield, and on the Osborn and Heintzelman farms, in the eastern part of the township. It is also open on the farms of G. Harding, in the east part of Ellsworth, and this is probably the seam worked by Thomas Rose, in the southwestern part of Jackson. It is also known to exist on the farms of Luding, Ripple, and Wagner, in that vicinity. At the mines of Frank Robbins and Thomas Rose, the coal is three and one half feet thick, comparatively pure, but having little cover, is quite tender.

The limestone over Coal No. 3 is the most constant limestone bed in the county. It is usually from two to three feet in thickness, sometimes resting on the coal, sometimes as much as twenty feet above it. The iron ore which lies upon it is visible in all its exposures, but varies considerably in thickness. Occasionally it is seen as a solid sheet of ore, from six to eight inches thick; more generally a series of flattened nodules. The limestone over Coal No. 3 is extensively quarried by Mr. H. C. Bowman, on the land of Curtis Beardsley, in the northwestern part of Canfield. It is shipped to Leetonia for use as a flux in the furnace.

Coal No. 3*a*.

From forty to fifty feet above Coal No. 3—the interval being occupied by limestone, shales, and sometimes a band of sandstone—lies another seam of coal, and sometimes over it another limestone; this latter is, however, much less constant than the lower limestone. Coal No. 3*a* has been opened in many places in the county, but is very rarely worked at present, as it is generally of inferior quality. In Canfield, it appears on the lands of J. Bruce, and J. Kirk, in the northwestern part of the town, on Infelt's, Osborn's and Swanton's lands, in the eastern part; on the east side of Ellsworth, on the Kenninger and Dursman farms, etc.; it is, however, here soft and sulphurous, and the mines opened on it have been abandoned. In the southern tier of counties it is generally below drainage, but west of the Niles and New Lisbon Railroad, it outcrops in a few places, and in others has been reached by shafts. In all this region it is of workable thickness, sometimes four feet, but is much inferior to the next seam above it, which is that most mined. In the gorge at Lowellville, the second coal seam which is probably Coal No. 3*a* lies sixty feet above Coal No. 3. It is here about eighteen inches thick. On the north side of the river it is four feet thick, and supplies a good coal, formerly quite largely coked for the Lowell furnace.

Coal No. 4.

After Coal No. 1—"the Block Coal,"—Coal No. 4, "the cannel seam," is the most important coal bed in the county. It is a very variable seam so far as regards thickness and character, but is almost always present in one or another of its phases at the horizon where it belongs. In some localities it is six feet in thickness, all cannel coal of good quality; in others it is a remarkably pure bituminous coal two and one half to three feet thick, while more generally it is found to have a thickness of about three feet, of which six to ten inches of the upper part is cannel. This is the somewhat famous Leetonia seam, which is largely worked in Beaver and Green townships. About New Albany it attains perhaps its best development, being here a remarkably pure coking coal well adapted to the manufacture of coke and gas. It was first opened in the county in the southwest corner of Canfield, by Messrs. J. and W. Wetmore. It is here about five feet thick, nearly all cannel. On the Erving farm, in the southwest corner of Canfield it is two and a half feet thick, two feet bituminous, and six inches of the upper part cannel. Here another coal seam two feet thick, probably Coal No. 3*a*, lies about eight feet under it, but the interval is usually much greater. In Springfield and Beaver, Coal No. 4 is opened at a great number of localities, and is the chief source of supply of fuel. It here exhibits all its characteristic variableness, being in some places six feet thick, all cannel, in others three feet thick, half cannel and half cubical coal, and in still others three feet thick, with six inches of cannel at top. Where all cannel, it contains on an average about fifteen per cent. of ash, and will compare favorably with any other cannel mined in Ohio. The quantity of earthy matter is about half that contained in the Darlington cannel, and it may therefore be mined and shipped with profit to the markets where cannel coals are in demand. Where containing no cannel, as at Washingtonville, it is one of the purest coals in the State, containing very little sulphur, and not more than two per cent. of ash. The changes which this seam of coal exhibits illustrate the differences in the mode of formation of cannel and the ordinary cubical coal. The cannel is evidently an aqueous deposit. It contains much ash, and is stratified like a bituminous shale; its fossils are indicative of its origin, since they consist of mollusks and the remains of fishes.

In the center of a block of cannel, taken from the Wetmore mine in Canfield, an entire fish was found with all its scales and fin rays complete.

The most northerly outcrop of Coal No. 4 is at the center of Canfield, where it lies under the sandstone which forms the surface rock on Academy Hill. In most parts of the county south of this point it may be found either outcropping, or at no great depth. It passes under the divide between the waters of the Mahoning and Little Beaver, but appears on most of the tributaries of the latter stream, and is most extensively worked about New Albany, Green Village, and Washingtonville. Passing southward from Washingtonville it becomes thinner and the associated black shales thicker, until at New Lisbon the coal is entirely lost in a mass of bituminous shales some twenty feet in thickness. Further details in regard to this interesting coal seam will be given in the notes on the different townships.

COAL NO. 5.

In the southern part of Mahoning county we find a thin seam of coal some thirty or forty feet above Coal No. 4. At New Albany it is seen cropping out in the ravine above the mines opened on Coal No. 4, and is there about eight inches in thickness. In various places about Green Village, and near the top of the hill on which the town stands, this coal seam makes its appearance, but nowhere more than one and one-half feet thick, and of no economic value. Further south it increases in thickness, and is locally worked. Whether this coal is identical with Coal No. 5 of the Yellow Creek Valley and the more western counties, remains to be determined, but it holds about the same position, and it seems probable that we have in southern Mahoning the extreme edge of a coal seam of which the basin lies chiefly south and west.

THE WHITE LIMESTONE.

A few feet above Coal No. 5 occurs a thick bed of limestone, which only caps the higher points in the southern part of Mahoning county, but which in Columbiana becomes a continuous sheet, and is a marked feature in the geology. It is from six to eight feet in thickness, generally quite light in color, though sometimes weathering brown, and so deserving the name given it in Stark county of the *buff* limestone. In localities where it has this character it contains an unusual quantity of iron. It is generally destitute of fossils, but where purest, as in many parts of Columbiana county, forms a nearly white line when burnt, and is largely used and much esteemed for building purposes. In going southward through Mahoning county this limestone is first seen capping the hill between Green Village and Canfield, on the land of Nicholas Goodman. It is seen again about a mile and one-half east of Franklin Square, and on the highlands, east of Washingtonville, large detailed blocks of it are visible. In Beaver township we have not yet found this upper limestone, but on the farms of Andrew Sidner and George Rock, in the southern part of Springfield, are outcrops of what seems to be the same bed. On the farms of Messrs. Miller and Hoffmeister, in the southern part of Poland, and at the head of the gorge above Lowell, a thick limestone is found which has been generally supposed to be identical with the upper limestone of Green township. It is fully exposed near Lowell, having been largely quarried here for use as a flux in the furnaces of the valley. The fnll thickness of the bed at Lowell is fourteen feet, but only the upper half is worked. The same stratum crops out on the north side of the river, above Lowell, and is there twelve feet thick.

The identification of the Lowell Limestone with that of Green township, and hence with the White Limestone of Columbiana county, has been questioned by the Pennsylvania Geologists, who claim that the Lowell Limestone is the continuation of the Ferriferous Limestone of Western Pennsylvania, and that the White Limestone of Columbiana county is the Upper Freeport Limestone of Rogers, which lies one hundred feet higher. Without more thorough investigation than we have felt justified in giving to this question, it cannot be asserted that the

Lowell Limestone is identical with that on the Goodman farm at Green' since the connection is severed by valleys and obscured by Drift. The Lowell Limestone is thicker than the White Limestone is any where known to be, and it contains some fossils which I have never found in the latter; but the Lowell Limestone lies ninety feet above the limestone next below it, and more than one hundred and fifty feet above Coal No. 3; it also lies nearly three hundred feet above the level of Coal No. 1, at its nearest outcrop at Nebo; so that if the Lowell Limestone is the equivalent of the Ferriferous, and not of the Freeport Limestone, we have here an immense local thickening of the Lower Coal Group. It is also true that we have here a bed of limestone of greater thickness than any other in Northern Ohio, which has completely disappeared, or dropped one hundred feet from its level, and greatly diminished in dimensions in passing into the next township west. From the great number of borings made in the townships west and north of Poland, we learn that the limestones over Coals Nos. 3 and 3*a* generally lie considerably within two hundred feet of the Block Coal, and that the limestone of Greene township, which is certainly identical with the White Limestone of Columbiana county, is not more than three hundred feet above that seam. In the southwest corner of Youngstown some of the borings made are said to have passed through three strata of limestone, the upper one being reported to be from one hundred and eighty to two hundred and sixty feet above the Block Coal. It is possible that the upper one of these represents the Lowell Limestone, here diminished in thickness, and that further west it disappears, the lower two limestones only being found west of that township. If this should prove true we should be compelled to conclude that the Lowell Limestone is not identical with that on the Goodman hill, and was confined to a territory lying within five or six miles of the Pennsylvania line; also, that the Lower Coal Measures thicken rapidly toward the east, and by the introduction of new elements present a quite different composition from that we generally find in Northern Ohio. Until further exploration shall throw more light on this question it must be left undecided.

Coal No. 6.

Unless it should prove, as does not now seem probable, that the Lowell Limestone is the equivalent of the White Limestone of Columbiana county, and the coal which lies above it, and is opened on the farm of James Moore, is Coal No. 6, this seam cannot be reckoned as forming part of the economic resources of Mahoning county. In Columbiana it is from three to seven feet in thickness, and one of the most important and reliable coal seams. It probably makes its appearance in the tops of the hills east of Green Village, but if so it has very little cover and no value.

Some of the more interesting local facts in the Geology of Mahoning county are given below in notes on the different townships.

MILTON.

This township lies so low, topographically and geologically, that none but the lowest coal seam can be found on any considerable portion of the surface. This has been sought for quite assiduously, and has been struck both east and west of the Mahoning. On the west side the basin is probably continuous with that of Palmyra. In the valley of the river Coal No. 1 outcrops, but is generally thin. Borings on the east have reached the coal in several places where it is of workable thickness.

The following section of a boring on the farm of Jacob Helsel may be taken as a type of the structure of this part of the township where the coal occurs :

		FT.	IN.
1.	Surface deposits	45	..
2.	Sand rock	35	..
3.	Dark gray shale	7	..
4.	Light gray shale	6	..
5.	Reddish shale	1	..
6.	Coal No. 1	3	3

Coal No. 3 is found in the southeastern corner of the township of workable thickness and pretty good quality, but rather tender. On the farm of Gideon Clingham, Coal No. 1 is reported to have been struck under sixty feet of cover three feet eight inches in thickness, but the statements made to me were so vague that it is doubtful whether the report can be accepted as reliable. The exact locality of the boring could not be ascertained, nor the elevation of the surface. The territory is not far from that where Coal No. 3 is mined by Mr. Robbins, and it is quite possible that this was the seam struck.

JACKSON.

In the southwest part of Jackson township Coal No. 3 has been mined for some time on the farm of Frank Robbins. It is said to be three and one-half to four feet in thickness, but has little cover and is quite tender. This unusual development of Coal No. 3 extends southward into Ellsworth, where it is mined on the farm of Thomas Rose. In the southeastern portion of Jackson, Coal No. 3 has been opened in several places, but it is of rather inferior quality. The coal opened on the farm of John Ewing, in the valley of the Meander, is the Briar Hill seam, Coal No. 1 ;

it is of good quality, but the deposit has not yet been shown to be very extensive. The shale over this coal contains a great number of very beautiful impressions of fossil plants.

AUSTINTOWN.

This has been proved to be one of the richest townships of the county in both coal and iron. It contains the southern extension of the Mineral Ridge belt of mines, which have now produced a large amount of coal and blackband ore for many years. The principal mines of this series are:

Todd & Wells Coal Co.'s shaft, the Junction Coal Co.'s shaft, Baldwin Bros. slope, Harris, Maury & Co.'s shaft, the New Lisbon Coal Co.'s shaft, and Harroff Coal Co.'s slope.

The sections of the strata overlying the coals as reported by the owner of the different shafts, present some interesting variations which are given below. The structure of the blackband basin, as indicated by the sections of the shafts of Morris and Price, Todd and Wells, and the Junction Coal Company, is similar throughout, but the sections reported of the Pennell and Harroff slopes differ considerably from each other, and from those of the mines further north.

Sections of Coal Shafts at Austintown.

Morris and Price:

		FT.	IN.
1.	Earth	12	..
2.	Sand-rock	25	..
3.	Gray shale	14	..
4.	Black shale	16	..
5.	*Coal*	1	10
6.	Gray shale	13	..
7.	Brown shale	12	..
8.	Black shale	26	..
9.	Sand-rock	7	..
10.	*Top coal*	3	..
11.	Blackband ore	..	8
12.	Black shale	2	..
13.	Block coal	..	8

Tod and Wells:

		FT.	IN.
1.	Earth	13	..
2.	Sand-rock	26	..
3.	Gray shale	15	..
4.	Black shale	20	..
5.	*Coal*	1	10
6.	Gray shale	15	..
7.	Brown shale	12	..

		FT.	IN.
8.	Black shale	24	..
9.	Sand-rock	7	..
10.	*Top coal*	3	..
11.	Blackband ore	..	6
12.	Black shale	2	..
13.	Block coal	..	10

Junction Coal Company:

		FT.	IN.
1.	Earth	10	..
2.	Sand-rock	15	..
3.	Gray shale	44	..
4.	Black shale	16	..
5.	*Coal*	1	10
6.	Gray shale	15	..
7.	Black shale	18	..
8.	Sand-rock	7	..
9.	*Top coal*	3	..
10.	Blackband ore	..	6
11.	Black slate	2	..
12.	Block coal	..	8

Pennel slope:

		FT.	IN.
1.	Earth	10	..
2.	Hard limestone	10	..
3.	Gray shale	36	..
4.	Sand-rock	30	..
5.	Fire-clay	10	..
6.	Black shale	30	..
7.	Brown shale	35	..
8.	*Coal*	4	.

Harroff slope:

		FT.	IN.
1.	Earth	20	..
2.	Gray shale	20	..
3.	Fire-clay	8	..
4.	*Coal*	1	..
5.	Fire-clay rock	20	..
6.	*Coal*	..	6
7.	Gray shale	8	..
8.	*Coal*	1	..
9.	Fire-clay rock	10	..
10.	Gray shale	8	6
11.	Fire-clay rock	5	..
12.	Black shale	34	..
13.	*Coal*	4	..

In the foregoing sections it will be noticed that a thin coal seam occurs near the middle of all except that of the Pennell slope, where it is perhaps cut out by a sandstone which runs through all the sections except the last, and is what has been designated in the preceding notes as the Massillon sandstone. We here have nothing like its greatest development, as in the Foster shaft it is one hundred and forty-six feet in thickness.

The limestone ten feet in thickness reported as cut in the Pennel slope, if what it is represented to be, is an anomaly in the county. It lies one hundred and thirty-six feet above the Block Coal, and doubtless represents the upper of the two limestones which traverse the county; but this is nowhere else nearly so thick, unless we can imagine that this is the Lowell limestone here brought down more than one hundred and fifty feet nearer the level of the Block Coal than it is at Lowell. We had no opportunity of examining this rock, and the section is that furnished by the proprietors of the mine.

In the southern part of Austintown, Coal No. 3 is found in place from one and a half to three and a half feet in thickness, but generally not of very good quality. Limestone and ore occur over it.

YOUNGSTOWN.

The first development of coal mining in the valley of the Mahoning took place at the old Brier Hill and Crab Creek mines near the north line of Youngstown. The search for coal has radiated from this center in every direction, and as a consequence the country about Youngstown has been more thoroughly explored than any other part of the county. A number of extensive basins have been discovered here, and several of them quite largely worked.

The most important mines in Youngstown are those of the Brier Hill Coal Co., Arms & Bowers, Wick, Ridgeway & Co., the Holland Coal Co., on the south side of the river, and the mines of the Powers Coal Co., Andrews & Co., the Kyle Coal Co., the Foster Coal Co., the Mahoning Coal Co., the Brier Hill Coal Co., and H. B. & P. Wick, south of the river. Of these one of the most interesting is that of the Foster Coal Co., located in the southern part of the township. The coal here lies at the shaft about two hundred and thirty feet from the surface, and in the bottom of the basin is five feet 6 inches thick, of excellent quality. The basin forms a narrow channel with a general east and west bearing, but its extent and connections have not yet been fully ascertained. About one hundred and forty feet of the shaft was sunk through sand rock (Massillon sandstone) which was found saturated with salt water. This is said to have yielded on evaporation one pound of salt from one and a half gallons of brine. The water found in the underlying shale and coal was fresh. In sinking this shaft no limestones were met with, as they were probably cut out by the sandstone, but in a boring made on the old Mikesell place, eighty rods from the Boardman line, three limestones were passed through. The section afforded by this boring is as follows:

		FT.	IN.
1.	Earth	23	9
2.	Black shale	5	6
3.	Sandrock	12	..
4.	Gray shale	17	6
5.	Limestone	2	7
6.	Brown shale	5	..
7.	Gray sandy shale	31	5
8.	Limestone	3	9
9.	Gray shale	31	3
10.	Limestone	6	..
11.	Reddish sandy shale	23	..
12.	Brown shale	25	..
13.	Gray sandy shale	30	..
14.	Sandrock	18	..
15.	Gray shale	24	..
16.	Black shale	1	6
17.	Coal No. 1	5	..

It will be seen from this boring that the places of Coal No. 3 and 3*a* were passed, but they were not met with.

In the intervals between the basins now known in this township much boring has been done, and the existence of considerable barren territory demonstrated. There is, however, no reason to suppose that all possible coal discoveries have been made here, and it is even highly probable that valuable deposits of coal will yet be found lying between and more or less connected with those now known.

COITSVILLE.

Up to the present time comparatively little success has attended the efforts to reach the Block Coal in this township. Messrs. Andrews & Hitchcock have a valuable mine in the northwest corner, and some coal has been found south of this on the lands of the Jackson Coal Co. The central and eastern portions of the township are as yet untested or proved barren; but there is ample room for valuable coal basins in the territory not yet bored, and it would be not at all surprising if the very extensive and now productive basins of Hubbard should be found to extend southward into Coitsville.

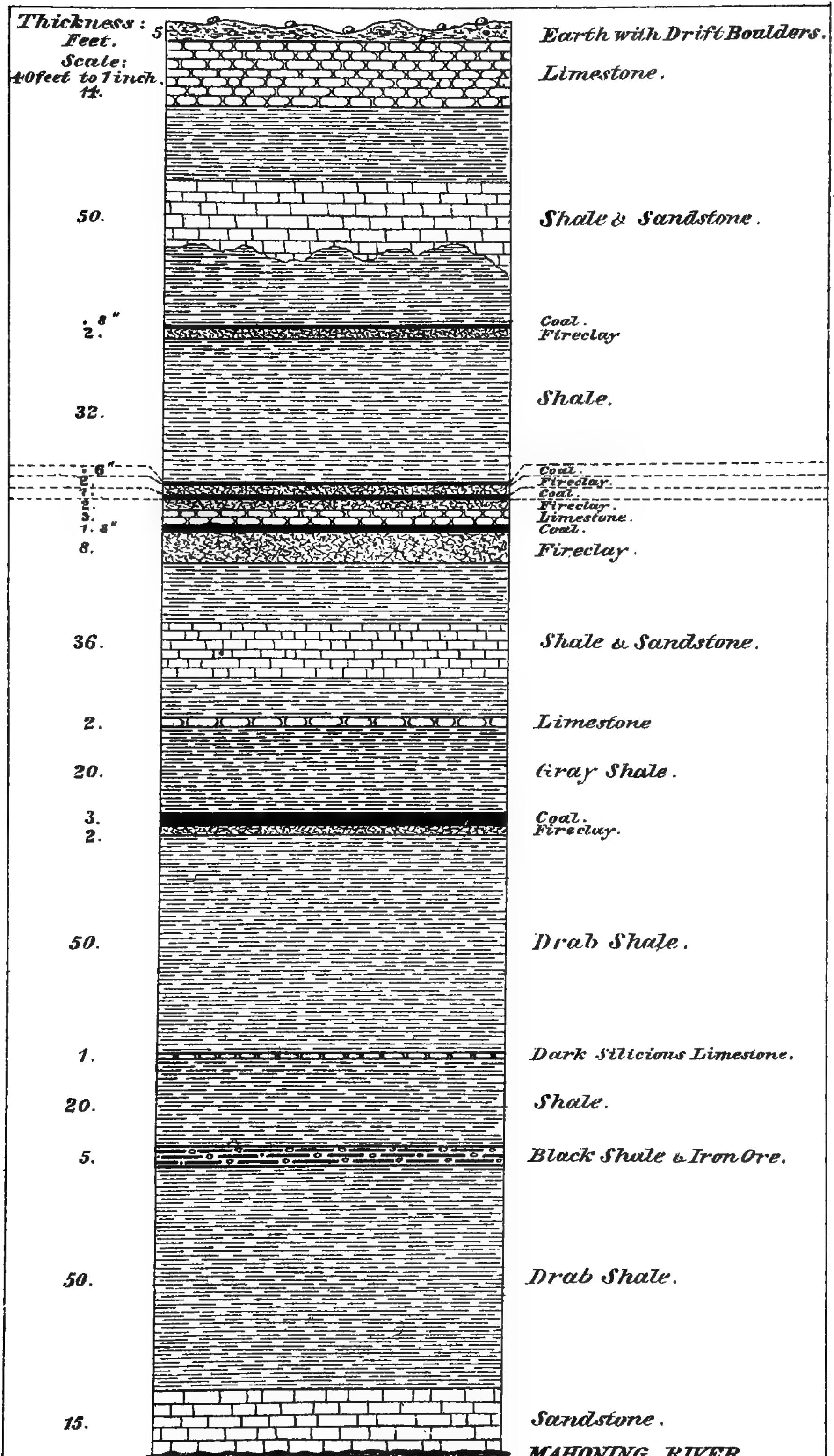
POLAND.

A large part of the township of Poland lies high above the level of Coal No. 1, and borings to the depth of from two hundred to two hundred and fifty feet will be necessary to reach its place in nearly all portions of the township back from the valley of the Mahoning. This fact has limited the amount of exploration, and has, in some instances, led to the discouragement of operators before the proper depth was reached. So far as I can learn no really valuable deposits of the Lower Coal are known to exist in the township. The Mt. Nebo mine, worked in the bottom of the valley on the south side, was formerly quite productive; but it is now abandoned, and the basin which it tapped is supposed to be nearly exhausted. Coal No. 3 has been opened in the gorge south of Lowell, and on the opposite side of the river Coal No. 3*a*, both of workable thickness and of fairly good quality. The section in Grindstone Run on the south side of the river is given in the engraved sheet which accompanies this report. A few notes upon it are here given.

The bed of the Mahoning at Lowell is cut in flaggy sandstone, which is well exposed to a depth of about fifteen feet. At the height of fifty to sixty feet above the river is generally supposed to be the place of the Block Coal, but it is no where visible in this vicinity, and it seems probable that there was here a ridge of Waverly shales which bounded its deposition. About sixty feet above the railroad a band of iron ore is found which was formerly worked by stripping. The outcrop is now covered, but the ore bed is said to have been double, with a band of shale two to four feet thick between the two benches. The upper deposit of ore is said to have consisted of an irregular sheet of nodules four or five inches in diameter; the lower stratum to have been regularly bedded from eight to twelve inches in thickness. This band of ore has been mined at numerous places between Lowell and Youngstown.

About one hundred and thirty-five feet above the railroad, the first of the limestone coals is exposed. It has here a thickness of thirty inches, and has been considerably mined for local consumption. The coal is "dry, or open-burning, with considerable bone coal," or impure cannel. The limestone is about twenty feet from the coal, and two feet in thickness. Above this is a bed of shale, and then a stratum of bluish white micaceous sandstone which has been largely used for furnace hearths in the Mahoning Valley. Above the sandstone is a bed of shale, and over this a stratum of fire clay eight feet thick on which rest, first, a coal seam one and one-half feet thick, then limestone three feet in thickness, and above this two thin seams of coal and two layers of fire-clay. This mixed group of coal, limestone, and fire-clay probably represents Coal No. 3*a* and its limestone, but the thin coals above the latter are features not elsewhere noticed in Mahoning county. Thirty-two feet higher in the section is another seam of coal eight inches in thickness, with two feet

SECTION AT LOWELL.



W. J. Morgan & Co. Photo Lith Cleveland, O.

of fire-clay beneath, and fifty feet above this is the Lowell limestone fourteen feet thick, which caps the hill and terminates the section. Half a mile further back from the river, on the farm of Mr. J. Moore, and twenty feet above the limestone, a coal seam is reached and somewhat worked. The first conclusion arrived at in regard to the upper part of this section, was that the thick limestone was identical with the upper limestone of Columbiana county; that the overlying coal was Coal No. 6, and the thin seam below, No. 4; but, as remarked on a previous page, the identification of the Lowell limestone with the "white limestone" further south cannot be demonstrated on account of the Drift-covered area which separates their outcrops; and until proof to the contrary shall be gathered, we must admit the possibility that the Lowell limestone is a different stratum, lying at a lower level, and distinct from any met with further west. If this is true, we have here a remarkable thickening of the Lower Coal Measures, for the Lowell limestone lies nearly three hundred feet above the nearest outcrops of Coal No 1, and nearly a hundred feet higher than the "white limestone" at Palestine, twelve miles south.

The Lowell limestone is an element of great economic importance in the geology of this region, since it has been largely used for blast furnace flux, and in fact supplies nearly all the limestone consumed for this purpose in the Mahoning Valley. Only the upper half of the stratum is quarried, as the lower portion contained more chert, and is less esteemed. The principal quarries on the south side of the river are those of Mr. J. Moore, Messrs J. and L. Earle, and Mr. Pence.

On the north side of the river the exposures are less complete, but they show some remarkable changes which very well illustrate the local and uncertain character of some of the strata in the Lower Coal Measures of this region. The Lowell limestone is here found capping the hills about fifteen feet in thickness, and affords a reliable starting point, making the section which is given below:

		FT.	IN.
1.	Limestone	15	..
2.	Argillaceous shale	3	..
3.	Coal	..	8
4.	Fire-clay	2	..
5.	Argillaceous and sandy shales	30	..
6.	Coal, "dirt vein"	1	..
7.	Gray shale	10	..
8.	Coal (No. 3*a*) 2 ft. 6 in. to	4	2
9.	Fire-clay and shale	55	..
10.	Limestone	2	..
11.	Sandy shale 10 to	15	..
12.	Coal No. 3	2	..
13.	Fire-clay, shale, and sandstone, etc., imperfectly exposed to river.	175	..

In comparing this section with that taken on the south side of the river, we find the following differences:

1st. A coal seam three feet beneath the Lowell Limestone, not seen on the south side of the river.

2d. The interval between the Lowell Limestone and Coal No. 3*a* diminished nearly forty feet.

3d. But one thin coal over Coal No. 3*a*.

4th. The limestone wanting.

5th. The coal thickened in places to four feet two inches, and the only workable seam on this side of the river.

6th. Coal No. 3 diminished to two feet, and of no value.

Coal No. 3*a* is here a good cementing coal, which has furnished considerable coke, used in the Lowell Furnace. It is mined on the farm of Lowerly and McClintock by Johnson, Brown & Co., where it consists of two benches of cementing coal, with a parting four to six inches from the top, and a third bench of cannel six inches thick at the bottom.

In the southern part of Poland township, as in most of Springfield and Beaver, the surface is covered with Drift, and the geology is concealed. On Section 30, of Poland, a coal seam is opened, which is apparently No. 4. It is thirty inches thick, and of good quality. In the eastern part of the town, coal is mined at Park and Lowe's slope, and on the farm of Samuel Hines. This is apparently above the Lowell Limestone, and yet would seem to be the same coal as that last mentioned, and as that mined by Azariah Paulin in the north part of Beaver, which is, unquestionably, Coal No. 4.

SPRINGFIELD.

In Springfield, coal has been opened at a great number of localities, but is nowhere largely worked. If we are not mistaken in its identification, all the mines are in Coal No. 4. These are:

1. "Somers' bank," on Jacob Kurtz's farm, Section 4, coal thirty inches thick, of good quality, the top somewhat open-burning.

2. Thomas Dyce's bank, on the Reaulman farm, Section 15, coal two feet nine inches, cementing, and much esteemed for blacksmith's use; limestone and iron ore reported below it.

3. McGill and Livingston's mine, on the farm of J. Egerts, Section 24, coal twenty-seven to thirty inches thick, in two benches; the upper (cannel) one foot nine inches; the lower (bituminous) six inches thick.

4. Chris. Beck's bank, fifty to sixty rods south of No. 3, coal twenty-six inches thick—all bituminous.

5. Jeremiah Brown's farm, Section 8, coal thirty-eight to forty inches,

in two benches; the lower (bituminous) twenty-four to thirty inches; upper (cannel) six to twelve inches.

6. Solomon Poland's bank, Section 7, coal thirty inches; lower bench (bituminous) twenty-two inches; upper (cannel) eight inches.

7. David Poland's bank, Section 6, coal twenty-four to thirty inches, with six inches of cannel above; lower bench, bright and handsome, resembling the Leetonia coal.

Coal is also reported opened on the land of J. McCullough, G. Myers, Sarah Hans, and J. W. Heindle.

At Petersburg, Coal No. 4 is mined in several places; in some, a rather poor bituminous coal; in others, a good cannel. Two outcrops of coal are seen above it, but they have not been opened. The section of the hills here, though partially concealed, is as follows:

		FT.	IN.
1.	Slope, covered, with thin streak of coal near top	50	..
2.	Coal, heavy outcrop.		.
3.	Slope, mostly sandy shales	85	..
4.	Coal No. 4	2	6

In this section, the strong outcrop of the second coal is probably Coal No. 6, and perhaps the streak of carbonaceous matter at the top of the hill represents No. 7. Unfortunately, no limestone is visible here, and we get little to help us in the correlation of the Lowell section. If, as some have supposed, the Lowell Limestone is the equivalent of the white limestone, it should lie seventy or eighty feet above Coal No. 4, or just below the outcrop of Coal No. 6; whereas, if its place is below Coal No. 4, it should be found within twenty feet of that seam; but, so far as we could learn, no such limestone has been struck in any wells or borings in this vicinity.

BEAVER.

The surface of this township is generally rather level, and few outcrops of the strata are seen. Coal has been mined, however, in a great number of localities, but so far as we could learn, only one seam, No. 4, has been opened. The principal mines are as follows: In the south part, P. B. Yoder's and J. Wilderson's; in the east part, G. W. Heindel's A. Yoder's, and G. Mercer's; in the north part, Azariah Paulin's, David Sprankel's, and George Coler's. The character of the coal varies very much in these different openings; for example, at A. Paulin's it is twenty-eight to thirty-two inches thick, with eight or ten inches of cannel above.

On the Sprankel farm, it is six feet thick, all cannel, of good quality, the average of several proximate analyses, showing about 15 per cent. of ash. On the next farm, that of George Coler, it is all bituminous, and at the mine of Jeremiah Brown, already referred to, in the adjacent part of Springfield, it consists of two feet of cannel and two feet of bituminous coal. At Heindel's bank, section 13, the lower bench is twenty-six to thirty inches, bituminous, the upper from twelve to eighteen inches, cannel. Jacob Wilderson's coal is only two feet thick, but is partially cut out by sand-rock.

In the north-west corner of Beaver township two wells have recently been bored to a considerable depth for the Block Coal. The first is on the farm of Samuel Barr, and the second on that of Noah Messerly, some forty rods distant.

The register of these borings is as follows:

		FT	IN
1.	Surface deposit	32	..
2.	Sand-rock	34	6
3.	Black shale	5	..
4.	Cannel coal (No. 4)	4	6
5.	Black shale	1	6
6.	Fire-clay	14	..
7.	Fire-clay rock	17	..
8.	Gray shale, with thin coal	8	6
9.	Gray shelly rock	1	4
10.	Gray shale	17	..
11.	Dark blue shale, with thin coal	3	..
12.	"Very hard rock"	1	6
13.	Brown shale	7	..
14.	Fire-clay	4	6
15.	Gray shale	8	..
16.	Light sand-rock	9	6
17.	Gray shale	5	..
18.	Black shale	1	..
19.	Flinty rock	1	8
20.	Coal No. 1	1	6
21.	Sand-rock	3	..
22.	Bottom rock (Waverly).		

		FT.	IN.
1.	Surface deposits	30	..
2.	Sand-rock	48	..
3.	Black shale	8	..
4.	Cannel Coal (No. 4)	5	6
5.	Black shale	1	..
6.	Coal, very sulphurous	3	..
7.	Dark gray shale	8	..
8.	Coal No. 3*a*	2	..
9.	Black shale	5	..
10.	Sand-rock	10	..
11.	Gray shaly rock	15	..

		FT.	IN.
12.	Gray shale	4	6
13.	Black shale	4	6
14.	Coal and shale	1	..
15.	Fire-clay	3	..
16.	Fire-clay rock	10	..
17.	Gray shale	6	..
18.	Brown sand-rock	8	..
19.	Fire-clay	1	..
20.	Gray sand-rock	12	..
21.	Black flinty rock	1	6
22.	Black shale	1	..
23.	Bottom rock.		

In the first hole, the Brier Hill coal was undoubtedly struck; in the second, it is wanting, or is represented by a black shale. It is probable that borings made near the first hole, but further north, would strike the Block Coal, of greater thickness, as the basin probably extends in this direction.

BOARDMAN.

But little has yet been learned in regard to the economic resources of Boardman township. Coal No. 1 has been struck in borings made for Mr. C. H. Andrews, near the north line of the township; but up to the present time no considerable basin of good thickness has been discovered. The limestone coals are here apparently thin, and of little value; and Coal No. 4 has only been opened in the south-west corner of the township, at the Powell mine, which is not now worked.

CANFELD.

The outcrops of Coal Nos. 3 and 3*a*, in the northern part of Canfield, have been already alluded to. Coal No. 4 has been proved, by explorations made by Mr. Wm. Wetmore, to underlie the Academy Hill, but it has little cover, and is not regarded as of great value. It also underlies a detached hill on the Swanton farm, east of town, but has not been opened there. On the banks of Indian Creek, below the place of Coal No. 4, are outcrops of Coals No. 3 and 3*a*, with two limestones; and it is said that the Block Coal, three feet in thickness, was reached here by boring, one hundred and forty feet below Coal No. 3.

Mr. Wetmore reports that he found Coal No. 4 four feet thick, from twelve to fifteen feet below the grade of the railroad, on the land of Warren Hine, west of the Fair Grounds. It had there no roof and was covered with gravel and sand. He states that in one place it was folded up into an arch, evidently by lateral pressure, probably that of the glacier which once covered the surface here, moving southward. There is a ridge of Drift material, gravel and sand, two miles long west of the center. Blocks of sandstone are here scattered for half a mile in a S. S. E. direction from their place of origin.

Much of the southern part of Canfield is underlain by Coal No. 4, and it was at one time quite extensively worked by Messrs. John and Wm. Wetmore, on Section 24. The coal is here about five feet thick, all cannel, with the exception of a thin sheet at the bottom. The coal of the upper bench contains about nineteen per cent. of ash, that of the lower eleven and one-half per cent. A beautiful fossil fish was obtained in the center of a block of this cannel while the mine was worked. It is a species of *Palæonicus*, (*P. Peltigerus*, N.), and is now in the possession of Mr. Wm. Wetmore. The cannel seam has been opened west of Wetmore's mine, both north and south of the township line, but is apparently less pure and good in this direction. In the southwest corner of the township it is opened on the land of Mr. Ewing, near the steam saw mill. It is here but two and one half feet in thickness, the lower two feet being bituminous coal, of good quality, the upper six inches cannel. Eight feet below this coal seam is another, which is regarded by Mr. Wetmore as Coal 3*a*; if so, it approaches much nearer to No. 4 than it is known to do elsewhere. Possibly this is only one of the local seams so frequently met with in this part of the series.

ELLSWORTH.

Coals Nos. 3 and 3*a* are known to exist in greater or less development in most parts of this township. In tae northeastern part, on the lands of G. Harding, and in the northwestern part, on the farm of Thomas Rose Coal No. 3 has been somewhat worked; and in the east and southeast section Coal No. 3*a* has been opened on the lands of Henninger and Dursman, but is not now mined.

No successful boring has been made for the Lower Coal in Ellsworth, and the presence or absence of this seam must be determined by further search.

Very beautiful crystals of gypsum are found in a clay bank just south of the center of Ellsworth, and from this locality they have been very generally distributed to the mineralogists of the country.

BERLIN.

No coal is worked in this township. Coal No. 3 is found in many localities, but is generally thin. It has been opened on the Kline farm. It is believed that good basins of Coal No. 1 underlie this township, but very little has been done to test the truth of this impression. From the proximity of the basins in Milton and Palmyra, it would seem probable that some valuable deposits would be found here.

SMITH.

The surface of the township lies high enough to include Coal No. 4, and in some places No. 5; but it is nearly level, and the outcrops are few. Coal has been worked on the Laughlin farm, east of Alliance, and its northern outcrop. It is friable and contains much sulphur, is about three and one-half feet thick, and is probably Coal No. 4. On Rebecca Mathers's farm the same coal is worked by an entrance from the southeast. The roof is shale, above which is the sand rock, but the hills are only thirty feet higher than the coal, and the cover is sufficient to protect it. On Jacob Wright's farm, near the foregoing, the second seam of coal was formerly worked by a level near the bottom of the valley, through which the Pittsburg and Fort Wayne Railroad runs. This coal (No. *3a*) is about three and one-half feet thick, but is reported to be of rather inferior quality.

GOSHEN.

Coal is worked in the northwest corner of the township on the land of C. Bowman. This is Coal No. 4, and of pretty good quality. The same seam stretches under the highlands of some other parts of the township, but has been little worked. It apparently deteriorates in quality toward the west. Coals No. 3 and *3a* may be reached by shafting at no great depth, but whether they are thin as in Ellsworth, or thicker and purer as at Alliance, can only be determined by exploration. So far as known, no boring has been done in this township for Coal No. 1, but as it has been reached at Limaville, a few miles west of the county line, there is a fair probability that some basins of it will be found here.

GREEN.

This township is one of the most productive in coal of any in the county, for Coal No. 4 here assumes its best phase, and is opened and worked at a great number of localities. The surface is quite varied, and the highest hills rise from seventy-five to one hundred feet above the horizon of No. 4, while the next seam below is cut in the bottom of the valley of the Little Beaver. The principal mining is done about New Albany. The coal (No. 4) is here from three to three and one-half feet thick, of very good quality, and is worked chiefly for the supply of the town of Salem, where it is preferred to coal of the same seam taken from the shaft in the village. The mines at New Albany are Stout's, Wilson's, Gates's, Bonsall's, Pow's, Gordon's, and Brooks's.

About twenty-five feet above Coal No. 4, Coal No. 5 (?) shows itself eight to ten inches in thickness. In the valley of the Little Beaver, between New Albany and Green Village, Coals No. 3*a* and 4 are exposed and somewhat worked on the farm of George Barnes. Coal No. 4 is here three and one-half feet thick, and of very good quality. Coal No. 3*a* is said to be three and one-half feet in thickness, and looks well, though containing more sulphur than the upper seam. Wikart's bank is opened in No. 4. In the east part of the township, Coal No. 4 has been opened on the farms of Reichstahl and Roller, but is not now worked. At Washingtonville Coal No. 4 has been mined for many years. It is here about two and one-half feet thick, the lower two feet the best, and showing scarcely a trace of sulphur; the upper six inches is somewhat slaty. The lower bench furnishes a coal of moderate hardness, cubical fracture, a silvery resinous luster, and is found by analysis to contain only about two per cent. of ash. It is, therefore, one of the purest coals in the State. It was formerly coked in considerable quantity by Messrs. Whistler, Walter, and Rolla, and their coke was regarded as superior to any other in use in Pittsburgh.

In conclusion, I take pleasure in expressing my great obligations to Mr. Wm. Wetmore, of Canfield, and to Mr. Chauncey H. Andrews, of Youngstown, for important information, and aid in gathering the material for this report. The assistance rendered by Mr. Wetmore was peculiarly valuable, as he has a good general knowledge of the geology of the county, and a minute and accurate acquaintance with all the facts which have been collected in the exploration for coal south of the Mahoning, in much of which he has taken an active part. He has also most generously given much time to the furtherance of the objects of the Survey.

A few analyses of the useful minerals of Mahoning county are given in the succeeding pages. The mineral wealth of the county merited a larger amount of chemical work, but it unfortunately happened that before the collections made in this county were reached in the progress of analyses in the chemical laboratory, all appropriations for this object were stopped, and they were left untouched with the exception of the few now reported as made by Dr. Wormley.

Those made by Messrs. Hooker, Lilienthal, and Holbrook were done in the laboratory of the School of Mines, without cost to the State.

Analyses of Coal, Iron Ore, and Limestone from Mahoning County.

Coals.

1. Coal No. 1, Brier Hill..Dr. Wormley.
2. " Veatch's Mine.................................... "
3. Coal No. 3, Walworth Shaft, Canfield .... "
4. Coal No. 4 (Cannel), Sprankel Farm, Beaver township .....W. A. Hooker.
5. Coal No. 6 (?), Moore Farm, Poland township............... "

	1.	2.	3.	4.	5.
Specific gravity	1.284	1.260	1.323	1.367	1.246
Moisture	3.60	2.47	3.90	1.39	2.68
Ash........................	1.16	1.45	6.60	13.60	3.02, red
Volatile matter........................	32.58	31.83	29.10	34.43	36.47
Fixed carbon........................	62.66	64.25	60.40	49.58	56.04
Total	100.00	100.00	100.00	100.00	100.00
Sulphur........................	0.85	0.56	0.82	0.86	1.79

Ultimate Analyses of Coal No. 1, Foster Bank, J. L. Lilienthal, E. M.

Carbon..	77.88
Hydrogen	6.56
Nitrogen	1.51
Oxygen	10.57
Sulphur	0.64
Ash	2.84
Total	100.00
Phosphorus..	Trace.
Iron..	0.11
Moisture	3.28
Oxygen in moisture..	2.92
" coal	7.65

Iron Ores.

1. Black-band, Mineral Ridge ....Dr. Wormley.
2. Kidney Ore, Washingtonville.................................. "
3. " over Coal No. 3, Austintown .... "

	1.	2.	3.
Specific gravity	2.494	2.539	3.509
Volatile matter	30.50	....	....
Water	....	0.78	....
Silicious matter	11.84	11.94	6.06
Carbonate of iron	43.26	56.23	78.64
Sesquioxide of iron	9.94	12.34	8.96
Alumina	Trace.	0.50	0.40
Oxide of manganese	1.00	1.70	1.00
Phosphate of lime	Trace.	1.74	0.83
Carbonate of lime	1.87	8.59	1.55
" magnesia	2.03	5.33	2.08
Sulphur	0.18	Trace.	Trace.
Total	99.62	99.15	99.52
Metallic iron	27.12	35.88	44.23
Phosphoric acid	Trace.	0.79	0.38

Limestones.

1. N. Goodman's, Green township .... W. A. Hooker.
2. J. Moore's, Lowell .... "
3. " " .... F. N. Holbrook.

	1.	2.	3.
Silica and Silicates	11.00	2.08	1.61
Iron and alumina	4.39	1.33	2.55
Carbonate of lime	80.43	95.58	91.86
" magnesia	2.29	1.30	0.59
Organic matter and water	2.25	0.06	3.45
Total	100.36	100.35	100.05

CHAPTER LXXXVIII.

SUPPLEMENTAL REPORT ON PERRY COUNTY, AND PORTIONS OF HOCKING AND ATHENS COUNTIES.

BY E. B. ANDREWS.

The Ohio Geological Survey was inaugurated in June, 1869. A considerable part of the working season of that year was spent by me and my assistants in determining the general outlines of the different geological formations in the Second, or South-eastern, district, and in preparing my portion of the geological map published in the Report for 1869. That work done, the remainder of the season was devoted to the Hocking Valley, and the region east of it in portions of Perry, Hocking, and Athens counties. The dominant geological feature of the region was the Nelsonville seam of coal, which was traced through many townships, and its varying fortunes of thickness and quality carefully noted. Many analyses of the coal from various locations were made by Professor Wormley, and the value of the coal of this great seam so fully authenticated that, in a short time, capital was attracted to the region, and railroads were constructed to carry the products of a stimulated mining industry to various markets. Cautiously, Professor Wormley and myself felt our way to the conclusion expressed in the first Report, that the coal of this seam, from certain localities investigated, was adapted, in the raw or uncoked state, to the manufacture of iron in the blast furnace. This conclusion has since been abundantly verified, and to-day furnaces are in successful operation in locations among the hills which, in 1869, would have been considered very remote, if not entirely inaccessible. The coal has also been found to be well adapted to many other important uses, which, if less exacting as to purity of fuel, are none the less important.

Besides the investigations of coal, such other leading geological features of the region as the limited season of labor in 1869 left it possible to gather up, were presented in the Report. The next year our steps were necessarily directed elsewhere, for it was expected that the survey of the whole State would be completed in three years, and the law so required.

No report touching the Second Geological District has provedof more practical value than the one giving the results of our brief labor in this coal-field in 1869. Since that time I have gathered many additional facts. A part of these were gathered while in the employ of the State, and, of course, belong to the State. Many more were obtained while making professional investigations for private parties or companies, who kindly consent to my publishing them in the State Reports. A large number of facts I have gathered, from time to time, at my own private expense. The more important of these facts will be given in this report.

GEOLOGICAL FORMATIONS.

Those in the descending order are—

Drift.

Coal Measures.

Maxville Limestone.

Waverly Sandstone Group.

Waverly.—Only the two upper members of the Waverly Group are found within the district now referred to. The lowest of these is the Waverly Conglomerate. This is always a coarse sand-rock, and oftentimes contains numerous white quartz pebbles.

The top of this Conglomerate is to be seen near Logan, at the mouth of Scott's creek, and also in larger exposures in the bed of the Hocking River, at the falls, a little above the town. From this latter point the coarse rock rises gradually above the level of the river as we ascend the stream. It forms the cliffs which render the scenery along the banks of the Hocking so picturesque and beautiful. At Lancaster, Mt. Pleasant, a bold isolated cliff, nearly three hundred feet high above the level of the Hocking, represents the Conglomerate portion of the Waverly, here probably somewhat thicker than is usual.

The Conglomerate ledges on the Licking river at Black Hand also belong to this horizon of the Waverly Group.

Logan Sandstone.—At Logan, we find overlying the Conglomerate a series of comparatively thin bedded, fine grained sandstones and sandy shales, which are something more than one hundred feet in thickness. These were called in the earlier report the Logan sandstones. The same series of fine grained sandstones and shales is found overlying the Black Hand Conglomerate, and is to be traced along the railroad from Black Hand Station to Pleasant Valley.

There is no mistaking this Logan sandstone series for any other rocks above the horizon of the Waverly Conglomerate. In lithological characteristics, it is totally unlike any sandstones and shales of the productive Coal Measures, and it also contains a different assemblage of fossils.

Maxville Limestone.—The Maxville Limestone rests upon the Waverly, and its deposition marked a new era in geological history. It is no part of the Waverly series, and has nothing in common with the Productive Coal Measures. As the last statement has recently been questioned by my associate, President Orton, who has expressed to me and to others his strong belief that the Maxville Limestone is one of the regular Coal Measure limestones, having its true place about one hundred feet above the base of the Coal Measures, I shall be expected to give the reasons for the conclusions reached during the progress of the Survey, and which I yet firmly hold.

The Maxville Limestone, as found at Maxville, is taken as a representative of several similar limestone deposits in South-eastern Ohio, all of which group themselves, as I believe, along the same geological horizon.

These deposits are found, beginning on the north, (1) at Newtonville, on the western side of Muskingum county, and extending along the lowest valleys into the eastern part of Perry county; (2) in the western part of Perry county, not far from the Fairfield county line, near the village of East Rushville; (3) at Maxville, in the south-western part of Perry county; (4) in Hocking county, a little below Logan, in Green township; (5) at Reed's mill, near Hamden, in Vinton county; (6) in Hamilton township, Jackson county, on the land of Enoch Canter, Section 24; (7) besides these in Ohio, we find another and heavier deposit of this limestone in the Ohio river hills on the Kentucky side, a few miles above Sciotoville. All these seven localities I have carefully examined, most of them many times, and the results of these examinations I will giveas briefly as possible.

In the Kentucky locality last mentioned we find, on Josiah G. Merrill's hill, one mile above Wheelersburg, Ohio, a section as follows:

		FT.
1.	Coal Measure rocks—ore, coal, sandstone, etc	60-70
2.	Sandy clay and shale, containing two layers of iron ore and coal plants	8
3.	Limestone fossiliferous, used for burning and furnaces	31
4.	Limestone, highly sandy	15
5.	Not exposed	10
6.	Waverly sandstone, with characteristic fossils	215

The above section was taken when the rocks were exposed in an almost vertical cliff.

Here forty-six feet of limestone were found under the Coal Measures and resting upon the Waverly. The fossils, so far as gathered, are specifically like those seen at Newtonville, Muskingum county, the most northern deposit of the Maxville group. None of these fossils have I ever found in any Coal Measure limestone. Since the above section was taken, in 1869, the State of Kentucky has been prosecuting a Geological Survey, and, in the reports of Professor Shaler and his assistants, the limestone, which extends southward, is called a *Sub-Carboniferous* limestone. No hills on the opposite or Ohio bank of the river were high enough to take the limestone, and the higher hills further north do not contain it, so far as I could learn. A limestone on the land of the Harrison Furnace Company, several miles north of Sciotoville, which I once saw, some years before our Survey began, may be the equivalent of the Kentucky limestone, but no special investigation has been made to determine this.

In the south-western part of Jackson county, in Hamilton township, on the land of Enoch Canter, I found the following section:

		FT.	IN.
1.	Coal, reported	1	6
2.	Shales and sandstone	15	..
3.	Fire-clay	3	..
4.	Iron ore from 6 inches to	3	..
5.	Flint	..	6
6.	Light colored limestone	8	..

Mr. Canter reported drilling below the limestone and the finding of fine grained Waverly sandstone twelve feet down, there being a clay or "soapstone" between.

No coal in this neighborhood, so far as I could learn, was below the horizon of the limestone ore, believed to be the equivalent of that found on the limestone seen on the land of Enoch Canter, resting directly upon the Waverly. Jackson Gilliland's coal, the finest of block coal, on a slight elevation west of Mr. Canter's, is by barometer forty-five feet above the Waverly. Here the limestone was not seen.

At Reed's mill, near Hamden, in Vinton county, we obtained the following section:

		FT.
1.	Coal Measure rocks.	
2.	Iron ore, a thin stratum.	
3.	Limestone (brecciated in part)	16
4.	Upper Waverly or Logan sandstone, with characteristic fossils.	

Here the Waverly is seen to pass directly under the limestone. The same limestone extends down the Little Raccoon Creek, where it is seen in the bank twelve to fourteen feet thick, with iron ore over it, and with ten feet of fine grained Waverly sandstone underlying it, constituting the bed of the creek. This is a little north of the railroad bridge (M. &

C. R. R.) and near the "Old Fort," built by the Mound-builders. Below the railroad bridge the limestone thins out and disappears, and we find over the Waverly four feet of blue shales with iron ore, and over the shale a hard sandstone with coal plants. The relation of the limestone to the Waverly is unmistakable, and the sections were taken where the banks are vertical.

A few miles below Logan, on the land of James Tannihill, Section 28, Green township, Hocking county, is another deposit of limestone belonging to the same horizontal series. It has been largely quarried at this point for quicklime and for furnace flux. The bottom was not seen, but about nine feet were measured, the upper two feet two inches being of buff color. Above are two feet seven inches of clay shale containing at the top about fifteen inches of limestone, with a layer of nodules of ore over it. Quartz pebbles were seen in this ore, a feeble representation of the Coal Measures' Conglomerate. The Logan sandstone, or Upper Waverly, which lies in the lower part of all the hills along the river, must necessarily pass closely under this limestone, and I have no doubt that search will reveal exposures along the outcrop of this apparently limited deposit of limestone, where both the limestone and the Waverly will appear in vertical section in close contact, or separated by only a few feet of shale.

We now reach, in our progress to the northeast, the limestone at Maxville and vicinity, in Perry county, the location which gave the name to the formation. On the land of David Hardy, near Maxville, the limestone measured eight feet eight inches in thickness, the upper three feet two inches being of buff color, and the lower five feet six inches in layers of hard bluish-gray stone. The five feet immediately below the limestone were not seen, but below this small interval, or *five feet beneath the Maxville limestone, comes in the Logan or Upper Waverly sandstone with its usual fucoids and shells.* Eight feet of this sandstone were seen above the bed of the stream. At this exposure two feet of sandstone were seen directly over the limestone, but at other points there is ore on the limestone with sometimes black shale over the ore. In some places the limestone is thicker than at the Hardy exposure, especially in its upper buff portion. The latter portion is apparently more fossiliferous than the other, and is often singularly mottled with dark bluish blotches. The limestone below Logan exhibited a similarly mottled aspect. Following this limestone from Maxville down the Little Monday Creek to the Winona Furnace, we find a thin development of it in the point of the hill near the furnace. Here above it is an iron ore, which is drifted for, and a very thin seam of coal three or four feet higher. At this place there was no exposure of any thing below the limestone, but a few rods distant, a wel eighty feet deep has been bored, which Col. Churchill believes to have penetrated only the Waverly sandstones and shales of the upper or Logan series, certainly no coal seams nor rocks of the Coal Measures were passed through.

Mr. James D. Poston, of Logan, who has had a large experience in obtaining ores and limestones for the Logan Furnace, and has a great familiarity with the geology of this region, states that in all his operations, when digging or blasting below the Maxville limestone, or below the ore which marks its horizon over areas where the limestone itself is wanting, he has invariably come directly down upon the Logan sandstone.

The next deposit of limestone believed to belong to the same horizon with that at Maxville is seen a little east of Rushville, in Reading township, Perry county. In the deep ravine between East Rushville and West Rushville we have undoubted Waverly rocks, traceable through a vertical range of nearly one hundred and eighty feet. Resting directly upon this series of Upper Waverly rocks come in, to the eastward, the Coal Measures, and at the very base of these Measures is the limestone. At one point I saw a thin ore four inches thick imbedded in a bluish clay. Fifteen feet below this clay—the interval without exposure of rock—I found undoubted Waverly. Farther on I found what I believed to be the same ore embedded in similar clay, and five feet above ten feet of Maxville limestone. As the top of the limestone was not seen, the true interval may be even less than five feet. This limestone was largely quarried on the land of John P. Hodge, in section 26, Reading township, Perry county, for macadamizing the Zanesville and Maysville turnpike. Stone for this purpose is now obtained from some limestone located further east. Fossils are more numerous here than at Maxville.

The last deposit of this limestone to be noticed, is found in the eastern part of Perry county and in the western part of Muskingum. It is sometimes called the Newtonville limestone, from the village of that name. It forms the bed of Jonathan's Creek and Kent's Run for several miles. Wherever the streams have eroded channels sufficiently deep, the Logan or Upper Waverly sandstone and shale are to be seen. In Section 16, Madison township, Perry county, Jonathan's Creek has scored its bed fifty feet into the Logan sandstone, which contains all the usual fossils. Four feet of sandy shale separate the sandstone from the limestone, which is here seventeen feet thick. Above the limestone are rocks of the regular Coal Measures.

We may, I think, very reasonably conclude from the above recital of facts that the Maxville limestone rests upon the Upper Waverly or Logan sandstone rocks, and that it is not one of the interstratified limestones of the Coal Measures, with a position more than a hundred feet above the base of those Measures.

But there is proof that this series of limestones belongs positively to the Lower Carboniferous division of the great Carboniferous System. As many of the fossils of this limestone as could be conveniently gathered at Maxville and Newtonville were sent in 1870 to the late Prof. Meek, the accomplished palæontologist of the Ohio Survey, who had previously had much experience in determining the animal fossils of the Coal Measures and of the Lower Carboniferous limestones of the West. The result of this determination was published in the *American Journal of Science*, February, 1871. In his letter to me at the time, Professor Meek wrote as follows: "From these fossils it is clearly evident that the limestone from which they were obtained belongs, as you had supposed, to the horizon of the Lower Carboniferous limestone series of the Western States." In no case did he find any fossils peculiar to the Coal Measures. Only ten species were well enough preserved to be determined specifically, and of these, eight were of Chester types, and two of St. Louis types, both of the Lower Carboniferous. Professor Meek adds: "From these facts I can scarcely doubt that we have in these local masses of limestone a representation of the Chester group of the Lower Carboniferous limestone series; though it is possible that there may also be some representation of the St. Louis limestone of the same series at some of the outcrops. * * * The discovery of these beds is, I believe, the first indication we have had of the existence of any member of the Lower Carboniferous *limestone* series of the West in Ohio." Many other fossils have been obtained from the horizon of the Maxville limestone since Professor Meek wrote the above; but not one of them, so far as I know, has been found to be of a species characteristic of the Coal Measures.

In addition to the argument derived from the fossils of these beds, it may be stated that the limestones themselves, although presenting some differences of lithological structure at different points, are every where unlike any of the limestones found above them in the Coal Measures.

In the report for 1869 it was suggested that these areas of Maxville limestone may represent local basins in which the limestone was depos ited. This may have been wrong, for it is quite possible that in the original deposition the areas were connected and the formation continuous. After deposition, large areas of it might have been removed with much of the Waverly before the beds of the Coal Measure rocks were laid down. This would leave valleys between the remnants of the Maxville limestone series. The subject of the erosion of the Waverly and consequent uneven character of the floor on which the Coal Measures rest, has often been referred to in the Ohio reports, and by different persons. In the report on Holmes county, in the present volume, Mr. M. C. Read gives on page 544 an interesting illustration of this. Waverly rocks, capped with Conglomerate, are seen on one side of a hill, while on the other there are one hundred and ninety-eight feet of Coal Measures, including five seams of coal. There was evidently an ancient valley in the old Waverly in which the Coal Measures were formed. Proofs of similar valleys in regions adjacent to deposits of the Maxville limestone were long since observed. Of course the levels of the coals in them if continued would pass below the level of the limestone; *but in no case have any rocks of the true Coal Measures been found directly underneath any of the limestones of the Maxville series,* and I do not believe that such a case is possible.

The Maxville limestone is generally of much economical value. The purer portions of it make excellent quick-lime. The quarries near Newtonville have furnished the stone for the beautiful new Court House at Zanesville. It is a firm, compact, durable stone, a little hard to work, but incomparably better as a building stone than any Coal Measure limestone in the State. When the projected railroads are completed into the Upper Sunday Creek Valley coal-field, this limestone will be carried to furnaces in that region. There are large areas of it along the streams with little or no covering of soil. Dynamite would rend it to fragments, and millions of tons could be obtained at a trifling expense. At Maxville and vicinity, this limestone is destined to play an important part in the growing iron manufacture of that region. The deposit below Logan has formerly furnished limestone to the Logan and Five Mile (Union) Furnaces. I have suggested to Mr. Walter Crafts, of the Crafts Iron Works at the mouth of Little Monday Creek, the desirableness of this limestone for his furnace, should he find it sufficiently near to be available. The deposit in Hamilton township, Jackson county, furnished limestone for the old Webster Furnace.

Coal Measures.—The Coal Measures rest upon the Maxville limestone, and, where that is wanting, upon the Logan sandstone, or Upper Waverly. They consist of seams of coal, with interstratified deposits of sandstones, shales, limestones, iron ores, and fire-clays.

The coal seams are not scattered at hap-hazard through the series, but have their places in the vertical range. A seam often becomes thin and worthless, and, indeed, in some places, fails altogether—the conditions having been unfavorable for coal-making at such points—but each seam has its own place in the series, and for this reason classification and system become possible.

In the Coal Measures of Ohio there are several layers of fossiliferous limestone found near seams of coal, which are very useful in aiding the geologist in determining the coal seams. Coal seams were formed of the vegetation of broad horizontal marshes, generally near the sea level. If, when the land had settled below the water, and the material for a layer of limestone had been spread on the surface of the buried marsh, that limestone, thus formed, would have a regularity borrowed from the regularity and evenness of the underlying floor. It is not unusual, however, to find such a limestone separated from the coal by several feet of shale.

Taking for our base the Maxville limestone, as developed in various parts of Perry county, we find about eighty feet higher a limestone with a thin coal seam under it. In the northern part of Muskingum county, I have met with a fossiliferous limestone between these two. From twenty to thirty-five feet higher is a limestone, often flinty, under which is a thin coal. About forty feet (possibly sometimes a little more) is another limestone, found in the Putnam Hill, opposite Zanesville, which is called, in the reports, the Putnam Hill Limestone. There is generally a seam of coal under it. This limestone is usually from seventy-five to eighty feet below the Nelsonville seam of coal. I have recently found it near Straitsville, seventy-two feet below the Great, or Nelsonville, seam. Between the Putnam Hill limestone and the great seam, or from thirty to forty feet below the latter, we find, sometimes, a thin limestone with flinty tendency, on which rests the Baird ore found in the hills west of Straitsville. This ore appears to have its place at the bottom of the white sandy clay underlying the coal seam next below the Nelsonville seam. Besides these lower limestones, there are two between the Nelsonville seam and the horizon of the Pomeroy coal, one called the Ames limestone, about one hundred and forty feet below the Pomeroy seam, and another, called the Cambridge limestone, about eighty-five feet lower. There is another fossiliferous limestone a little below the latter, and I have also met with one in more eastern counties, between the Pomeroy seam and the Ames limestone. There are, possibly, other fossiliferous limestones, but the above-mentioned are the leading ones to be found in Perry county, and in the portions of Hocking and Athens included in this report. Besides these, there are many other limestones which are not fossiliferous, except, perhaps, to a very slight degree. One of these has its place perhaps sixty feet above the Nelsonville seam, and from it several furnaces obtain their limestone. An earthy buff limestone, often nodular and ferruginous, comes in sometimes a few feet above the Nelsonville coal. Another limestone is often seen a little above the Bayley's Run coal, and an additional one sixty to seventy feet above the same coal. A little below the Pomeroy seam of coal, on the high knobs east of Lower Sunday Creek, we find many feet of limestone. Still further east, we find similar limestones above the horizon of the Pomeroy seam.

Coal Seams.—The lower coals in this region are generally very thin, and are seldom worked except in a small way for local use. A thin seam is sometimes seen three or four feet above the Maxville limestone. It is only four inches thick in the drift-way at the Winona Furnace, on Little Monday Creek. In some places a trace of coal is found about twenty feet higher. A seam, three feet three inches thick, is found in Section 16, Madison township, Perry county, about fifty-eight feet above the Newtonville (Maxville) limestone, and it is doubtless to be found elsewhere on the same horizon.

Twenty or thirty feet higher is a seam of coal of wide range, but always thin in the region now under discussion. Its place is about eighty to ninety feet above the Maxville limestone. There is generally a fossiliferous limestone above it. It has been supposed to be the equivalent of Coal Seam No. 3 in the classification of the coals of the First District. Sometimes we find ore upon the limestone. We find a thin coal a few feet above, and, indeed, we find, sometimes, in the space of thirty or forty feet above the limestone, three or four very thin seams of coal. In favorable exposures, all of these are seen in the same bank. Over the upper one of these coals, we often find a fossiliferous limestone, sometimes passing into flint. This limestone over this coal may help to the identification of the coal with Coal No. 3*a* of the First District. But we find, sometimes, other limestones or flint layers between Coals No. 3*a* and No. 3, and when, in a ravine or hill-side, there is an exposure of only one of these several possible limestones, there is great difficulty in determining its exact place. I am inclined to believe that the limestone with a thin coal under it, found in most of the valleys of Upper Monday creek, about one hundred and ten feet below the Great or Nelsonville seam, is the limestone which properly belongs over Coal No. 3*a*. In some places the coal is seen without the limestone. In the ravine below the old Maginnis bank, near Old Straitsville, we find, one hundred and ten feet, by barometer, below the Great seam, a calcareous shale, containing shells, etc., with a thin coal below it. Twenty-one feet lower, by Locke's level, is a fossiliferous limestone, with thin coal under it. On another hill, to the north-west of Old Straitsville, a measurement with Locke's level gave one hundred and fifty-five feet to a group seen on Mr. Moore's land, in the valley of Monday Creek, as follows:

		IN.
1.	Block ore	6–8
2.	Blue shale	6–8
3.	Limestone, fossiliferous	8
4.	Thin coal.	

At Henry Hazelton's, a little higher up Monday Creek, the ore, seen in the bed of the creek, which was believed to be the equivalent of the block ore last mentioned, was found by Professor Irving, in 1869, to be one hundred and fifty feet below the great seam. There is flint under the ore, and a thin coal under the flint. At McCuneville, on Monday Creek, still higher up the stream, there is a blue fossiliferous limestone reported by Mr. McCune to be one hundred and fifty feet below the Great or Nelsonville seam of coal. Thirty feet above this blue limestone is a seam of coal from two to three feet thick. We have, I think, in a horizon about one hundred and fifty feet below the Great, or Nelsonville seam, the representative (if such exists in this region) of the Zoar limestone of Tuscarawas county, which is said to overlie Coal No. 3. About forty feet higher is the place of Coal No. 3*a*, with generally a limestone or fossiliferous shale over it; while approximately midway between the two coals mentioned is another thin seam also with a fossiliferous limestone overlying it. The place of the Putnam Hill limestone is approximately forty feet above Coal No. 3*a*, and the coal seam often found under it is the seam No. 4. This makes the usual interval between Coals No. 3 and No. 4, about eighty feet. This I have found to be the case in extended examinations made in several counties in the First District, where these numbers were first applied. Over each of these seams I have commonly found a limestone, and quite often a limestone over No. 3*a*, which is generally about half-way between the others. The Putnam Hill limestone, the place of which is about eighty feet below the Nelsonville seam, is not often seen in the Monday Creek region. On the hill back of the Bessie Furnace, west of New Straitsville, there is a fossiliferous limestone one foot in thickness, which is seventy-three feet below the Nelsonville or Great seam of coal. I have no doubt that it is the equivalent of the Putnam Hill limestone. The horizon of the Baird ore—here imbedded in fire-clay—is thirty-four feet higher.

In the report for 1869, and more particularly in the map, the limestones were confused, and in some cases the limestone over Coal No. 3*a* mistaken for the Putnam Hill, and perhaps in one or two cases a still lower limestone was called the Putnam Hill stone. So far as the errors applied to the more eastern part of the region covered by that report, they were corrected in the report on Muskingum county, in Vol. I, of the Final Reports.

From fifty to sixty feet above the horizon of the Putnam Hill limestone there is a seam of coal, called in the early report the Lower New Lexington coal, as it is found in the vicinity of New Lexington, and may be traced readily from that place to Zanesville. It is the lower seam at the Del Carbo mines, where the coal is good. In the high lands north west of New Lexington this seam appears. In the opposite direction—toward the village of Moxahala—it may also be readily traced. On the Sunday Creek waters it is below the surface of the valleys, but it has often been met with in borings. It is occasionally seen in the Monday Creek Valley, and also in the Hocking Valley, in the neighborhood of Nelsonville. On the land of John L. Gill, Esq., on Meeker Run, it is found in the bed of the stream; also on the land of the Lick Run Coal Company. The seam is one of wide range, but there are many localities where it is entirely wanting. This seam is probably Coal No. 5 of the First District.

Nelsonville Seam—We have now reached in our upward progress the most famous coal seam of the district, one which already plays an important part in the mining industry of Ohio. This seam of coal was noticed by the early geologists—Doctor S. P. Hildreth and Doctor C. Briggs—in the first Geological Reports. It was then appropriately named the Nelsonville seam, it being mined at that time at Nelsonville, where it is still largely mined. This is the best name the seam could have. It is the historical name, and it distinguishes the seam by a well known locality, where it is mined and where no other seam is worked. It is now called by a great variety of names, as the "Great seam," the "Great vein" (the word *vein* is entirely inapplicable to a seam of coal), the "Straitsville seam," the "Shawnee seam," the "Upper Sunday Creek seam," the "Upper New Lexington seam," "Coal No. 6," etc., etc. It is thicker at some points than at Nelsonville, but it is there a fine, large seam and worthy of honor. The famous Pittsburgh seam of coal is thicker at some other places than at Pittsburgh, but it would be very unwise to substitute a dozen different local names for the old one, or even attempt to make the world know it in the numerical disguise of Coal No. 8.

The Nelsonville seam is found along the Hocking River for many miles, rising to the west or northwest, and gradually sinking in the opposite direction until it passes below the level of the valley, not far from the mouth of Monday Creek. From that point it is reached by shafts. At the mouth of Hamley's Run the seam is from fifty to sixty feet below the surface, and at Salina and Chauncey about one hundred feet. At Athens it was reached in a shaft two hundred feet below the surface. It is to be seen in the hills bordering the river on the west, from the mouth of Floodwood Creek, where the coal is pretty low—yet amply above drainage—to the region of the Lick Run mines. The seam is every where of working thickness, and, while the quality of the coal is generally excellent, it is in some places very superior.

On Floodwood there are places where the sandrock "cuts away" or replaces a portion of the coal, but the mines of Messrs. Sheffield generally disclose the seam in fair development and of good quality of coal. On Meeker Run the seam ranges from a thickness of six feet to nearly nine feet. The following are two sections taken on the land of J. L. Gill, Esq:

1.

		FT.	IN.
1.	Yellow shale	12	7
2.	Top coal	5	..
3.	Shale	..	4
4.	Coal	2	2
5.	Shale	..	3
6.	Coal	2	2
7.	Shale	..	1½
8.	Coal	1	7

2.

		FT.	IN.
1.	Yellow shale	10 ?	..
2.	Coal	2	8
3.	Shale	..	3
4.	Coal	2	1½
5.	Shale	..	2
6.	Coal	1	10

Three samples of coal were taken from the lower three benches respectively, at the locality where the first of the above sections was measured, and analyzed by Prof. Wormley, with the following result:

1. Lower bench.
2. Second bench.
3. Third bench.

	1.	2.	3.
Water	5.80	6.80	6.00
Ash	4.50	2.10	4.00
Volatile combustible matter	31.60	29.40	29.40
Fixed carbon	58.10	61.70	60.60
Totals	100.00	100.00	100.00
Sulphur	0.90	0.63	0.74
Sulphur left in coke	0.60	0.21	0.46
Per cent. of sulphur to coke	0.95	0.32	0.71
Gas	3.50	3.61	3.73
Ash	Gray.	Yellow.	Dull white.
Coke	Compact.	Compact.	Compact.

The ultimate composition of sample No. 2 was determined as follows:

Carbon	71.43
Hydrogen	5.92
Nitrogen	1.54
Sulphur	0.63
Oxygen	18.38
Ash	2.10

The moisture (6.80 per cent.) is included in the above constituting 0.75 hydrogen and 6.05 oxygen.

Passing from the head of Meeker Run northward, we find the original mine of W. B. Brooks, Esq. Here the Nelsonville seam presented the following structure:

	FT.	IN.
Shale.		
Coal	2	..
Shale	..	3
Coal	2	4
Shale	..	2
Coal	1	7

It is sometimes a little thicker, the thickening taking place in the upper bench.

The first analysis of any coal from the Hocking Valley proper, after the Geological Survey was inaugurated, was of a sample furnished by Mr. Brooks from this mine. It is here given because it attested the great excellence of the coal, and proved quite a stimulus to those of us who were engaged in the investigation of the Nelsonville seam:

Specific gravity	1.259
Water	6.80
Ash	2.46
Volatile combustible matter	33 28
Fixed carbon	57.36
Total	99.90
Sulphur	0.74

At a later date I visited the mine and obtained samples of the coal from the three different benches of the seam, which were analyzed by Prof. Wormley:

No. 1, lower bench.
No. 2, middle bench.
No. 3, upper bench.

	No. 1.	No. 2.	No. 3.
Specific gravity	1.285	1.272	1.284
Water	6.20	6.65	5.00
Ash	2.70	1.90	9.05
Volatile combustible matter	31.30	33.05	32.80
Fixed carbon	59.80	58.40	53.15
Totals	100.00	100.00	100.00
Sulphur	0.97	0.41	0.94
Sulphur remaining in coke	0.082	Trace.	Not determined.
Ash	Gray.	Yellow.	Gray.
Coke	Compact.	Compact.	Compact.

If we exclude the top coal, which contains more ash than the rest, we have a coal of the very highest merit. No coal from the Hocking Valley has perhaps ever surpassed in popularity that from Mr. Brooks's west-side mine. It is dry-burning, and I should not hesitate to predict for it success in blast-furnace use, although not as dry-burning as the coal from Straitsville, Shawnee, and Sunday Creek.

In the Lick Run region the coal presents the same general structure of seam as further south. Here measurements showed the seam to be six feet two inches thick, with the usual partings. In this region the overlying sandrock has sometimes been found to be troublesome. The coal has been largely mined, and is valuable fuel. I find in my note-book no record of any analysis of the coal from this neighborhood.

From the shaft of the Columbus and Hocking Coal Company, at the mouth of Hamley's Run, samples of the coal of the Nelsonville seam were sent by Mr. Ogden, the Superintendent, to Prof. Wormley, and analyzed, as follows:

No. 1, bottom bench.
No. 2, middle bench.
No. 3, top bench.

	No. 1.	No. 2.	No. 3.
Water	4.80	4.70	4.80
Ash	6.30	4.50	8.90
Volatile combustible matter	30.40	30.30	28.00
Fixed carbon	58.50	60.50	58.30
Totals	100.00	100.00	100.00
Sulphur	1.15	0.71	4.20
Sulphur of coal in coke	0.46	0.24	2.47
Sulphur in per cent. of coke	0.71	0.37	3.67
Ash	Reddish.	Yellow.	Reddish.

On the east side of the Hocking River the Nelsonville seam is easily traced from the hills back of Haydenville, down past the town of Nelsonville to the mouth of Monday Creek. The coal is everywhere successfully mined. At the extensive mines of Peter Hayden, Esq., the seam measured six feet four inches in thickness, with partings quite similar to those found in the Brooks bank already referred to. Samples of coal sent from this mine were analyzed by Prof. Wormley:

No. 1, lower bench.
No. 2, middle bench.
No. 3, upper bench.

	No. 1.	No. 2.	No. 3.
Specific gravity	1.271	1.258	1.340
Water	6.45	5.30	5.45
Ash	2.25	1 09	9.36
Volatile combustible matter	32.74	30.12	29.88
Fixed carbon	58.56	63.49	55.31
Totals	100.00	100.00	100.00
Sulphur	1.19	0.64	1.63

These analyses show an excellent quality of coal. No. 2 shows an unusually small ash, a very large percentage of fixed carbon, and little sulphur.

Several years since, Wm. B. Hayden, Esq., conducted, in Columbus, a series of experiments with this coal to determine, in the usual working practice, the relative evaporating power of the coal from different parts of the seam, with the following results:

	Gals. water.
480 lbs. fresh-dug coal, without selection, evaporated	337
480 lbs. stained outcrop coal from top bench evaporated	315
480 lbs. Straitsville coal evaporated	330
160 lbs. coal, Hayden's middle bench, evaporated	97
160 lbs. " upper "	93

"The draft was the same in all cases, and the temperature of water in boiler the same. The feed-water was cold but of uniform temperature. Pressure of column of water in draft-gauge, 3-16 of an inch."

No analyses have been made of the coal from other banks on the east side of the river. The coal, as a rule, is excellent and popular. There are of course localities where the coal contains more than the usual percentage of sulphur—and the upper bench of coal varies somewhat in earthy impurities—but good coal is sent to market from all the mines.

The coal is easily mined by drifts into the hillsides, and good drainage and ventilation are easily secured.

The Nelsonville seam is easily traced from the mouth of Monday Creek along the valley of that stream up to Straitsville and Shawnee. At Bessemer, on the Cawthorn farm, it is seen in a temporary opening, and the quality of the coal appears to be good. There are here the usual three benches of coal, but on the top of the upper comes in a highly bituminous shale, with more coal above it. This shale is generally met with for some distance up Monday Creek, and along the valley of Snow Fork. It is sometimes a foot thick. At the mines at the Akron furnace, it is left for a roof, for which it will serve a good purpose. In places, the coal above this shale will be good, and probably reward its removal.

A little above the site of the Monday Creek Iron Company's Furnace, I noticed recently the beginning of a drift into the Nelsonville seam. The three lower benches were seen and measured, as follows:

	FT.	IN.
Coal	1	10
Shale parting	..	3
Coal	2	..
Parting	..	1
Coal	1	10

Over the upper coal of this section was seen the laminated bituminous shale observed on the Cawthorn farm, with more coal above, but measurements were impossible. The general quality of the coal appeared to be good, and although, perhaps, less dry-burning than at some other points in this coal-field, I should think it could be used in the manufacture of iron. I saw little sulphur in the small pile of coal at the outcrop, but the sulphur question always demands careful and special investigation wherever coal is to be used in furnaces.

Higher up Monday Creek, at Carbon Hill, I examined the coal some years since. At the point examined the coal is in three benches, the top of the upper being irregular and waving. Shales and not sand-rock formed the roof. The section is as follows:

	FT.	IN.
Clay shales.		
Coal, thickest place seen	4	..
Shale	..	4
Coal	2	6
Shale	..	1
Coal	2	..

Here the bituminous shale and top coal, noticed down the creek, were not seen.

Passing over the hill to Sand Run, I found, about half a mile south of the road from Carbon Hill to Straitsville, an exposure of the Nelsonville seam, which gave the following measurements:

	FT.	IN.
Yellow shales.		
Coal	1	4
Highly bituminous shale	..	10
Clay shale	..	6
Coal	3	7
Shale	..	3
Coal	2	1
Shale	..	1½
Coal	2	1

On the lands of the Crafts Iron Company, near the junction of Little Monday Creek with Monday Creek, the Nelsonville seam lies in the high hills west or north-west of the furnace. I made no measurements of the coal, but the seam is reported to be nine and one-half feet thick. The coal, as mined, appeared remarkably well. It mines in large blocks, is free from slate, and contains very little visible bi-sulphide of iron. Unless there is sulphur in other combination—which analyses only will detect—I should confidently predict that this will prove a very successful furnace coal. The coal will be brought down to the furnace by a tram-road, and the same road will bring down the ore.

The valley of Lost Run reveals the coal in fine thickness, as we should expect, this branch of Monday Creek being the next one south of Sugar Run, where are the New Straitsville mines. At one exposure—at what was called J. D. Clarke's opening—the coal was found to measure ten feet four inches, exclusive of the usual shale partings. On the land of the late William Ward, Esq., the lower eight feet of good coal were seen, the top not being uncovered. On the land of Thomas Barnes, the seam measured nine feet ten inches. In 1869, I obtained samples of the Lost Run coal—three from the Ward opening, and three from the Clarke bank—which were analyzed by Professor Wormley: No. 1 from middle of lower bench; No. 2 from middle of the middle bench. Nos. 3, 4, 5, and 6 represented the upper bench in ascending order. Of these, Nos. 1, 2, and 4 came from the Ward land, and the others from Clarke's bank.

	No. 1.	No. 2.	No. 3.	No. 4.	No. 5.	No. 6.
Specific gravity	1.278	1.290	1.257	1.284	1.287	1.274
Water	7.15	6.80	5.85	6.15	5.80	3.05
Ash	2.41	2.05	1.93	4.88	7.63	11.05
Volatile matter	35.28	36.16	37.10	33.22	36.42	38.39
Fixed carbon	55.16	54.99	55.12	55.75	51.15	47.51
Total	100.00	100.00	100.00	100.00	100.00	100.00
Sulphur	1.35	1.07	1.42	1.88	1.01	4.04
Sulphur remaining in coke	1.81	0.79	0.51	1.00	0.50	2.02
Percentage of sulphur in coke	1.31	1.30	0.85	1.56	0.81	3.35
Color of ash	Lt. fawn.	Lt. fawn.	Lt. fawn.	Gray.	Cream.	Gray.

As the coals, with the exception of No. 6, showed to the eye little of the usual bi-sulphide of iron, and as a similar suite of samples from the same seam at Old Straitsville, had, upon analysis, revealed much less sulphur, I expressed to Professor Wormley some surprise at the larger per centage of sulphur in the Lost Run samples. He at once repeated the sulphur determinations, and with exactly the same results. This led to a request that he would determine, by analysis, the exact amount of iron there might be in the samples, so that we might see if there was enough to absorb, as a bi-sulphide, the sulphur. This he kindly consented to do, and the results given in the Report for 1869 are here copied, as follows:

	No. 1.	No. 2.	No. 3.	No. 4.	No. 5.	No. 6.
Sulphur	1.35	1.07	1.42	1.88	1 01	4 04
Iron in coal	0.77	0.57	0.38	1.42	0.09	2.11
Percentage of sulphur required by the iron.	0.878	0.650	0.433	1.620	0.102	2.408

In no case was there iron enough to take up in combination all the sulphur. In No. 5 only one-tenth of the sulphur could be thus taken up. Professor Wormley followed up these researches with reference to the combinations of sulphur in coals with distinguished success, and previous opinions of scientific men in regard to such combinations have been abandoned. Professor Wormley discusses these matters in the Annual Report for 1870. These special investigations may be said to have originated in the finding of a little more sulphur in the Lost Run coals than I had expected to find.

It is very probable that there may now be new openings into the

Nelsonville seam on Lost Run, from which the coal will show less sulphur, no more, indeed, than at Straitsville.

At Old Straitsville, at the original Maginnis bank, the Nelsonville seam is eleven feet thick, divided as follows:

	FT.	IN.
Blue shale.		
Coal, upper bench	6	10
Shale	..	4
Coal, middle bench	1	8
Shale	..	2
Coal, lower bench	2	..

A suite of samples was taken in 1869 for analysis. These were No. 1 and No. 2, from the lower bench; No. 3 and No. 4, from the middle bench; Nos. 5, 6, and 7, from the upper bench.

	No. 1.	No. 2.	No. 3.	No. 4.	No. 5.	No. 6.	No. 7.
Specific gravity	1.291	1.241	1.239	1.241	1.307	1.247	1 248
Water	7.90	8.15	7.26	7.55	7.60	6.00	5 35
Volatile matter	34.63	27.46	32.29	35 61	29 65	32 15	30.48
Fixed carbon	54 29	61.73	59.44	54 90	52.77	59 41	57.21
Ash	3.18	2.66	1.07	1.94	9 95	2 44	6.96
Total	100.00	100.00	100 00	100.00	100.00	100 00	100.00
Sulphur	0.98	0.78	0.73	1.05	0.68	0.50	1.52

The average percentage of sulphur is 0.85, which is very small. The average percentage of ash is 4.03. During the first year of the Survey, the Maginnis bank was the only place in all this region where fresh, firm specimens of the whole seam could be obtained. Although little coal had ever been taken from this bank, it was, nevertheless, famous on account of the thickness of the seam, and the seam itself was often called the Straitsville seam. At the beginning of the Survey, it was popularly believed to be another seam than the one at Nelsonville.

When the branch railroad was afterwards built from Logan to the Sugar Run valley, the town of New Straitsville was laid out, and extensive mines opened. Here the seam is as thick as at Old Straitsville, and similar in its structure, and in the quality of the coal. Samples selected by Professor Wormley and myself from the mine of the Straitsville Mining Company were analyzed.

No. 1, lower bench; No. 2, middle bench; No. 3 and No. 4, from upper bench.

	1.	2.	3.	4.
Specific gravity	1 260	1.281	1.262	1.276
Water	7.70	7.40	7.20	5 30
Ash	2 60	2 95	5.15	7.95
Volatile matter	30 70	29 20	30.10	31.00
Fixed carbon	59.00	60 45	57.55	5[illegible].75
Total	100 00	100.00	100.00	100.00
Sulpur	0.49	0.93	0 57	1 18
Sulphur remaining in coke	0 082	0 015	0 26	0.082
Per centage of sulphur in coke	0.133	0.023	0 41	0.128

Here was an unexpected revelation in the behavior of the sulphur in the coking of the coal. The old belief had been that about one-half of the sulphur passes off in coking, but here in all the samples except one nearly all the sulphur was driven off. In No. 2, 0 93 per cent. of sulphur was found in the coal, and of this only 0 015 per cent. remained in the coke, leaving the coke almost as pure as charcoal. It was at once concluded that a coal which would part with nearly all its sulphur in the top of the furnace in the process of coking, would serve admirably for a furnace fuel. On further investigation it was found that the coal was sufficiently dry-burning to warrant its use in furnaces in the raw or uncoked state. Thus it was determined, by scientific methods, that the coal of the Great Nelsonville seam, at New Straitsville, which could be mined most cheaply, and with every advantage for perfect drainage and ventilation of mines, was a superior iron-making coal, and as the greater includes the less, was also well adapted to almost every other use.

In 1869, few good exposures of the Nelsonville seam were found on Shawnee Run. The report states that "on the lands of J. Gordon and Henry Welch the coal is very heavy, but the mines are so fallen in at the openings that no measurements could be made" These farms are now included in the village of Shawnee. The seam of coal ranges from eight to eleven feet, with partings generally similar to those at Straitsville. Here the coal is very extensively mined for shipment by railroad, and four furnaces at Shawnee are using it with great success in the smelting of the ores of Iron Point, near by.

At McCuneville the same seam of coal is worked, both for shipment and for fuel for the salt works. Here the seam is less thick, and indeed it generally grows thinner to the northward, and less dry burning. Between McCuneville and the Bristol Tunnel there are several mines, and the coal is of excellent quality, and popular as a house and steam coal.

In the hills west of Monday Creek, between it and Little Monday

Creek, are several valuable bodies of the great seam. The coal on the Jared Dennison farm, in Monday Creek township, Perry county, was referred to in the First Report. I afterward revisited this region and examined the coal on this ridge more carefully, and found some of the finest coal in the State. A good exposure of the seam was found on the land afterward bought by the Baird Iron Company, and the coal was thought to be very pure and well adapted to the blast furnance. Ores of excellent quality from this region had for many years been taken to the Logan furnace, with which Mr. Baird had formerly been connected. Hence, with tried ores and coal of the highest promise, it is not to be wondered at that the pioneer furnace in this immediate coal field should be located at this point. It should be stated that Mr. Baird had previously used the coal of the same seam from the Straitsville mine in the furnace under his management, at Columbus. To the late Samuel Baird, Esq., must, therefore, be accorded the honor of being the first to realize in practice the value of the coal of this field as an iron-making coal, it being first successfully used by him at Columbus, and afterward at the Baird Iron Works. The Winona furnace, on Little Monday Creek, will doubtless be able to obtain coal from the Dennison lands, or from that vicinity. A tram-road would take down both fuel and ore. South of Gore are similar out-liers of coal, from which the Thomas furnace obtains its fuel. Two or three miles north of the Baird furnace I found what I thought to be the Nelsonville seam, on the land of George Kochensperger. No levels were taken, nor intermediate sections, and there may be a mistake in identification, but I think not. The seam is much thinner than farther south, but the loss is, as usual, chiefly in the diminution of the upper bench. The whole section taken here and on the adjacent land of Jacob Martzoff is as follows:

	FT.	IN.
Coal not opened.		
Interval	27	..
Coal not opened.		
Interval, lower ten feet yellow shale	25	..
Coal, upper bench	..	7
Shale parting	..	2½
Coal, middle bench	1	9
Shale parting	..	1
Coal, lower bench	1	5
Interval	22	6
Bituminous shale	..	6
Coal	2	6
Interval	16	..
Ore, limonite	1	..
Flint	1?	..

Samples of the lower and middle benches of the coal from Mr. Kochensperger's bank were analyzed by Prof. Wormley, as follows:

No. 1, lower bench; No. 2, middle bench.

	1.	2.
Specific gravity	1.285	1.267
Water	7.20	5.70
Ash	2.00	4.20
Volatile matter	34.20	34.90
Fixed carbon	56.60	55 20
Total	100.00	100.00
Sulphur	1.20	2.13
Sulphur left in coke	0.52	1.01
Per cent. sulphur in coke	0.88	1.71
Ash	Gray.	Gray.

Snow Fork is the most eastern tributary of Monday Creek. Rising east of Straitsville it flows south, near the east line of Ward township of Hocking county, and bends westward to meet Monday Creek a little below Bessemer. The Nelsonville seam is to be seen at intervals along this stream and on its western tributaries. By these tributaries a vast body of coal is made accessible. The coal can be mined up the dip, and easy drainage secured. Ward township contains so much coal that the existence of it on any farm gives the farm no distinction whatever. The Nelsonville seam extends as a continuous sheet of coal through the whole township, varying in thickness from six to eleven feet. There are localities where the coal has been made thin, or been entirely removed by eroding agencies exerted during the deposition of the Coal Measures; but the limits of these can only be ascertained by practical tests. There are places along Snow Fork where I am led to think the coal is too thin to be of any value. We see the intrusive sand-rock at some points usurping the place of the coal. As a general rule—but a rule to which I have in my observations found many exceptions—the quality of the coal under an immediate sand-rock cover is much more likely to be contaminated with bi-sulphide of iron. This was seen to be the case at some points on Snow Fork.

In section 4, Ward township, Mr. Gilbert, my assistant, took the following section:

	FT.	IN.
Coal, not opened (Bayley Run seam).		
Interval	25	..
Limonite ore (sandy)	..	4
Interval	1	..

	FT.	IN.
Limestone, not measured.		
Laminated sandstone	14	..
Coal, not opened, (Norris seam).		
Clay shale	5	..
Laminated sandstone	25	..
Sandstone	15	..
Coal, upper bench, Nelsonville seam	3	6
Shale, "	..	3
Coal, middle bench, "	1	5
Shale, "	..	1
Coal, lower bench, "	2	6

On the land of James Hawkins, Section 3, Ward township, I obtained the following section :

	FT.	IN.
Sand-rock.		
Coal	1	3
Bituminous shale	1	..
Coal in three benches	6	..

On the La Follett farm, Section 2, Ward township, on Brush Fork, one-third of a mile above the mouth, I obtained the following section :

	FT.	IN.
Sand-rock.		
Yellow shale	2	6
Coal, Nelsonville seam	1	8
Bituminous shale, Nelsonville seam	..	7
Coal, "	3	..
Clay parting, "	..	4
Coal, "	1	8
Parting, "	..	1
Coal, "	1	8

About forty-five or fifty feet above is the trace of another seam of coal.

On the land of J. Mancoff, now a part of the Bessemer property, in Section 1, in the same township, I found:

	FT.	IN.
Yellow shales.		
Coal	2	2
Bituminous shale	..	11
Coal	2	3
Shale	..	4
Coal	1	8
Parting	..	1
Coal	2	..

On the lands of Messrs. Buckingham and Wright, on the east side of

Snow Fork, I obtained three measurements of the Nelsonville seam, as follows :

NUMBER ONE.

		FT.	IN.
Sand-rock.			
Irregular shale		..	6
Coal	3 feet to	3	6
Clay		..	3
Coal		1	5
Parting		..	1
Coal		2	..

NUMBER TWO.

	FT.	IN.
Clay shale.		
Coal	1	..
Bituminous shale	1	..
Coal	3	6
Clay	..	3
Coal	1	4
Parting	..	1
Coal	2	...

NUMBER THREE.

	FT.	IN.
Sand-rock.		
Clay shale	3?	..
Coal	2	..
Slaty coal, or highly bituminous shale	1	5
Coal	2	..
Clay	..	3
Coal	1	6
Parting	..	1
Coal	2	..

In Nos. 2 and 3 there is a fourth bench of coal. This is to be seen everywhere in the lower part of the Snow Fork valley, where the seam is in its complete or normal state. In some places not only is this top coal gone, but the bituminous shale below it, both being replaced by sand-rock.

No mines have been opened on Snow Fork so far as I know, except thos recently opened at the Ogden and Akron furnaces. At the former the top coal and shale are replaced by sand-rock, and the coal is probably less good than will be obtained under better cover. The Ogden Furnace is an exceedingly perfect one in all its equipments, and is worthy to be fed with the very best fuel the Snow Fork valley affords.

At the Akron Furnace mines the Nelsonville seam is overlain by yellow shales. The upper or fourth bench, with the bituminous shale under it, is left for the roof. It may not be very good coal, but I think it is sure to be very dry burning, and it should be investigated. I obtained the following measurements of that portion of the seam mined:

	FT.	IN.
Coal	2	7
Parting	..	2
Coal	2	..
Parting	..	½
Coal	1	6

The quality of the coal is good, and is reasonably dry-burning. Since my visit the furnace has commenced its blast, and the coal is reported to work satisfactorily.

I have no detailed measurements of the coal in the upper part of the Snow Fork valley. In the Report for 1869, reference is made to the coal on the land of A. Marshall, Section 35, Salt Lick township, Perry county. It was then reported to me to be eleven feet thick, but the pit being filled with water, no measurements were possible. I have since visited the place but the water was still in the way of measurement. About three hundred yards above the Marshall opening, Mr. Thomas Black bored for the seam and found it six feet thick, twenty-seven feet below the surface. On the land of Bayliss Glenn the Nelsonville seam is quite thin, two feet six inches, if that be it which appears in the floor of the spring-house. Twenty feet and eight inches higher is a thin unopened seam, the interval being yellow clay shale, and at an elevation of eighty-two feet, by barometer, is another seam reported to be three and one-half feet thick and of excellent quality. This upper one is doubtless the Bayley's Run seam. East of Bayliss Glenn's, in Bear Run, on the Maxwell land, a shaft was sunk to reach the Nelsonville seam. It was found to be quite thin. About forty-five feet above the seam in the shaft is the middle or Norris coal, and about forty-five feet higher the Bayley's Run seam. The last interval was wrongly given in the Report for 1869. On the profile map, published with the Report of the State Inspector of Mines, the latter seam at this locality is stated to be the "Great Vein." In the shaft large concretionary masses of an exceedingly hard sandy limestone, were found embedded in a laminated sandstone twelve feet above the Nelsonville coal. Such masses are very common on some of the branches of Sunday Creek, in places where the coal is thin and the shales over it have been disturbed. That the thin coal in this shaft is the Nelsonville seam, I have not the least doubt. Its place along Snow Fork is everywhere apparent, and the regular dip should place it beneath the surface on Bear Run. The two seams of coal above hold to it the same relation they everywhere hold to the Nelsonville seam. In this obvious view of the matter I am sustained by Mr. Thomas Black, who sunk the shaft, and has bored a large number of test holes in this field to determine the location and thickness of the Nelsonville seam.

The Nelsonville Seam in the Sunday Creek Valley.—Passing over the ridge from the head of the right-hand fork of Snow Fork we descend into the valley of the West Fork of Sunday Creek. Here the Nelsonville seam is seen on Priest's Fork of the West Fork, but I have no measurements of its thickness. At the mouth of Priest's Fork, at the little village of Hemlock, in Perry county, we find the coal disturbed by intruding sand-rock, which replaces a part of the coal, and, indeed, takes its place altogether at localities near by. This disturbance extends up Sulphur Fork as far as the sulphur spring, and from this point the coal becomes more regular, as we go northward. The best exhibition of coal above the sulphur spring observed is at the bank of the late Samuel Lyons, where, in some rooms, the coal is from seven to eight feet thick, and of good quality. From this point the seam probably thickens to the east, for on another branch of the West Fork, not far distant in that direction, the seam is twelve feet thick.

At an old opening on the farm of Mr. Benjamin Sanders, a little below Hemlock, a laminated sand-rock replaces all the upper part of the seam, leaving only two feet ten inches of the middle seam with the lower one. But not far east, we find in the bed of the stream the seam with no sand-rock over it, but clay shale with coal plants. Here the upper bench measures three feet four inches, and four feet or more of the middle bench are visible above the water. It would appear that the great seam had now gotten beyond its troubles, but a little below we find an ancient channel-way, in which the whole seam is cut almost square off, and the channel filled not with sand, but with unstratified mud, now hardened into a tough clay-rock. A similar removal of the coal by a square cut-off and replacement with clay is seen near the stream a little below. This eroded channel, which apparently extends to some depth below the coal, has no connection whatever with the other eroded channels filled with sand-rock. The former was probably formed by a narrow, confined current, which cut through the coal after it had become hard, and afterwards the channel was filled with mud. In the other case, it is quite possible that the currents of water which removed the coal also brought in the sand now changed to sand-rock. A few miles north, in a railroad cut, I found a fine rounded bowlder of hard coal in the sand-rock over the same seam. I found, a few years since, in West Virginia, many angular fragments of coal imbedded in a sand-rock in a similar way.

Below Mr. Sanders's, the seam presents the following measurements:

NUMBER ONE.

	FT.	IN.
Clay shale, coal plants.		
Coal, upper bench	1	1
Shale	--	3
Coal, middle bench	5	9
Shale	--	1½
Coal, lower bench	3	--

NUMBER TWO.

	FT.	IN.
Shale.		
Coal, top	3	9½
Shale	--	2½
Coal, middle	5	2½
Shale	--	1
Coal, bottom	3	--

NUMBER THREE.

	FT.	IN.
Shale.		
Coal, top	3	--
Shale	--	2½
Coal, middle	5	6
Shale	--	2
Coal, bottom	3	1

The thickness of coal, exclusive of the thin partings, is nine feet ten inches, twelve feet, and eleven feet seven inches, respectively, at these different openings. These openings are all near the town site of Buckingham. It will be noticed that there is an unusual thickening of the middle bench. This everywhere characterizes the Nelsonville seam on Upper Sunday Creek. At Straitsville and Shawnee, on the Upper Monday Creek, the upper bench is the thickened one. Three specimens of the coal from Buckingham were analyzed by Professor Wormley. Two of the samples I selected from the middle bench at locations of measurements No. 1 and No. 2, and the third from the lower bench at No. 2. The analyses are as follows:

	No. 1.	No. 2.	No. 3.
Specific gravity	1.300	1.315	1.328
Water	5.60	5.20	4.70
Ash	2.03	3.50	7
Volatile combustible matter	29.92	30.80	31.30
Fixed carbon	62.45	60.50	57.
Total	100.00	100.00	100.00
Sulphur	0.76	0.68	1.01
Sulphur left in coke	....	0.41	0.68

The coal mines very large and blocky, and is, I have no doubt, peculiarly adapted to the blast furnace.

On Rechter's (or Coal) Fork, the coal is to be seen for a long distance in the bed of the stream. An excavation was made to allow of a vertical measurement, where I found the seam as follows:

	FT.	IN.
Shale	20	..
Coal, top bench	3	7
Shale	..	3½
Coal, middle bench	5	6
Shale	..	1½
Coal, bottom bench	3	..

Making twelve feet one inch of coal, exclusive of partings. Three samples of the upper bench, to represent different parts of it, were analyzed by Professor Wormley, and the average is given in No. 1 of the table below. No. 2 of the same table is the average of five analyses of samples of the thick middle bench.

	No. 1.	No. 2.
Specific gravity	1.295	1.321
Water	4.76	5.16
Ash	6.50	6.66
Volatile combustible matter	32.23	28.84
Fixed carbon	56.50	59.34
Total	99.99	100.00
Sulphur	0.91	0.81
Sulphur left in coke	0.29	0.43

At the Welsh bank, on McDonald's Fork, I obtained the following measurements of the Nelsonville seam:

	FT.	IN.
Blue clay shale, with plants.		
Coal, top bench	3	11
Shale	..	2½
Coal, middle bench	5	10
Parting	..	¾
Coal	..	4
Parting	..	¾
Coal, lower bench	2	9

Making a total thickness, from roof to floor, of thirteen feet two inches, from which four inches of partings must be deducted. It may be stated that the large block of coal, twelve feet eight inches high, at the Centennial Exposition at Philadelphia, in 1876, came from this vicinity.

From the Welsh bank I selected five samples for analysis: No. 1, middle of top bench; No. 2, upper part of middle bench; No. 3, middle of middle bench; No. 4, lower part of middle bench; No. 5, middle of bottom bench.

	No. 1.	No. 2.	No. 3.	No. 4.	No. 5.
Specific gravity	1.302	1.316	1.300	1.385	1.312
Water	4.60	5.20	4.30	4 90	4 40
Ash	4.70	5 00	4.20	13 30	2.70
Volatile combustible matter	33.40	31.40	32.70	28.30	30.60
Fixed carbon	57.30	58.40	58.80	53.50	62 30
Total	100.00	100.00	100.00	100 00	100.00
Sulphur	0.71	0.74	0 71	0.79	0.90
Sulphur left in coke	0.35	0.38	0.35	....	0.43

Higher up the stream, on Rogers's Fork, near the north line of the north-west quarter of section seven, Monroe township, the coal was found to be twelve feet thick, in a boring made by Mr. Thomas Black. The seam is about twenty-eight feet below the level of the stream.

On the Middle Branch of Sunday Creek the same seam is also found in fine thickness. At the Sands bank the seam shows the following structure:

	FT.	IN.
Shale, with plants.		
Coal, top bench	2	11
Parting	..	1
Coal, middle bench	5	3
Parting	..	2
Coal, lower bench	2	10

Analyses of seven samples representing the same seam, were made by Professor Wormley, and published in his report in the Geological Report for 1870. The average of the seven analyses is as follows:

Specific gravity	1.300
Water	6.42
Ash	5.54
Volatile combustible matter	33.87
Fixed carbon	54.17
	100.00
Sulphur	0.88

The percentage of sulphur in the upper seven feet of the seam is only 0.53, per cent. which is quite small.

Many test borings have been made at points where the seam is below the beds of the streams. At Ferrara, the seam was found to be eleven feet six inches thick twenty-nine feet below the surface of the bank of the creek. On Dodson's Branch of the Middle Fork, a boring on the Fisher place revealed the coal to be ten feet ten inches thick fifty-three feet below the surface. Here the seam was covered by four feet of shale. In a branch of the West Fork, between Ferrara and Buckingham, Mr. Black found, in boring, the coal to be twelve feet thick. On the Abraham Post farm, on Middle Fork, section twenty-seven, Monroe township, a boring revealed a thickness of nine feet six inches.

From these facts it will be seen that there is on the upper Sunday Creek waters an immense body of coal, and that here the Nelsonville seam has its greatest development. I know of no other locality west of the Alleghany Mountains, where so much good coal can be found in a single seam. The coal is very dry-burning, and also remarkable for its very small percentage of sulphur. That it will prove a very superior fuel for smelting iron, I have not the least doubt, nor that it is to play a most conspicuous part in the future metallurgical industries of the West. When railroads now projected are completed, this coal field will be brought into easy connection with the vast deposits of black-band ores of the State, and with the rich Lake Superior ores. The latter ores will be brought to this coal as cheaply as they are now taken to Pittsburgh, where fuel is more expensive. Recent investigations made by me, show that Ohio is extremely rich in black-band ores, not only in those over Coal No. 7, as in Tuscarawas county, but over Coal No. 5—the latter being of great promise.

If we follow the Nelsonville seam south of Buckingham into Athens county, we find a considerable area, or perhaps several small areas, where the seam is thin and of little value. South of this defective region, the coal becomes thick and valuable. I have the detailed record of a large number of borings within the doubtful territory. They generally disclose the Nelsonville seam, but in diminished thickness. It is always found, if found at all, in its proper geological horizon, and where the dip would carry it. A profile, published in the Report of the State Mine Inspector for 1877, stated to have "been compiled from materials gathered by the Geological Survey," showing the supposed position of the coal seams along a north and south line between Snow Fork and Sunday Creek, presents a very remarkable anticlinal in the Nelsonville seam. This seam is known to dip below drainage south of Buckingham; and at the Blondin shaft, in fraction thirty-six, Trimble township, Athens county, it is ninety-four feet six inches below the surface. Between these points, on Johnson's Run, the profile referred to brings up the seam above the surface, that point being the crown of a great arch. At the same place, the Bayley's Run seam is brought down in the form of a synclinal, so as almost to meet the Nelsonville seam. It is like two parentheses, or two bows, placed horizontally back to back, as here shown, ≍. Directly over these curves, the strata of the Coal Measures are horizontal. I must express my dissent from this profile. If we should admit that after the deposition of the Nelsonville seam some force threw it up in the form of an arch, it would be impossible to produce a synclinal over the arch. Coal could not be formed at the bottom of a deep depression and at the same time be continuous with the coal beyond the limits of the depression; and if a subsidence took place here after the regular Bayley's Run seam was formed, so as to lower the seam fifty feet, more or less, such subsidence must necessarily flatten the arch of the Nelsonville seam underneath. It must be remembered that these supposed curves were formed during the progress of the formation of the coal series, for the horizontal strata above show that afterwards the work of deposition went on regularly without disturbance. Anticlinals and synclinals are not uncommon in our coal fields; but all I have ever seen took place after the whole series was formed, and all the strata undulate together.

But the most simple and practical refutation of this geological profile, is the fact that everywhere in the region of this supposed arch of the Nelsonville seam the borings show the existence of the Nelsonville seam *below* the arch. Mr. Thomas Black, whose knowledge of the coal seams in the Sunday Creek valley is more full and minute than that of any other person, has made a large number of borings in this vicinity for the sole purpose of finding the Nelsonville seam. The borings were made with care, and I have the utmost confidence in the trustworthiness of his records. From him I have received the detailed records of eight test wells, extending east and west across this supposed arch. Some of these are in the very axis of the anticlinal, some a little south and others north of it. In one well he found no coal of any seam. In six, and perhaps in the seventh, he found the Nelsonville seam, in thickness varying from one foot six inches to six feet six inches. In four cases he found the middle or Norris seam above the Nelsonville seam, and in one case he bored below the latter seam where it was four feet thick, and found the Lower Lexington seam twenty-eight feet lower, three feet six inches thick. The depths of the Nelsonville seam beneath the surface, of course, varied with the different elevations of the surface, and with the dip of the seam, but they ranged from thirty-five to eighty feet. Mr. Black found the seam where the dip would take it, that is, below the surface in all the valleys, indeed, just where it ought geologically to be. The profile places it above the surface on Johnson's Run, where it certainly ought not to be.

In a marginal note on the profile section we read as follows: "Maxwell's bank, one-half a mile west of line of section, Great Vein coal five feet ten inches thick, including seven inches cannel at bottom." This note is so placed on the profile as to imply that the Maxwell bank is within the range of the supposed uplift or anticlinal.

By the term "Great Vein" is doubtless meant the Nelsonville seam. I have often visited the so-called Maxville bank, with the cannel coal or cannel shale at the bottom. Two feet below the coal is a limestone covered with iron ore. This seam of coal I have traced over wide areas, and feel entirely confident that it is the Bayley's Run seam. The ore and limestone below it are probably the equivalent of the Bessemer ore. The coal some forty-five feet lower (by barometer) is the middle or Norris seam, and the coal seam in the shaft about forty-two feet lower is the Nelsonville seam or the "Great Vein," *i. e.*, what is left of its greatness, for the seam is very thin. If the Nelsonville seam had been gradually rising from the south on Snow Fork, to the elevation of the Maxwell bank, it is impossible that Mr. Black and others interested, should not have somewhere met with it in the hills. Expensive researches below the surface would thus have been saved. Further south in the same range of hills I find the equivalent of the Maxwell coal four feet eight inches thick, and ninety feet (by barometer) above the Nelsonville seam, which there shows a total thickness from roof to floor of nine feet.

Returning from these digressions we find, in following the Nelsonville seam down Sunday Creek, that in Trimble township, Athens county, it becomes thick again and of much value. In the Geological Report, Vol. I, I have published in the report on Athens county, the more important facts respecting the coal in Trimble and Dover townships. Besides this I have contributed to two private Reports on the same field. Since the last Report was printed, a shaft has been sunk to the coal. This is near the center of fraction 36, Trimble township. At a depth of ninety-four feet from the surface, the Nelsonville seam was reached and found to be twelve feet thick. The reported structure of the seam is as follows:

	FT.	IN.
Shales.		
Coal, bone coal	1	..
Splint coal	2	..
Cannel coal	1	..
Coal, dry-burning and excellent	3	..
Parting	..	½
Coal, somewhat bituminous	5	..
Total	12	½

The coal of the lower bench is apparently less dry-burning than that above the parting, but the sample of it shown me appeared to be of good quality. I am inclined to believe that the layer of cannel is merely a local modification of the coal, and that there will be found, when the seam comes to be worked a little distance from the shaft, six feet of good dry-burning coal above the parting. The upper foot of coal, which is earthy, will probably be left in the roof. For household and steam purposes the remaining eleven feet could be mined and shipped together, but for furnace use the coal above the parting will, I think, prove the more desirable.

In addition to this shaft several test wells have been sunk to the Nelsonville seam, viz., the Chappalear well within the town site of Ewing, Trimble township, in which the coal was reported to be eight feet four inches thick; Green's Run well, Section 13, Trimble township, revealing a thickness of ten feet of coal; a well at the head of Green's Run, Section 25, Trimble township, with seven feet of coal, and the Bayley's Run well, Section 21, Dover township, in which the seam is eight feet two inches thick.

These borings cover a pretty large area, and it is believed that there is here a large field in which the Nelsonville seam will be found persistent and in fine thickness. At Chauncey the same seam is six feet thick, and has been mined by a shaft for many years for the supply of fuel to the salt works.

Five analyses of the coal obtained from the borings in the test wells alluded to were made by Prof. Wormley. The average of the five is as follows:

Water	3.85
Ash	6.94
Volatile combustible matter	33.61
Fixed carbon	55.60
Total	100.00
Sulphur	0.96
Sulphur remaining in coke	0.40

The percentage of water is a little less than is usual with the coal of this seam, and that of sulphur about the same. The ash is a little greater, but it should be remembered that the samples analyzed were borings in which the shale of the partings might have been mixed. When a railroad is constructed down the Sunday Creek valley, this coal will be very accessible, as shafts can be sunk by the side of the road and the coal be mined up the dip.

North of the upper Sunday Creek we find the Nelsonville seam on the waters of the Moxahala; and the seam may be traced to New Lexington in one direction, and McLuney Station and thence to Zanesville in another. It is much thinner, and is somewhat changed in character. It is mined at many points on the Cincinnati and Muskingum Valley Railway east of New Lexington, and is the basis of a pretty large traffic. The coal is more soft and melting than where the seam is thicker; but many people prefer such coal. Along the Ohio River, the Pittsburg coal, which is highly melting and adhesive, is generally preferred to the harder and dryer coals. In the very high hills south of Somerset, Perry county, the Nelsonville seam is found. At Joshua Green's coal bank, Reading township, the seam measures five feet in thickness. The coal is rather dry-burning, and is prized for domestic and steam purposes. Patrick Redman and Michael Gainer, in the same township, have also mined the Nelsonville seam. There are, by estimate, 1,000 acres of productive coal land containing this seam, in Reading township. The same seam was noticed on the land of Hon. Lewis Green. About forty feet above, is the Middle, or Norris coal of upper Sunday Creek, which has been mined. Traces of the Bayley's Run, or Stallsmith seam were found thirty five to forty feet higher. Below the Nelsonville seam, the Lower Lexington seam is reported. Thus four distinct coal horizons are found in this ridge. These high grounds are remarkably well adapted to fruit, and large vineyards and peach and other orchards were seen. The ridge is, by barometer, about 320 feet above St. Joseph's Run, on the road to Somerset.

The Nelsonville seam appears farther east, in Clayton and Harrison townships. On a hill, a mile and a half west of Saltillo, a section was taken, which showed the coal seams as follows:

	FT.	IN.
Coal, Nelsonville seam, not measured.		
Interval	25	..
Coal, Lower Lexington seam.		
Interval	40	..
Coal, thin.		
Interval, estimated	15	..
Coal	..	10
Interval, estimated	10	..
Ore, siderite.		
Flint, fossiliferous, the equivalent of the Putnam Hill limestone	2–3	..
Clay	1	6
Coal	1	..

On the land of James Watts, a little south-east of Saltillo, a bank is opened in what I supposed to be the Nelsonville seam, the coal being three feet six inches thick, and of good quality. In the bed of the stream was seen the Putnam Hill limestone, with four inches of flint above it and eight to ten inches of siderite ore upon the flint. In the bed of Buckeye Creek, a little below Saltillo, we find a body of laminated micaceous sandstone, in which lie buried petrified logs of coniferous wood. This is the finest locality for specimens of such wood I have met with in the State. The top of the laminated sandstone is only a few feet below the Putnam Hill limestone, the interval being chiefly made up of bluish clay shale, of which six feet were seen. In the sandstone are many indistinct impressions of plants, all showing that they were drifted.

In all this region, the Nelsonville seam of coal is to be found, as shown in the Report for 1869.

Coal Seams above the Nelsonville Seam.—In the Report for 1869, two seams of coal were seen on the upper waters of Sunday Creek; the lower called the Norris, or Middle seam, and the upper the Stallsmith seam. I am now inclined to believe that there is, in the Hocking Valley, a third, the place of which is between the horizon of the Norris seam and the Nelsonville seam. At various places we find a coal from eighteen to thirty feet above the latter, and generally separated from the latter by clay shales weathering yellow.

On the land of Thomas M. Boyles, near the mouth of Meeker Run, York township, Athens county, there is a seam of coal about twenty-seven feet above the Nelsonville seam, the interval, so far as seen, composed of clay shales. It is three feet thick. Over it is a black bituminous shale, containing marine shells (*Lingula*), with a clay shale above, containing coal plants. A sample of this coal was analyzed by Professor Wormley, with the following result:

Specific gravity	1.338
Water	4.30
Ash	6.20
Volatile combustible matter	34.80
Fixed carbon	54.70
Total	100.00
Sulphur	2.149
Sulphur remaining in coke	1.19

On the Cawthorn farm, on the Bessemer Company's lands, is a seam of coal, about three feet thick, twenty-five feet above the Nelsonville seam. Here the interval is formed of yellow clay shale. On the upper Snow Fork the same kind of yellow shales are seen near the road, with an unopened seam of coal above. Here the distance down to the Nelsonville seam is twenty feet eight inches.

A few miles north-east of the Baird furnace, on the land of Jacob Martzoff, there is a seam of coal which I took to be the Nelsonville seam. Under the coal is Coal No. 5. About twenty-five feet above, is another seam, not opened; and twenty-seven feet higher, another. The latter I supposed to be the middle, or Norris seam. If the determinations are right, it is evident that there is a seam between the Norris seam (the probable equivalent, in this region, of Coal No. 6*a*) and the Nelsonville seam. Here ten feet of yellow clay shale were seen over the Nelsonville seam.

In the hills north of McCuneville, a seam of coal three feet thick is seen, twenty feet above the Nelsonville seam, with similar yellow clay shale between. More full investigations will, I think, reveal a well-defined horizon of a coal seam about midway between the Nelsonville (No. 6) and the Norris seam (No. 6*a*). The seam is not continuous by any means, nor is the one next above; and when one is found without the other, it is easy to confound them.

The Norris Coal is named from a bank near Millertown, on Upper Sunday Creek, in Perry county. At this bank the coal is six feet thick, with two partings, one one inch and the other three inches in thickness. The coal is of fair quality, and well adapted to all ordinary use. The seam was here determined by Mr. Gilbert to be forty-six feet above the Nelsonville seam. It is to be traced in most of the hills in this region, but sometimes it fails altogether. On the West Fork, above Buckingham, on the land of Benjamin Sanders, Monroe township, we see the outcrop of the same seam. The interval down to the Nelsonville seam—here well seen—as measured by Mr. Ballentine, is forty-seven feet. The coal on Mr. Sanders's land is thin and irregular. On the opposite side of the valley it measures only two feet in thickness. On the Grigsby farm, Section 9, Monroe township, the seam is four feet thick, and has been mined for neighborhood use. Two samples of this coal were analyzed by Professor Wormley, with the following results:

	No. 1.	No. 2.
Specific gravity	1.277	1.350
Water	3.80	3.80
Ash	4.60	6.30
Volatile combustible matter	38.80	37 00
Fixed carbon	52.80	52.90
Total	100 00	100.00
Sulphur	3.59	4.89

The same seam of coal has been opened and mined on the hill above the Sands bank, the latter in the Nelsonville seam. This is in Section 9, Monroe township. It is here four feet two inches thick, and has over it a roof of clay shale. The seam here is about fifty feet above the great seam. It may be traced from this point to the north. On the Latta farm it is seen on the hill-side above the great seam. North of this it is generally quite thin, but it may be traced all along the stream to a point east of Oakfield. From the last mentioned point it is, perhaps, a mile and a quarter over the ridge to the village of Moxahala, where the seam appears again as the Fowler or Black coal, it having been mined here by Mr. Thomas Black. It is here about five feet thick, and is a dry burning coal of great excellence, and has proved to be a very popular coal for domestic use. It makes a very large bright flame, and has been used in the gas-works at Circleville. It will be tried in the Moxahala furnace. It may contain too much sulphur for a good furnace coal, but further explorations may find it in requisite purity.

There has been much discussion relative to the true place of this coal in the series of coal seams. Professor Ballantine, assisted by Hon. Alvah Jones, of Roseville, traced, in 1869, the Nelsonville seam from Roseville, and found it to be below the Fowler coal. Mr. Black regarded the seam as the Norris seam. The author of the profile published in the Report of the Inspector of Mines makes it the northern continuation of the Bayley's Run seam of lower Sunday Creek, there eighty feet, more or less, above the Nelsonville seam. Mr. M. C. Read, who visited this field last fall, is reported to regard it as the upper portion or bench of the Nelsonville seam, while the lower part of the same seam is to be found in the bottom of a shaft fifty-two feet below; in other words, the Nelsonville seam (Coal No. 6) was here split into two parts, with fifty-two feet of sandstone, etc., between them. The reported proof that the Fowler coal is certainly a part of the great seam is derived from the supposed fact that on a branch of Sunday Creek the Great or Nelsonville seam is under a heavy sand-rock, and that this sand-rock may be traced to Moxahala, where the Fowler coal is found under it. In this confusion, Mr. J. G. Chamberlain, the intelligent manager of the Moxahala furnace, requested me to visit the ground. and aid in solving the problem. Fortunately, Mr. Chamberlain, who is a civil engineer, had instrumentally taken the interval from the Fowler coal to the regular upper limestone, which he had opened in many places in quarrying it for the furnace. Starting with the Fowler coal with the sand-rock above it, the section was carried as far as possible to the east, or a little south of east, into the ridge on which Oakfield is situated. The limestone and our levels helped us across the ridge. In a branch of Sunday Creek, a little east of Oakfield, we found the top of what we both believed to be the same heavy sand-rock found over the Fowler coal. It was brought by the dip down to about the level of the Fowler bank, as shown by the barometer. This dip would be about equal to the thickness of the sand-rock, or about thirty-five or forty feet. A very little above the top of the sand-rock, on the Sunday Creek side, we found, on the Donnelly farm, a seam of coal something more than four feet thick. This coal has all the appearances of the Stallsmith seam, in the vicinity of Buckingham, showing the same resinous and cementing character. Believing this to be the Stallsmith seam (the equivalent of Coal No. 7), I went into the ravine below the sand-rock, and searched for the Norris seam, which should be below that rock or some forty feet below the Stallsmith seam. I found a bituminous band, with only an inch of coal. This coal was carefully followed down the narrow valley. Under this coal, which is in places perhaps a foot thick, we found a sandy shale, which, lower down the stream, passes into sand-rock. Seen at a little distance, this sand-rock and the one above it appear to be merged into one. We traced the thin coal and the lower sand-rock down the stream, until, underneath the latter, the Great or Nelsonville seam comes to the surface. We had thus found in this branch three seams of coal—the Stallsmith (or Coal No. 7). the Norris (or Coal No. 6*a*), and the Nelsonville (or Coal No. 6.) The middle one of these is the Fowler seam of Moxahala, which is under a sand-rock, it is true, but not the same rock which covers the Nelsonville seam on the middle fork of Sunday Creek. I subsequently added strength to this conclusion by explorations in the valleys of some of the branches of the Moxahala. In a letter received subsequently from Mr. Chamberlain, he writes as follows: "The main question is settled. I am now fully willing to concede that the Fowler coal is the Norris, or the first above the great vein, and that the Donnelly coal is the Stallsmith."

West of Moxahala, the Fowler seam may be traced for several miles, but it is nowhere opened. Towards New Lexington it disappears, being replaced by a heavy sand-rock. In the high lands in Reading township it is again seen, and has been mined to a limited extent. For several miles south of Buckingham traces of the Norris coal may be seen, but it has not been met with on Lower Sunday Creek, neither in shafts nor in borings. On Snow Fork, in Ward township, Hocking county, it is frequently seen. My assistant, Mr. Gilbert, found it in Section 4, forty-five feet above the Nelsonville seam. Col. Charles Whittlesey reports it in a section taken by him on the Middle Fork of Snow Fork. It is there about forty feet above the Nelsonville seam, and from two to three feet thick. It is to be found on the Maxwell land about forty-five feet above the Nelsonville seam. At Bessemer, near the Akron furnace, it is two feet six inches thick, and fifty feet above the bottom of the Nelsonville seam. On the land of J. L. Gill, Esq., on Meeker Run, it is forty-three feet one inch above the same seam. It is only here one foot six inches in thickness. On the coal property of Peter Hayden, Esq., near Haydenville, it is about forty-two feet above the Nelsonville coal. It is to be seen at many other points, but it is needless to give them all. All the locations in the Hocking Valley where it has been found sufficiently thick to be worked have been mentioned.

The Bayley's Run, or Stallsmith seam (*Coal No.*7)—This seam is found on the Upper Sunday Creek, in Perry county, where it is known as the Stallsmith coal, and on Lower Sunday Creek, Athens county, where it has long been known as the Bayley's Run coal. It is a seam of wide range, and may be found almost everywhere where the hills are high enough to contain it, although it sometimes fails. Its place is approximately from eighty to ninety feet above the horizon of the Nelsonville seam. Generally the interval is greater where sand-rock intervenes than where we find shales, this being due, doubtless, to the greater compression of the shales. This coal, as found in Dover and Trimble townships, is noticed in the report on Athens county, in Vol I. The seam is from four to five feet thick—seldom less than four and one-half feet—with a thin parting about one-third of the distance from the top. As a rule, the quality of the coal in these townships is excellent; but in some places the coal contains too much sulphur to permit its use for the higher metallurgical purposes. The coal is always cementing in its character, and promises to be an excellent coking coal. The small trials already made prove this. I have obtained several samples of this coal from Trimble and Dover townships, which have been analyzed by Professor Wormley.

ANALYSES OF BAYLEY'S RUN COAL.

No. 1	Coal from	C. Southerton's bank, Section 34, Dover township.					
No. 2	"	J. Rutter's bank, near bottom, Section 10, Trimble township.					
No. 3	"	" "	middle	"	"	"	"
No. 4	"	" "	top	"	"	"	"
No. 5	"	R. Stover's "	"	"	23	"	"
No. 6	"	" "	lower part,	"	7	"	"
No. 7	"	" "	upper part,	"	"	"	"
No. 8	"	Chappalear bank, Trimble township.					
No. 9	"	Allen bank, mouth of Mud Fork, Trimble township.					

	1.	2.	3.	4.	5.	6.	7.	8.	9.
Specific gravity	1.309	1.301	1.264	1.381	1.300	....	....	1.280	1.291
Water	4.20	5.00	4.80	4.50	3.10	4.30	4.50	3.60	3.40
Ash	2.60	7.40	3.40	3.40	4.80	3.00	6.40	2.60	5.90
Volatile combustible matter	35.20	32.30	35.20	37.50	36.90	33.10	31.30	35.00	34.40
Fixed carbon	58.00	55.30	56.60	54.60	55.20	59.60	57.80	58.80	56.30
Total	100.00	100.00	100.00	100 00	100.00	100.00	100.00	100.00	100.00
Sulphur	1.04	1.85	1.26	2.96	3.54	1.20	1.15	1.29	1.09
Sulphur left in coke	0.41	0.42	0.69	1.89	1.70	0.46	6.52	0.49	0.60
Sulphur forming of coke	0.67	....	....	....	2.83	0.73	0.80	0.79	0.96

Three samples from the bank of A. B. Johnson, on Bayley's Run, Trimble township, were also analyzed.

No. 10, from bottom; No. 11, from middle, and No. 12, from top.

	10.	11.	12.
Water	4.00	4.90	4.20
Ash	2.30	2.90	3.30
Volatile combustible matter	36.00	33.10	35.40
Fixed carbon	57.70	59.10	57.10
Total	100.00	100.00	100.00
Sulphur	2.44	2.52	2.71
Sulphur remaining in coke	0.85	0.93	0.93
Per cent. sulphur in coke	1.41	1.50	1.53

In all cases Professor Wormley found the coke to be firm and compact, often presenting a metallic surface.

In many of the foregoing analyses it will be seen the sulphur remaining in the coke is not large enough to hinder the usefulness of the coke in the blast furnace. A good coking coal is a great desideratum in Southern Ohio. The supply is now chiefly brought from Connellsville, in Western Pennsylvania.

Two analyses of the coal of this seam on Upper Sunday Creek were made by Professor Wormley, with results as follows:

No. 1, coal from the Stallsmith bank; No. 2, coal from Benjamin Sanders's bank.

	1.	2.
Specific gravity	1.254	1.324
Water	3.80	3.00
Ash	4.14	5.00
Volatile combustible matter	40.21	42.00
Fixed carbon	51.85	50.00
Total	100.00	100.00
Sulphur	2.62	5.05
Sulphur left in coke	....	2.30

There is more sulphur than is desirable, but the coal is, nevertheless, popular in the neighborhood, and has been used in preference to that of the Nelsonville seam, on account of its melting property. The coke made from the coal is hard, and resembles that from the same seam farther south. The seam is here about four feet thick.

On the Donnelly farm, near Oakfield, the same seam is something over four feet in thickness.

On Snow Fork it is seen at many points. On the land of Messrs. Buckingham and Wright it is seen ninety feet (barometer) above the Nelsonville seam. It is four feet eight inches thick, with a two inch parting near the middle. On the Maxwell land, on Bear Run branch of Snow Fork, it presents the following structure:

	FT.	IN.
Coal	..	10
Shale	..	6
Coal	1	1
Shale	..	3
Coal	3	..
Cannel shale	..	5

At the Akron Furnace, near Bessemer, there is, I think, a remnant of the Bayley's Run coal, in a local deposit one foot ten inches thick in the center, but thinning out on either hand, the whole horizontal extension being only a few rods. It curves down in the middle, where it is close upon the "Bessemer ore." Assuming that its true place is about six feet above the ore, it is then about eighty-eight feet above the Nelsonville seam. This is certainly the relative position for the Bayley's Run coal, although the interval is subject to a little variation. There is no other known seam which this coal can represent, and Mr. T. Black, who has charge of the mining of the coal and ore for the Akron furnace, has found no other seam in this general horizon. If this conclusion about the coal is a correct one, the place of the "Bessemer ore" is, unmistakably, *below the Bayley's Run seam.*

On Floodwood Creek, on the land of Hon. J. W. Nelson, the Bayley's Run seam is four feet two inches thick, with a two inch parting. Its place was found by barometer to be between eighty and ninety feet above the Nelsonville seam. On the south branch of Meeker Run, on the land of J. L. Gill, Esq., the same seam is four feet three inches thick, and eighty-nine feet above the Nelsonville coal. Traces of this seam appear at many points at the proper horizon in all the Hocking Valley coal field. At the Bristol Tunnel, in Pike township, Perry county, this coal is seen on the ridge over the tunnel on the land of Mr. Clark. It is here about three feet six inches thick, and from eighty to ninety feet above the Nelsonville seam exposed in the railroad tunnel. The coal is of the melting class, but contains a good deal of sulphur.

Above the Bayley's Run seam, which is probably Coal No. 7 of the northern series, there are several thin seams which appear to be persistent in their several horizons, but there is no space for detailed notice of them. There is, on Lower Sunday Creek, a thin seam of coal, about forty-five or fifty feet above the Bayley's Run seam, called, sometimes, the "Splint coal." This has, by some, been considered as the true No. 7 seam, and the equivalent of the Stallsmith seam or Upper Sunday Creek. I see no reason for changing my original opinion, that the Bayley's Run and the Stallsmith seams are the same. Furthermore, I find on Upper Sunday Creek, traces of the Splint coal seam above the Stallsmith seam, holding the same relation to it in distance that the Splint coal holds to the Bayley's Run seam further south.

The Pomeroy seam is to be found in the high hills east of Lower Sunday Creek, but it is thin and of no practical value. Its place is, by barometer, about four hundred and twenty feet above the Nelsonville seam.

IRON ORES.

These may be grouped into two divisions—those below the Nelsonville coal, and those above it.

Lower Ore.—Iron ores are very frequently met with resting upon the Maxville limestone and its equivalent, and at some points directly under the limestone. These ores are generally oxydized on the outcrop. Such ore is seen above the limestone of the Maxville series below Logan, and above the Maxville limestone near the village of Maxville. A drift obtains this ore near the Winona furnace. I have found ore just over the corresponding limestone in Reading township, Perry county, east of Rushville, and also over the corresponding Newtonville limestone. A few samples of the ore of this horizon have been analyzed, and also of ores lying a little higher on the series. They were generally obtained by myself, but sometimes by my assistants. In Section 16, Madison township, Perry county, we found an ore ranging from four to eight inches in thickness, resting directly upon the limestone. This is No. 1 in the following table. Other thin ores are seen in the shales above. An ore lying a little over the Maxville limestone in Reading township, on the land of John P. Hodge, Section 26, was only from four to five inches in thickness where seen, but it may be thicker elsewhere. Its analysis (No. 2 of the table) shows it to be rich in iron. In this neighborhood we find much excellent ore. On the Vanatta farm (late N. Axline's), two and one-half miles east of Rushville, I found an ore of excellent quality forming a ledge across the road. It is reported to be one foot ten inches thick. This is a superior ore, as shown in No. 3 of the table. In the road, across a little valley, I noticed another ore, highly oxydized and chalky, eight inches thick, which comes out in large blocks, and is probably lower than that last mentioned. It is about five feet above a layer of bituminous shale, which furnished so many rare and beautiful coal plants described and illustrated in the Palæontology, Vol. II. This ore is also of good quality, as shown in No. 4 of the table. No. 5 of the table is still another ore from the same farm, but higher in the series. On the land of Thomas Garrison, Section 35, Reading township, I found an excellent ore, about five inches thick. This is No. 6 of the table. On the lands of Simon King and Henry Bugh, Section 6, in the same township, is a persistent layer of ore from six to eight inches in thickness. The ore is well oxydized, and appeared to be very promising.

No. 1, Ore, Edward Dennison's land, Section 16, Madison township, Perry county, resting upon Newtonville limestone.

No. 2, ore, over the limestone, J. P. Hodge's farm, Section 26, Reading township, Perry county.

No. 3, ore, Vanatta or Axline farm, 2½ miles east of Rushville, Reading township.

No. 4 " " " " " " "

No. 5 " " " " " " "

No. 6 " Thomas Garrison's farm, Section 35, Reading township.

	No. 1.	No. 2.	No. 3.	No. 4.	No. 5.	No. 6.
Specific gravity	3.600	....	....	....	....	....
Water	5.70	17.70	10.90	8.00	8.43	10.00
Silicious matter	5.32	6.30	14.90	20.94	35.88	13.04
Iron sesquioxide	13.30	68.88	68.94	66.13	54.19	72.63
Iron protoxide	37.36	....	....	....	....	....
Iron carbonate	....	....	....	....	....	....
Carbonic acid	28.10	....	....	....	....	....
Alumina	....	1.20	0.70	1.80	0.01	0.20
Manganese	4.30	....	1.75	Trace.	....	....
Lime	2.90	....	....	....	....	....
Lime phosphate	....	1.28	0.76	1.24	0.05	0.68
Lime carbonate	....	2.96	0.07	0.08	....	....
Magnesia	2.77	....	....	....	....	....
" phosphate	....	....	....	....	0.18	....
" carbonate	....	2.49	1.09	1.20	1.64	3.54
Sulphur	....	0.0	....	0.05	0.08	0.04
Total	99.75	100.81	99.11	99.44	100.63	100.13
Metallic iron	38.87	48.22	48.26	46.29	37.93	50.84
Phosphoric acid	Trace.	0.83	0 35	0.57	0.12	0.31

Most of the above ores are of good quality, and all will be needed in the future.

A very good ore is found near Crossenville, south-east of Bremen, on the Cincinnati and Muskingum Valley Railroad. It has been brought to Bremen and shipped to the furnace at Zanesville. It is one of the lower ores, but its exact position I have not ascertained. I have seen other good ores by the roadside in the Crossenville region. A selected sample of the Crossenville ore was analyzed by Prof. Wormley, and the result is given in the following table.

On the roadside, between Maxville and Bremen, I found a layer of ore of great excellence, but its thickness was not ascertained. The analysis of it is given.

No. 1, ore from near Crossenville; No. 2, ore, roadside between Maxville and Bremen.

	No. 1.	No. 2.
Water	10.00	10.70
Silicious matter	17.92	13.76
Iron sesquioxide	69.90	73.80
Alumina	0.60	0.10
Manganese	0.00	0.50
Lime phosphate	0.41	0.41
" carbonate	....	0.38
Magnesia phosphate	0.96	....
" carbonate	0.73	0.07
Sulphur	0.02	Trace.
Totals	100.60	99.72
Metallic iron	48.97	51.56
Phosphoric acid	0.63	0.19

The lower Coal Measure limestones often carry ores. In the bed of Monday Creek, near Henry Hazleton's, below Shawnee, ore and flint are found in the horizon of one of the lower limestones. The former place of exposure of this ore is now concealed by the fine coal and débris brought by the stream from the Shawnee mines above, but it is seen on the land of Mr. Moore a little below. The ore is in three benches or layers, the lower one being very flinty. There are altogether about fifteen inches of ore. Analyses of samples of these ores were made by Prof. Wormley, with the following results:

	Top ore.	Middle ore.	Lower ore.
Specific gravity	3.540	3.833	2.675
Iron protoxide	39.62	40.67	19.48
" sesquioxide	15.07	8.54	4.01
Manganese	....	0.54	....
Lime	0.60	1.06	....
Magnesia	0.38	1.33	....
Foreign and silicious matter	6.95	21.72	62.60
Carbonic acid	24.21	20.80	7.15
Sulphuric acid	0.48	0.75	....
Phosphoric acid	0.18	....	....
Water	3.70	0.40	....
Organic matter and loss	1.74	4.19	1.55
Totals	100.00	100.00	97.79
Metallic iron	41.37	37.59	17.99

On the land of Mr. Moore is the same ore from six to eight inches thick, resting upon blue shale of six inches; below which is a fossiliferous limestone of eight inches, and underneath all a thin coal. This group is by Locke's level one hundred and fifty-five feet below the Nelsonville coal. A similar block ore is found on the lands of the Crafts Iron Company at the mouth of Little Monday Creek, and at very nearly the same distance below the Nelsonville coal. It rests upon a flint layer—elsewhere a fossiliferous limestone—with a thin coal beneath. This ore is not thick (from four to six inches), but it is of excellent quality as seen from the following analysis by J. Blodgett Britton, kindly given me by Mr. Crafts:

Metallic iron	48.12
Silica	1.52
Sulphur	0.84
Phosphorus (mean of two trials)	0.175
Alumina	1.86
Lime	0.19
Manganese protoxide	0.37

The ore above a fossiliferous limestone found in the hill back of the old furnace and thirty feet above the railroad, at Haydenville, doubtless belongs to this horizon as the instrumental measurements give it very nearly the same distance below the Nelsonville seam of coal. This ore was formerly mined, but probably no analysis of it was ever made. In 1869, I found a rejected pile of ore at the Five Mile (Union) furnace, which doubtless belonged to the lower series of ores but its stratigraphical place was not ascertained. It had many years before been rejected because of the supposed excess of phosphorus in it. A sample of the pile was analyzed by Prof. Wormley and found to contain 42.53 per cent. of metallic iron and only a chemical trace of phosphorus.

An ore mined somewhat at Webb's Summit, on the Straitsville branch railroad, and also said to rest upon a flint layer, has been analyzed by Prof. Wormley for the Thomas Iron Company, and Gen. Thomas has kindly given me the result, as follows:

Sesquioxide of iron	61.02
Alumina	8.80
Silicic acid	20.76
Oxide of manganese	1.10
Lime carbonate	3.10
Magnesia	1.14
Sulphur	0.18
Phosphoric acid	1.31
Water combined	2.30
Total	99.71
Metallic iron	42.71

The percentage of phosphoric acid is too great for a good ore.

Baird Ore.—We now reach the horizon of the Baird ore—so called because it is the ore chiefly used at the Baird Iron Works, in Monday

Creek township, Perry county. The place of this ore is about thirty-five feet below the Nelsonville seam of coal. This brings it below the Lower Lexington coal, or Coal No. 5 of the northern series. In the vicinity of the Baird Furnace this lower coal is often seen, especially on the ridge between the furnace and Maxville. The ore is here about ten feet below the latter coal and at the bottom of the light colored fire clay. Sometimes there is under the ore a thin layer of fossiliferous limestone, but this is often wanting, and sometimes it is changed into flint. The ore in this region is generally oxydized on the outcrop, but, under deep and impervious cover, it retains its original quality of a carbonate. The thickness of the layer is from eight to ten inches, but it is often thinner in its outer margin, where the ore is decomposed and crumbling. Before the erection of the Baird Furnace, ores from this neighborhood had been taken to the Logan Charcoal Furnace and used with entire success.

I have seen but a single analysis of the ore, from this region. It was such as was used in the Thomas Furnace, at Gore. It was given me by Gen. Thomas and has already been published by Mr. E. C. Pechin in the *Metallurgical Review.*

CALCINED BAIRD ORE.

Sesquioxide of iron	66.86
Oxide of manganese	1.10
Silicic acid	21.64
Alumina	2.35
Lime carbonate	1.75
Magnesia carbonate	1.07
Phosphoric acid	0.73
Sulphur	0.26
Water combined	4.05
Total	99.81
Metallic iron	46.80

I have no doubt that much of the Baird ore is better than this. Northeast of the Baird Furnace on the land of Jacob Martzoff, in Monday Creek township, I found in the road an ore resting on flint which I took to be the continuation of the Baird seam. It is one foot thick and thirty-eight feet below a seam of coal supposed to be the Nelsonville seam, and also below Coal No. 5. It is a very superior ore as shown by the following analysis by Prof. Wormley:

Specific gravity	2.692
Water combined	7.20
Silicious matter	13.20
Iron sesquioxide	75.35
Alumina	0.00

Manganese	2.00
Lime phosphate	0.54
Lime carbonate	0.91
Magnesia carbonate	0.83
Sulphur	0.00
Total	100.03
Metallic iron	52.76
Phosphoric acid	0.25

This is one of the best ores to be found in the district.

Several furnaces are expecting to draw their chief supply of ore from the Baird seam—the Thomas, Winona, and Bessie Furnaces on the line of the railroad from Logan to Staitsville, and Crafts Furnace at the mouth of Little Monday. The ore is everywhere to be found in the high grounds between the valley of Monday Creek and the Hocking River. The Bessie Furnace, near Straitsville, will obtain ore chiefly from the lands of the Company west of Monday Creek. Explorations for the Baird ore on the hill n rth of the furnace revealed the ore in nodular form distributed in a three feet bed of fire-clay. I am indebted to Mr. Benjamin Marshall, one of the proprietors of the furnace, for a carefully measured section.

		FT.	IN.
1.	Nelsonville or Great seam of coal.		
2.	Fire-clay	6	..
3.	Kidney ore	1	..
4.	Shale	3	..
5.	Coal	0	6
6.	Shale	16	..
7.	Gray carbonate of iron, irregular	..	4 to 10
9.	Sandstone	9	..
10.	Fire-clay, with nodules of ore	3	..
11.	Sandstone	34	..
12.	Fossiliferous limestone	1	..
13.	Chiefly sandstone	2	..
14.	Coal	2	6
15.	Interval not exposed	31	6
16.	Limestone, fossiliferous	1	2
17.	Coal	..	4
18.	Interval to top of boring	10 to 15	
19.	From top of well to ore	54	9
20.	Iron ore	..	4
21.	Coal	..	6
22.	Interval	5	6
23.	Ore	1	8
24.	Sand-rock.		

No. 10 represents the horizon of the Baird ore. No. 12, a fossiliferous limestone, seventy-two f eet and ten inches below the Nelsonville seam, represents the Putnam Hill limestone. No. 5 is a distinct coal horizon. I have met this coal in many places. The shales over it and also the nodules of ore, are often rich in coal plants. They are separated from the coal above by the regular under clay of that seam.

At the Crafts' Iron Works, now building, at the mouth of Little Monday Creek, Green township, Hocking county, the Baird ore is by measurement thirty-seven feet and six inches below the Nelsonville seam of coal. Mr. Crafts has favored me with a measured section of the formation on the company's lands.

		FT.	IN.
1.	Buff limestone, nodular on outcrop.		
2.	Interval	10	..
3.	Nelsonville coal	9	6
4.	Interval not exposed	37	6
5.	Baird ore, from 6 to 14 inches, average	..	10
6.	Interval, sandstone in part	92	..
7.	Black shale	4	..
8.	Flint	..	8
9.	Blue fossiliferous limestone	1	6
10.	Coal	2	..
11.	Interval	14	..
12.	Block ore	..	6
13.	Flint, sometimes fossiliferous limestone	..	10
14.	Coal thin and poor.		

No limestone was seen under the Baird ore.

I am indebted to Mr. Crafts for three analyses by J. Blodget Britton of the Baird ore from his lands.

	1.	2.	3.	Average.
Metallic iron	42.45	53.24	44.27	46.65
Silica	12.31	8.64	12.59	11.18
Sulphur	None.	0.09	....	....
Phosphorus	0.29	0.066	....	0.178
Alumina	7.03	2.78	3.64	....
Lime	2.64	0.09	2.57	....
Manganese protoxide	0.86	0.99	....	....

With an ore of so high a percentage of iron, with so little phosphorus and relatively so little silica, and furthermore, with a coal of great promise, it may be predicted that Mr. Crafts, who combines a scientific knowledge of iron-making with much successful practice, will make his furnace an entire success.

On Monday Creek, a few miles below the Crafts' Furnace, is the furnace, now nearly completed, of the Monday Creek Iron Company. Mr.

Frank Baird, the superintendent, informs me that he has the "Baird ore" and also the "Bessemer ore." At the time of my late visit the ores were not opened sufficiently for inspection. At Bessemer, and on Snow Fork, the Baird ore, if it exists, is below drainage, but Mr. Buchtel, of the Akron Furnace, proposes to search for it. Mr. W. B. Brooks has shown me samples of the Baird ore from his lands north of Nelsonville, and states that it is to be found there in its proper place below the Nelsonville coal. I have seen the same ore on the Hayden lands, east of Haydenville. It is here thirty-five feet below the Nelsonville coal, and at the bottom of the clay under Coal No. 5. It is ten inches thick and has the appearance of the Baird ore of the best type. Mr. Hayden has kindly given me an analysis made by Prof. Wormley :

Iron sesquioxide	34.29
Iron carbonate	37.88
Silicic acid	11.68
Alumina	0.95
Manganese oxide	0.75
Lime carbonate	7.86
Magnesia carbonate	1.59
Sulphur	0.24
Phosphoric acid	0.61
Water	4.00
	99.88
Metallic iron	42.32
Phosphorus	0.28

No limestone has been seen under this ore.

It will be observed that much of the iron in this ore is in the form of a carbonate of iron. This feature of the ore I have noticed at other localities. It [illegible]monly shows an oölitic structure, the grains of ore being embedded in a silicious matrix. These grains, originally a carbonate of iron, are not very readily oxydized. In some cases there is a similar oölitic structure of the "limestone ore" of the Hanging Rock Iron District, and the grains are found by analysis to be largely carbonate of iron. Two samples, one from the Vesuvius Furnace and the other from the Buckeye Furnace, gave respectively 40.91 per cent. and 48.44 per cent. of carbonate, with 24.37 and 23.36 per cent. of sesquioxide. Each was high in silica, the former containing 26.32 and the latter 23.36 per cent. The percentage of iron was low, being 36.81 and 32.59, while the average per cent. of hydrated sesquioxides or limonites of the "limestone ore seam" of the Hanging Rock region is 51.67. The average silica in these limonites is 8.08 per cent., but if we except three samples from near Vinton Station, as exceptionally high in silica, the average is only 3.76 per cent.

The Baird ore is sometimes called the "limestone ore," and has by some been regarded as the equivalent of the ore of that name in the Hanging Rock District. In no respect do the ores resemble each other except in th' oölitic structure and this is an exceptional feature in the Hanging Rock ore. It must be conceded that we have as yet found no ore of this class having any considerable range in the Coal Measures of Ohio, or of the Coal Measures of any western State, which possesses so high an average quality as the limestone ore of the Hanging Rock District. It has been smelted for the last fifty years, and the iron made from it, whether by charcoal or raw bituminous coal, has always been of a very superior character, and has commanded the highest market price.

The Baird ore, like most of its class, is in a relatively thin layer, and can not be economically mined by drifting—certainly not at the present prices of iron. This limits the mining to stripping along the outcrop, a fact which will of necessity limit the number of furnaces dependent upon its use.

Between the Baird ore and the Nelsonville coal we almost always find more or less ore, but in the Hocking coal field this is generally in a nodular form. In the region of the Baird Furnace I have seen this ore in a thin, continuous layer, but quite sandy in quality. On lower Monday Creek, and on Snow Fork, the ore is in flat discs, which contain coal plants in a state of beautiful preservation. The same nodular ore is seen under the Nelsonville coal, near the mouth of Meeker Run. Dr. C. Briggs, one of the members of the Corps of the first Geological Survey of the State, called attention to this ore in his Report in 1838. The section, already given, taken on the hill back of the Bessie Furnace, near Straitsville, shows a gray carbonate of iron, twenty-six feet below the Nelsonville coal, and nine feet above the clay containing the equivalent of the Baird ore. The place of this carbonate is above Coal No. 5. In this horizon there is in other parts of the State much ore. It is more often nodular, but sometimes passes into heavy masses of black band. Two analyses have been made of the nodular ores found eight or ten feet below the Nelsonville coal, the first sample from Snow Fork, analyzed by Prof. Wormley, and the other from near the mouth of Meeker Run, by Prof. T. S. Hunt.

	1.	2.
Specific gravity	3.200	....
Iron protoxide	37.22	....
" sesquioxide	3.64	....
Oxide manganese	1.20	....
Alumina	0.60	2.82
Lime	2.40	3.56
Magnesia	2.16	2.49
Silicious matter	18.82	11.87
Carbonic acid	27.00	27.82
Phosphoric acid	....	25.00
Water	4.40	....
Loss	2.56	....
Total	100.00	....
Metallic iron	31.50	36.89

Near Buckingham, on Upper Sunday Creek, are places where the Nelsonville coal is cut away, and the eroded channel filled with unstratified blue clay. In this clay are masses of iron ore, some of them quite large. The ore has never been analyzed, but much of it has a silicious appearance. The smaller nodules seen in the bed of the stream, appear to be richer in iron and less silicious. It should be stated that the cut-away places above mentioned are distinct from the eroded channel through the coal seam a little west, which is filled with a coarse sand-rock.

At one or two points in the Upper Sunday Creek Valley, I have noticed nodular ores in the stratified shales above the horizon of the Nelsonville seam, but at no place could they be profitably mined. Near Millerstown, a layer of ore five inches thick, and four feet below the Norris seam of coal, was seen. The ore at that point was a blue carbonate. No analysis has been made of it.

In the Upper Sunday Creek region, and northward to New Lexington we find an ore horizon a little above that of the Norris coal. This ore is locally called the "sour apple" ore, from an apple tree near one of the exposures of this ore, the apples of which were quite disappointing to a party of explorers. It is about fifteen feet above the Norris coal. On the farm of Wesley Moore, in Pike township, Perry county, this ore is, by barometer, sixty-three feet above the Nelsonville coal. Here the ore is nodular and embedded in white clay. The nodules are scattered through two feet eight inches of clay, and if in solid mass would form a layer of from eight to ten inches in thickness. On the land of Mr. Harper, a little south of New Lexington, the same ore is in good development.

ANALYSES OF "SOUR APPLE" ORE.

No. 1, Wesley Moore's.

No. 2, from Harper's farm.

No. 3, ore reported seven feet above the Norris coal at Moxahala.

	1.	2.	3.
Water	5.80	12.00	1.60
Silicic acid	15.32	14.96	15.96
Iron carbonate	....	....	44 91
Iron sesquioxide	66.66	66.44	28 57
Alumina	2 20	3.20	0.40
Oxide manganese	1.80	0.50	0.42
Lime phosphate	0.89	0.51	....
Lime carbonate	4.84	....	2.80
Magnesia phosphate	....	2.05	....
Magnesia carbonate	1.39	....	4.69
Phosphoric acid	....	....	0.32
Sulphur	0 13	0.08	0.33
	99 03	99.74	....
Metallic iron	46 66	46 57	41.68
Phosphoric acid	0.41	1.35	0.32

No. 1 and No. 2 by Prof. Wormley; No. 3 by E. S. Gregory.

A partial analysis of a sample of this ore from Sunday Creek gave 43 06 per cent. of iron. In places this ore will contain too much phosphorus, but it often appears promising. Where I have seen it, it is nodular, but further explorations may reveal it in a regular layer. South of New Lexington considerable quantities of it may be obtained by easy stripping.

The next ore of importance above the "sour apple" ore is the Bessemer ore. This has its most marked development at Bessemer, Athens county. At the Akron furna[illegible]semer, the ore is, by instrumental measurement, eighty-three feet above the floor of the Nelsonville coal. A little above the ore is seen at one point a seam of coal believed to be the Bayley's Run seam. At the outcrop the ore is nodular, but a little drifting reveals a layer of blue carbonate, which, at one point, I found to be two feet seven inches thick. Resting upon this layer are thickly packed nodules of ore, the mass averaging, according to Mr. Thomas Black, one foot six inches in thickness. The ore is generally more or less oxydized on the outcrop, but in the drifts becomes hard and blue. At first it was supposed that the overlying nodules were chiefly composed of carbonate of lime; indeed they were called "lime bowlders," and were to be used in the furnaces rather as a flux than an ore, but it is reported that they have been found, by trial, to be a useful ore. I have no analyses of the Bessemer ore at this place. The ore is silicious, and obviously not very rich in metallic iron. It doubtless contains phosphorus enough to make the iron cold-short; but it is abundant and near the furnace, and can be obtained very cheaply.

From eighteen to twenty feet below the ore is a layer of limestone one foot six inches thick. This is somewhat nodular on the outcrop, which makes it easily dug. This furnishes the flux at the furnace. At the base of the hills is the Nelsonville seam of coal, the three lower benches of which are mined, yielding a little more than six feet of coal. Thus all the raw materials, which are almost within a stone's throw of the furnace, are amazingly cheap, and although a very large amount of ore and coal is used in making a ton of iron, the manufacture is said to be profitable. The furnace is fifty feet high and sixteen feet wide in the bosh.

The Ogden Furnace, higher up the valley of Snow Fork, obtains its native ore from the Bessemer seam. The ore is similar in appearance to the ore at the Akron Furnace. The lower bench is reported to be from ten inches to two feet in thickness, with an estimated average of fifteen inches. Upon this rests a layer of the so-called "lime bowlders," the mass ranging from one foot to one foot eight inches in thickness. I have no analyses of the ore of the lower bench, but the nodules above are reported to yield from eight to twenty per cent. of iron. From fifteen to twenty feet below the ore is the usual limestone. The coal of the Nelsonville seam lies at the base of the hills, and here is overlain by sand-rock, which usurps the place of the usual overlying shales and of the upper bench of the seam. This intrusion of the sand-rock appears to have had an injurious effect upon the quality of the coal. But the seam can be found in an undisturbed condition not far away.

The Ogden Furnace is fifty feet high, with a width of bosh of fifteen feet, and is furnished with three Whitwell hot-blast ovens. On the land of Messrs. Buckingham and Wright, east of Snow Fork, I saw loose masses of ore supposed to be of the Bessemer seam.

On the Cawthorn farm, on Monday Creek, near Bessemer, the Bessemer seam of ore shows a fine outcrop of nodules, in all from four to five feet in thickness. There is no drift opened to reveal the thickness of the lower bench of ore. Here the ore is, by Locke's level, eighty three feet above the bottom of the Nelsonville seam of coal, and seventeen feet above the limestone, which, at this place, is from three to four feet thick. Some years since I obtained a sample of the outcrop ore, thoroughly oxidized, which Prof. Wormley analyzed with the following result:

ANALYSES OF BESSEMER ORE, CAWTHORN FARM.

Water	10.70
Silicic acid	36.45
Alumina	0.18
Oxide manganese	....
Lime phosphate	0.62
Magnesia carbonate	0.52
" phosphate	0.33
Iron sesquioxide	50.50
Sulphur	0.06
Total	99.36
Metallic iron	35.35
Phosphoric acid	0.48

The ore contains an undesirable per centage of silica, but in other respects is of fair quality. When the mine is driven under the hills the ore will become a blue carbonate, but probably much oxydized ore may be obtained by stripping along the outcrop. Here, as at the Akron Furnace, the ore, limestone, and coal are all in the same hill and can be put into a furnace at very small cost.

On Meeker Run, below Nelsonville, the Bessemer ore, one foot eleven inches thick, is reported on the land of J. L. Gill, Esq. It is seventy-six feet above the Nelsonville coal. It is eleven feet seven inches below the Bayley's Run coal, here about ninety feet above the great seam. About twelve feet below the Bessemer ore is the limestone, two feet ten inches thick. On this limestone is a deposit of ore reported to be a foot thick. I have no analyses of any of the ores on this estate, except that furnished by Prof. T. S. Hunt, of the ore below the Nelsonville seam of coal, which has already been given.

I have little doubt that the Bessemer ore will be found extensively in the hills west of the Hocking River, in the vicinity of Nelsonville. I think I have seen traces of it on Floodwood, and it is reported at Salina, and as far north as Lick Run. In the hills between the Hocking River and Monday Creek it is often seen. W. B. Brooks, Esq., reports its existence, in fine thickness, on his coal lands in Section 19, Ward township, Hocking county. It is said to be nodular above and in a solid layer below. This ore is about eighty-five feet above the Nelsonville seam of coal and eighteen to twenty feet above the limestone. The Bayley's Run coal, three feet thick, is found a little above the Bessemer ore. At an elevation of one hundred and fourteen feet above the Nelsonville coal is another reported deposit of ore, and still another one hundred and seventy-six feet above the same coal. It has already been stated that the Baird ore is found below the coal on the Brooks land.

The Bessemer ore is reported by Mr. F. Baird on the lands of the Monday Creek Iron Company, but at the time of my visit the test pits, which had revealed it, were not open. The same ore is reported at Carbon H ll. On the coal lands of Peter Hayden, Esq., a somewhat remarkable deposit of ore is found in the horizon of the Bessemer ore, eighty-seven feet above the floor of the Nelsonville coal. The usual limestone, three feet thick, is seen twenty-two feet below the ore, and a little lower, is a bituminous shale with a thin band of coal representing the horizon of the Norris coal.

At several points the ore on the Bessemer level is well opened and exposed. It is generally a dark red ore, well oxydized. In one hill the ore ranges in thickness from one to four feet. Over it is a thin silicious band four inches thick, and above this from two to twenty feet of clay, in which are occasional nodules of ore—some quite large. In another hill a pit revealed one foot eight inches of the same red chalky ore.

In a third hill the ore is nodular, but still red. The nodules are imbedded in a fire-clay, and the clay sometimes forms a part of the nodules, giving them a peculiar mottled appearance. Over these nodules is a layer of light colored limestone, but this sometimes becomes nodular. There is evidently a large quantity of the red ore on the estate. Two analyses of the red ore have been made by Prof. Wormley with the following results:

ANALYSES OF PETER HAYDEN'S RED ORE.

	1.	2.
Specific gravity	2.558	....
Water combined	3.00	1.70
Silicious matter	28.20	24 52
Iron sesquioxide	43.51	44.29
Alumina	2.00	1.80
Oxide manganese	1.00	0.75
Lime carbonate	21.21	21.99
Lime phosphate	0.41	2 49
Magnesia carbonate	0.52	1.36
Sulphur	0.12	0.10
Total	99.97	99.00
Metallic iron	30.56	31.00
Phosphoric acid	0.19	1.14

Another sample partially analyzed in Pittsburgh gave thirty-five per cent. of the lime and magnesia carbonates, with less silica and more iron.

The phosphorus in one of the samples analyzed by Prof. Wormley is pretty large, but that in the other is quite small for an ore from our Ohio

Coal Measures. The peculiarity of the ore is the large percentage of lime carbonate disseminated through it. Thus brought into immediate contact with the particles of silica, the lime will serve an admirable purpose for flux, and the ore will scarcely require any added lime in the furnace. The ore is a very peculiar one, and a little special practice with it may be needed to show the best manner of treatment in a furnace. This ore corresponds much more nearly to the famous Minette ores of the oölite in the Grand Duchy of Luxemburg, of which more than a million of tons is annually mined, than any American ore I have seen. The Minette ores generally contain more alumina and also more phosphorus. The average iron is thirty-three per cent. The ore often carries enough lime to serve as a flux without any foreign admixtures. The ore extends beyond the borders of Luxemburg, and is the basis of a large iron industry in neighboring kingdoms. More than one-third of the total production of pig iron in Belgium is made from these calcareo-silicious ores. Generally a ferruginous limestone is used for flux. "In the neighborhood of Longwyy, the predominance of silica and alumina is so noticable that the richness of the mixtures of ores decreases often to twenty five per cent., by the addition of sterile lime, notwithstanding which the blast furnaces are, of all the French blast furnaces, perhaps those which work the most economically." (Report of M. A. Habet, Liége.)

On lower Sunday Creek, in Trimble township, an ore found a little below the Bayley's Run coal has been reported. The ore is nodular, but the nodules are often large. Further explorations may reveal its existence in a solid layer. A sample was analyzed by Prof. Wormley.

ANALYSIS OF ORE UNDER BAYLEY'S RUN COAL, TRIMBLE TOWNSHIP, ATHENS COUNTY.

Water	6.15
Silica	18 41
Iron carbonate	31.16
Iron sesquioxide	26.68
Alumina	2.20
Oxide manganese	5.30
Lime phosphate	0.21
Lime carbonate	5.25
Magnesia carbonate	4.54
Sulphur	0.06
Total	99 99
Metallic iron	33.72
Phosphoric acid	0.10

ORES ABOVE THE HORIZON OF THE BAYLEY'S RUN COAL.

The first above the coal, and doubtless the most important, is the "Shawnee ore." This ore is best known from a fine development of it at Iron Point, a little north-east of the village of Shawnee, in Perry county. The elevation of the ore seam above the Nelsonville coal is probably not far from one hundred feet. This is about the average of many instrumental measurements, which, as reported, range from ninety-one to one hundred and ten feet. There are variations in the bedding of the ore, and no two measurements are exactly alike. At one exposure of the ore, where it was worked in open quarry, I took the following section:

	FT.	IN.
Yellow clay	6	..
Carbonaceous streak.		
Laminated ore	3	3
Coal	..	3
Clay.		

A few rods distant the laminated ore was two feet four inches thick. The minimum thickness is reported by Mr. E. C. Pechin as fourteen inches, and the maximum as four feet. In places the ore is a hard blue carbonate, showing less lamination, and resembling the "mountain ore" associated with the black band over Coal Seam No. 7, in Tuscarawas county. The laminated ore is, where I saw it, much oxydized. In its laminated structure it much resembles a black band, but is not like the typical black band in being a bituminous shale highly charged with iron. There are, however, sometimes thin films of coal formed by isolated fragments of coal-forming plants buried in the ancient ferruginous mud. This mud was deposited in layers; hence the lamination of the ore. The ore is divided by vertical joints, and is readily split and removed. The following analyses of the Iron Point ore have been made:

	No. 1. Raw Ore.	No. 2. Raw Ore.	No. 3. Calcined Ore.
Silica	33.44	......	10.00
Alumina	3.14	......	6.69
Oxide manganese	0.91	......	4.49
Lime carbonate	Trace.	......	Lime 2.35
Magnesia carbonate	Trace.	......	Mag. 0.60
Phosphoric acid	0.39	0.42	0.58
Sulphur	0.14	......	0.13
Water, contained	5.74	......	......
Iron sesquioxide	56.03	......	74.66
	99.79	......	100.10
Metallic iron	39.21	35.27	52.26

No. 1 was made by Mr. E. S. Gregory, and furnished me by Mr. J. G. Chamberlain; No. 3 was given by Mr. A. J. Long, of Akron, to Mr. Pechin; No. 2 was given me by General S. Thomas, of Columbus. An analysis of the pig iron from the Fannie Furnace is quoted from Mr. Pechin, as follow

FANNIE FURNACE PIG IRON.

Iron	91.45
Silicon	3.89
Carbon graphitic	2.31
" combined	0.24
Sulphur	0.03
Phosphorus	0.59
Manganese	0.85
Undetermined	0.64
	100.00

There are four furnaces in operation at Shawnee, all using the Iron Point ores. These are:

	Height. Ft.	Bosh. Ft.
Fannie No. 1	48	12
Fannie No. 2	48	13½
XX or "Double X"	50	14
Vilas	50	14½

The fuel used at all of these furnaces is raw coal from the Nelsonville seam. The limestone is from a seam generally found about sixty feet above the coal. It is here reported to be from two to two and one-half feet thick. Until drifts are required the stone may be obtained at little expense. All the raw materials are procured at a small cost, and pig iron is consequently made very cheaply. By admixture of the native ores with those from Lake Superior and elsewhere, iron adapted to meet different wants may be made. The area over which the Shawnee ore is known to exist in the Iron Point field is not very great, but new explorations will doubtless enlarge it.

South of Iron Point several shafts have been sunk for the ore on the lands of the Straitsville Cannel Coal Company of New York. J. H. Lyons, Esq., the Superintendent, has kindly furnished me with the facts ascertained. About forty feet above the Bayley's Run coal he found at every point a thin seam of coal. This is doubtless the equivalent of a seam found from forty to fifty feet above the Bayley's Run seam, on Lower Sunday Creek. In one shaft he found a blue carbonate of iron twenty six feet below this thin upper coal. Here the ore is two feet six inches thick. In the next shaft the section is very interesting and significant. The following is the section:

		FT.	IN.
1.	Thin coal	..	6
2.	Interval not reported in detail	27	..
3.	Blue ore	1	6
4.	Sand-rock	4	..
5.	Blue ore	1	6
6.	Shale, with nodular ore	5	..
7.	Coal, Bayley's Run seam	4	10
8.	Under clay and shale	8	..
9.	Sand-rock, etc	74	..
10.	Nelsonville or Great seam.		

Here the blue ores represent the Shawnee horizon. The upper ore is rich on the top, but grows more sandy until the sandstone is reached; while the lower ore begins sandy on the top and becomes rich at the bottom. The bottom of the ore is ninety-two feet above the Nelsonville coal, and five feet above the Bayley's Run seam, which is here in full thickness. In another shaft, beginning with the upper thin coal, we find other ores.

		FT.	IN.
1.	Thin coal	..	6?
2.	Shale, with nodular ore	3	..
3.	Clay shale	12	..
4.	Ore	1	..
5.	Interval	7	..
6.	Shawnee ore, blue	3	4

In another shaft the Shawnee ore is composed of a layer of two feet of blue ore, with one foot five inches of nodular ore underneath. There are also nodules of ore filling a space of one foot three inches about ten feet below the thin coal, which is here twenty-nine feet above the Shawnee ore. By three instrumental measurements, Mr Lyons made the interval from the Nelsonville coal to the Iron Point ore ninety-one, ninety-two, and ninety-three feet, respectively; but he found the ore varying in level ten feet in the space of six rods. These measurements appear to verify his conclusion that the blue ore from five to twelve feet above the Bayley's Run coal is the equivalent of the Iron Point seam, although it nowhere presents the laminated structure of the latter.

Through the labors of the Moxahala Iron Company, the equivalent of the Iron Point ore has been found at several places in thickness varying from one foot to thirteen feet. The Hone ore, first discovered by Mr. Lewis Wolfe, is on a hill between Moxahala and New Lexington. It is reported to be by measurement a little over one hundred feet above the Nelsonville seam of coal. The ore rests upon a sand-rock, and no coal was seen below it. In this region the Bayley's Run coal is generally absent—

replaced by sand-rock. The Hone ore is a local deposit, or pocket, on the summit of a knob, and covers from one and a half to two acres. It is seven feet thick in the center of the deposit—in one place swelling to eight feet, but becoming thinner at the outcrop. It is covered with clay from one to ten feet thick, but the covering has admitted the air, and the whole body of the ore is thoroughly oxydized. There is little appearance of lamination, and no traces of carbonaceous matter were detected. The ore was doubtless originally a carbonate deposited in the form of a mud remarkably free from silica and alumina. The borings, where the ore is seven feet thick, were intimately mixed, and constituted a sample, which, analyzed by Mr. E. S. Gregory, of Youngstown, showed the following constituent elements:

Water combined	10.61
Iron sesquioxide	79.58
Silicic acid	4.22
Alumina	1.16
Oxide manganese	1.06
Lime carbonate	1.38
Magnesia carbonate	0.29
Phosphoric acid	1.03
Sulphur	0.07
Totals	99.40
Metallic iron	55.71
Phosphorus	0.45

The ore is rich in iron, and is easily smelted. It is easily dug, and is delivered by railroad to the furnace very cheaply. There are probably 15,000 tons in this single deposit.

Another deposit of ore which is believed to be in the horizon of the Iron Point ore is found on the Whitlock farm, a little north-east of Moxahala. This deposit is irregular in outline, and the extent is not well ascertained. The ore where first opened is laminated with occasional films of coal formed from isolated fragments of coal plants. On the outcrop the ore is oxydized and dark red in color; but under cover it becomes a regular black-band, according to Mr. Chamberlain. I have no full analysis of this ore, but it appears to be of excellent quality, and has proved itself such in the Moxahala Furnace. A single determination of the iron in the oxydized portion of the ore, showed 44.50 per cent. of metallic iron.

More recent developments of the Whitlock ore show a change from a black-band to the unstratified oxydized character of the Hone ore previously described. The ore thus changed is very fine, yielding over fifty per cent. of iron in the furnace after it is calcined. Mr. Chamberlain also reports that in some places over the stratified or black-band portion of the Whitlock ore are considerable masses of nodular ore. Thus we have in the same horizon black-band, massive limonite, and nodular ore. As Mr. Chamberlain well says, the nodular ore may, in many places, serve to indicate the horizon, and further search may reveal the black-band itself.

In the neighborhood of Bristol, in the same county, much larger areas of the Iron Point ore have been found. These areas, already proven, would make an aggregate of from one hundred and fifty to two hundred acres, in which the ore is believed to range from two to thirteen feet in thickness. The ore under impervious cover will doubtless prove to be a typical black band, with more than ten per cent. of carbonaceous matter. Through the courtesy of Mr. Chamberlain, of the Moxahala Iron Company, I have received the following analysis, by Mr. Gregory, of this newly found ore. The sample analyzed was composed of borings obtained in sinking holes to test the deposit.

Analysis of Black Band, Moxahala Furnace, from the large deposit near Bristol:

Silica	20.
Iron carbonate	43.
Iron sesquioxide	18.
Lime and magnesia	4.
Alumina	0.72
Sulphur	0.04
Phosphoric acid	0.83
Water and organic matter	8.
	96.59
Metallic iron	33.50

It should be stated that Mr. Chamberlain estimates the stratigraphical position of this ore to be from twenty to twenty five feet above the Bayley's Run seam of coal, which, he says, is well developed in the neighborhood of the ore. It is believed that this will prove to be a most valuable deposit of ore.

On lower Sunday Creek large bodies of ore are found above the Bayley's Run seam of coal. The ores are, generally, nodular on the outcrop, but further exploration might bring to light localities where they form regular layers. The largest deposits, so far as I have seen, are found in a horizon ranging from ten to twenty-five feet above the seam of coal referred to. The ore is, in places, very abundant, and could be advantageously mined. At no point have I seen these ores assuming the character of black band. The following analyses were made by Prof. Wormley of samples taken by myself, from different localities:

ANALYSES OF LOWER SUNDAY CREEK ORES.

	1.	2.	3.	4.
Water	6.15	12.50	5.85	7.90
Silicious matter	18.44	21.96	15.97	8.36
Iron sesquioxide	26.68	59.48	28 86	36.70
Iron carbonate	31.16	......	19.38	12.87
Alumina	2.20	0.80	0.90	1.60
Manganese	5.20	1.40	0.95	6.20
Lime phosphate	0.21	Trace.	0.69	0.89
Lime carbonate	5.25	1.60	22 24	20.96
Magnesia carbonate	4.54	2.72	4.24	3.63
Sulphur	0.06	Trace.	0.06	0.10
	99.99	100 46	99.14	99.21
Metallic iron	33.72	41.57	29.56	31.90
Phosphoric acid	0.10	Trace.	0.31	0.41

No. 1 was from section 7, Trimble township, Nos. 2 and 3 were from the "Dugway," in Trimble, and No. 4 from Laurel Fork, in the same township.

Some of the ores are excellent. No. is quite rich in iron, with only traces of sulphur and phosphorus. Taking the four analyses together it will be seen that the average phosphoric acid is only 0.21 per cent., which is quite low for Coal Measure ores. The average per centage of iron is 34.19. It is to be expected that the ores under impervious cover will be carbonates exclusively, and, consequently, a little less rich in iron.

There are several horizons of ore above that last given in the hills bordering lower Sunday Creek, from which much ore could be obtained were furnaces established in the vicinity to create a demand for it. In some places there is an ore above the thin coal of the seam first above the Bayley's Run seam. A sample of this ore, from the Moody land, in Trimble township, was analyzed by Prof. Wormley:

Water	10.80
Silicious matter	40.87
Iron sesquioxide	41.24
Alumina	1.20
Manganese	Trace.
Lime phosphate	0.26
Lime carbonate	2.15
Magnesia carbonate	2.87
Sulphur	Trace.
	99.99
Metallic iron	28.23
Phosphoric acid	0.17

The excessive quantity of silica forbids the usefulness of this ore.

Better ores are reported from higher levels in the hills, but no analyses of these ores have been furnished me. High in the hills bordering lower Sunday Creek we find the limestones often associated with the Pittsburgh (or Pomeroy) seam of coal. They may be depended upon to furnish a large quantity of useful flux to furnaces located in that region.

The furnaces already in operation in the district covered by this report use, principally, the native ores. Some mix with such ores a larger or smaller portion of Lake Superior ore. One or two furnaces also use a portion of mill cinder. In former years much of the mill cinder of rolling mills was thrown away. This was especially true of the cinder from the heating furnaces, which was generally thought to be worthless. This condemnation of the heating furnace cinder came from the old world, and was widely accepted in Ohio. There appearing to me to be no good reason for such rejection, I was led, during the progress of the Survey, to obtain samples of the rejected cinder, together with samples of cinder produced in the puddling furnaces. These were analyzed by Prof. Wormley. As these analyses have never been brought together and published unitedly in one report I have thought best to give them here. In all cases I was assisted in selecting the samples by the superintendents of the several rolling mills, and every care was taken to secure representative samples.

ANALYSES OF MILL CINDERS FROM IRONTON ROLLING MILL.

	Puddling furnace cinder.	Heating furnace cinder.
Silicic acid	30.00	29.60
Iron protoxide	65.04	64.67
Metallic iron		2.35
Manganese oxide	1.60	Trace.
Alumina	1.20	2.40
Lime	0.20	0.44
Magnesia	Trace.	Trace.
Phosphoric acid	1.24	0.54
Sulphur	Trace.	Trace.
Totals	99.28	100.00
Metallic iron	50.59	52.65
Phosphorus	.54	.23

ANALYSES OF MILL CINDERS FROM MARIETTA ROLLING MILL.

	Puddling furnace cinder.	Heating furnace cinder.
Silicic acid	21.58	24.51
Iron sesquioxide	63.38	63.30
Metallic iron	7.12	6.80
Alumina	0.30	0.35
Manganese	Trace.	Trace.
Lime	2.10	2.50
Magnesia	1.50	1.40
Sulphur	0.33	0.17
Phosphoric acid	3.20	0.83
Totals	99.51	99.89
Metallic iron	51.42	51.10
Phosphorus	1.40	.36

ANALYSES OF MILL CINDERS FROM COLUMBUS ROLLING MILL.

	Puddling furnace cinder.	Heating furnace cinder.
Silicic acid	21.00	21.20
Iron oxide	67.69	69.44
Alumina	2.80	0.40
Manganese	0.50	0.15
Lime phosphate	6.42	2.06
" carbonate	1.05	1.93
Magnesia	0.37	0.90
Sulphur	0.17	0.25
Totals	100.00	99.33
Metallic iron	52.81	54.00
Phosphorus	1.28	.30

The foregoing analyses, instead of confirming the common traditional belief that cinders from the heating furnaces are worthless, show that, as compared with the cinders from the puddling furnaces, they are the purer and better of the two. The average phosphorus in the former is 0.33 per cent; while that in the latter is 1.07 per cent., or more than three times larger. There is also a trifle less sulphur in the heating cinder. There is in it a little more iron, and a little more silica. In regard to the latter element, it had generally been thought that inasmuch as the heating furnace has a sand bottom, the sand would be blended with the cinder and render it valueless. The analyses do not sustain such a conclusion. The average of the three analyses show only 0.98 per cent. more silica in the cinder formed in the heating furnace. In one case the silica is even less than in the other. There existed an impression—evidently an old world notion—that the iron in the heating furnace cinder had, by its second heating, been so burned that it was worthless. This has proved to be a mistake, for an intelligent iron manufacturer of Ohio, who had learned of the foregoing investigations, made a large quantity of iron from the heating cinder alone, and found the quality to be exceptionally good, and affirmed that the knowledge derived from these researches had been worth thousands of dollars to his company. Similar testimony has been received from others.

I have, in the foregoing pages, given all the more important facts known to me concerning the Hocking Valley coal-field. The feature of the first importance is the Nelsonville seam of coal. While some of this coal is too sulphurous for the higher uses, the best coal of the seam is of superior quality, and has authenticated itself as suitable in an uncoked state for the blast furnace. The vast quantity of furnace coal here to be obtained at the very lowest cost of mining, will, I think, more and more invite attention to the region as a desirable district for the manufacture of iron. For that class of iron, generally included under the name of foundry iron, the local ores will prove serviceable. For special uses, the iron will be improved by a mixture with Lake Superior ore. None of the ores of this field, found as yet in quantity, will serve to make pig-iron adapted to the manufacture of Bessemer, or Siemens Martin steel. For steel, other ores, free from phosphorus, must be brought from the rich iron mines of the Lake Superior region and of Missouri.

It is doubtful whether the northern ores can be brought to any cheaper fuel than the Hocking Valley coal-field affords. By the railroads now built, and others building from ports on Lake Erie, to the different parts of this field, it is believed that the lake ores may be brought so advantageously that, at a day not far distant, that iron for Bessemer and Siemens-Martin steel will be made from the coal of this part of Ohio. Should the displacement of iron by steel continue at the same rate for ten years to come as in the ten years past, the demand for pig-iron containing phosphorus will be limited to foundry iron. Ohio has long been remarkable for its production of the first quality of the latter class of iron. For more than fifty years the famous "lime-stone ore" of the Hanging Rock iron district, smelted with charcoal, has afforded a foundry iron of almost unequaled excellence. Whether in that district a suitable quality of mineral fuel can be cheaply obtained, so that this finest of Coal Measure ores may be converted into iron in coming years, remains to be seen. The future supply of foundry iron will be derived from fields where, other things being equal, its manufacture is the cheapest. In the great future struggle these ores will be the blackband ores* and the usual Coal Measure limonites, as factors in the competition. Fortunately Ohio is well supplied with both classes of ore, and it is believed that mineral fuel now known to exist, or yet to be found, will make it possible for Ohio to supply the West with all the foundry iron it will need. If to this statement we add what appears to me to be among the certainties of the future, that to the cheap and abundant coal of Ohio no inconsiderable part of the rich ores for steel making will be brought to be smelted, the State may well be congratulated on its vast mineral resources, and the great industries of which they will form the basis.

Drift.—The Drift formation is found abundantly in all the regions drained by the upper waters of the Hocking River, in Perry and Fairfield counties. In the valleys wells have revealed the blue bowlder clay, in which buried wood is often found. Gravel and bowlders are everywhere to be seen, even on the highest lands. Most of the bowlders are granites, quartzites, etc., but sometimes fossiliferous limestones are met with. Mr. Hyde, of Rushville, has obtained many interesting palæozoic fossils from the Drift in that neighborhood. Recently, Mr. Silas Courtright has shown me, in the northwestern part of Fairfield county, striated rock surfaces in the Waverly sandstone, where the striæ are very distinct. The more usual direction of the striæ is S. 62½° E.

* Since the foregoing was written, I have published a private report to the President of the Cleveland, Canton, Coshocton & Straitsville R. R. Co., in which I have authenticated very large deposits of blackband ore over Coal No. 5, situated on the upper waters of Sugar Creek (south branch), in Tuscarawas and Holmes counties. This ore is directly on the line of the railroad from Cleveland to the Upper Sunday Creek Valley, and must in the future be smelted by the fine fuel from that valley.

SUPPLEMENTAL REPORT

ON THE

GEOLOGY OF THE HANGING ROCK DISTRICT.

PROF. J. S. NEWBERRY, *Chief Geologist:*

DEAR SIR: I herewith transmit a brief supplemental report on the Geology of the Hanging Rock District. The report is based on an examination of the field which I made during the summer of 1877, the examination being undertaken under your authority as chief of the survey, but at my own instance and without compensation.

The object which I proposed was to trace if possible some of the well-known strata of the Hocking Valley southward to the Ohio River, or, to state my object more definitely, it was to follow the great coal seam of the Hocking Valley, and the most important bed of iron ore worked there, viz., the Baird Ore, as far southward as they extend within the limits of the State.

I think that I have accomplished this object in such a manner as to remove all question in regard to the points involved.

In executing this specific task, I have had occasion to review to some extent the structure of the lowest Coal Measures of the district, but this portion of my work I count incidental. In regard to it, I have to confess that I have raised more questions than I have been able to settle. There is no peculiar complication or difficulty in the field, but more time must be spent on the strata that underlie the Zoar Limestone before a full and connected account of them can be given.

The work that I have done on this portion of the series has obliged me, in some instances, to form conclusions at variance with those announced in the previous volumes of our report. The main points of difference are as follows:

1. The Conglomerate of Pike and Jackson counties which holds within it workable coal—is the Conglomerate of the Hocking Valley which has been proved to be of Sub-carboniferous age. There are several divisions of this Conglomerate, but they are all included within two hundred feet of vertical range and they all belong to one main series.

2. The Jackson Shaft Coal belongs within the limits of this conglomerate and is therefore of Sub-carboniferous age. The same thing is probably true of several other workable coal seams of the district.

3. The Maxville Limestone does not constitute the base of the Coal Measures of Southern Ohio, but its place is from fifty to one hundred feet above the lowest coal seams. The Sub-carboniferous age of the limestone is not hereby questioned, but the same age is asserted for the lowest Coal Measures of this district.

Upon these and kindred points, I have accumulated a large number of facts, which the proper limits of the present volume, already overrun, forbid me to make use of here, I am the more willing to delay the publication because I hope within the coming year to complete the examination of this part of the series.

In conclusion, I wish to express my obligation to the persons named below for important aid in accomplishing my work. I am greatly indebted to John Campbell, Esq., of Ironton, the veteran iron-master of the Hanging Rock region, who has a very wide and thorough knowledge of the southern portion of the field; to Hon. Elias Nigh and to John Peters, Esq., also of Ironton; to Col. W. M. Bolles, of Portsmouth; to Geo. E. Williams, manager of Scioto Furnace; to W. H. Sloan, manager of Monroe Furnace; to J. A. Turley, manager of Washington Furnace; to Hon. Jos. Stafford, late manager of Gallia Furnace; to Capt. Lewis Davis, of Jackson C. H.; to Hon. Andrew Roy, late State Inspector of Mines, now of Wellston; to Dr. D. V. Rannels, of McArthur; to John W. Jones, of Haydenville; to Gen. Samuel Thomas, George W. Gill, and W. H. Jennings, of Columbus. There are two other persons whom I wish to mention here with particular honor, viz., Dr. L. W. Baker, of Hamden Junction, and Samuel Baird, Esq., of the Hocking Valley—both of whom have died within the past year. Mr. Baird possessed a better knowledge of the Hanging Rock district, as a whole, than any other man that I have found in it, having been connected with furnace interests in every county between the Hocking Valley and the Ohio River. I am indebted to him for much valuable assistance and information.

Dr. Baker had studied most thoroughly and successfully the stratigraphical geology of his own region, and had communicated to me many of his facts and measurements. I have made free use of his sections, and desire here to express my great indebtedness to him. If he had lived a year or two longer, he would have embodied his observations in a report which would have gone far to settle the disputed or doubtful points in the geology of the interesting region in which he worked.

The assistance that I have received in the prosecution of this work from several of the students in the Ohio State University is important enough to be publicly recognized. Messrs. R. S. Towne, of Portsmouth, and Thomas Kelly, of Vinton Furnace, have done excellent field work in their respective counties, and I am indebted to Messrs. C. H. Dietrich, J. S. Humphrey, C. N. Brown, H. D. Gregory, and J. C. Atkinson, for carefully measured sections in various portions of the field.

To the labors of the geologists that have preceded me in this field, and especially to the reports of Prof. Andrews, I owe very much—more, I am sure, that I can definitely acknowledge. It is not alone for the recorded facts that I am indebted, but the awakening of interest, the impetus to intelligent exploration, and the diffusion of geological knowledge, that have resulted from the previous publications of the survey, have rendered all subsequent work much easier and more advantageous in many ways. I have made the freest possible use of the work of Prof. Andrews, and here express my great indebtedness to it.

When all these acknowldgements are made, I find very little in my report that deserves to be called original. My labor has largely consisted in putting together, in proper order, facts already held by various individuals. Both the field work and the preparation of my notes for publication have been accomplished in the intervals of my college engagements, and they bear witness to the fragmentary way in which they were, of necessity, undertaken. Minor errors of indentification and of stratigraphical order, will no doubt be found in this report, but I am sure that in it the true arrangement of the most important geological elements of the Hanging Rock district finds clear expression.

Very respectfully yours,

EDWARD ORTON.

OHIO STATE UNIVERSITY, *August* 1, 1878.

CHAPTER LXXXIX.

SUPPLEMENTAL REPORT ON THE GEOLOGY OF THE HANGING ROCK DISTRICT.

BY EDWARD ORTON, ASSISTANT GEOLOGIST.

A heavy sandstone covers Coal No. 6 through a considerable part of its outcrop in Ohio. In Lawrence county this rock is well developed, especially in those portions that border on the Ohio River. Near the village of Hanging Rock it shows itself in very bold and picturesque escarpments, from which the village derives its name.

The manufacture of pig iron in Southern Ohio was begun on Brush Creek, in Adams county, but the supply of ore found there, derived from Upper Silurian limestones, proved limited and uncertain, and it was not long until the seat of the manufacture was transferred to the western border of the Coal Measures in Scioto and Lawrence counties. A very prosperous and important industry was soon developed here. Several of the earliest furnaces were located near Hanging Rock, and their iron was distributed from that point as a center by means of river transportation. The products of these furnaces was thus known as far back as fifty years ago as the "Hanging Rock Iron." The name was naturally extended so as to include all the iron made from the general geological horizons that were worked by these earliest furnaces. These horizons were gradually followed back from the river through county after county, as far as the Hocking Valley, the old Logan Furnace being the last one whose iron was counted Hanging Rock Iron.

The belt of country thus occupied is about sixty-five miles long and from ten to twenty miles in breadth, its longer axis bearing about twenty degrees west of south. Upon it fifty furnaces have been established, and the best of the iron made in them has become the standard of comparison throughout a large portion of the Mississippi Valley. For some important uses, indeed, there is good reason to believe that no better iron has ever been manufactured in the country.

The ore seams that have been worked in the Hanging Rock district are very numerous, but one seam enjoys such easy and undisputed preëminence here that it may be taken as the proper representative of the whole field. This seam is known as the *Limestone Ore.* It gets its name from the fact that it is, for the most part, immediately underlain by a stratum of fossiliferous limestone, which is commonly called the *Gray Limestone* through the country that it occupies. The stratum was named by Prof. Andrews the *Ferriferous Limestone*, but, for reasons to be hereafter given, it is termed in this report the Hanging Rock Limestone.

Assuming this ore seam, then, to be the characteristic and determining feature of the Hanging Rock district, and counting in, as belonging to it, all the furnaces that are established on it, it will be found necessary to extend the limits already named, by a few miles, so as to embrace the new furnaces of the Hocking Valley that depend on the Baird Ore for their chief supply, the Baird ore being the name by which the limestone ore is known in its northern developments. The south line of Perry county thus becomes the northern boundary of the Hanging Rock district. The western margin of the Coal Measures constitutes its limit in that direction, while, upon the east, an equally irregular boundary is formed in the sinuous line that marks the descent of the limestone ore below drainage. Its southern limit is the Ohio River, for, though all the elements of our geological scale can be followed unchanged into Kentucky, we have no immediate interest in them there.

The present report will be confined to the discussion of one general topic, viz., *the stratigraphical order of the rocks that occupy this belt.* Nor will the whole series be considered here. Only that portion of it that begins with the Zoar Limestone and ends with the Cambridge Limestone, will be particularly treated, but two additional limestones, viz., the Maxville and the Ames, will be employed in the classification. Incidentally, the order of other parts of the series will be briefly discussed, and also the economical values of many of the more important deposits, but the limits of available space make this restriction necessary.

1. This district embraces the *Lower Coal Measures* and part of the *Barren Measures* of the generally received classification, in all amounting to about seven hundred feet, the Ames Limestone of Prof. Andrews being taken as the upper limit.

No two sections along this extended belt of country will prove exactly identical. Strata change from mile to mile, and even from farm to farm, somteimes in composition and sometimes in quality. Some are quite local in character, disappearing abruptly; others are more persistent, and can be traced over wide areas. A few hold their relative positions throughout the field, but even these are subject to very important modifications. The lime or ore of any one section may be replaced by flint in another.

Shales or sandstones take the place of coal, and the steadiest seam is constantly undergoing changes of quality, from good to bad, or to better, while the volume may expand and contract with rapid alternations.

The elements that are generally counted available for identification in separate sections are sandstone ledges, beds of coal, and fire-clay, seams of ore and strata of limestone.

The first named of these formations is the one that comes first into use. A sandstone twenty or thirty feet thick makes a conspicuous feature in every section. It can often be traced with the eye in unbroken outcrop for mile after mile. Though most commonly and confidently appealed to, a sand-rock needs to be used with great caution in establishing the identity of distinct sections. Ledges occupying different horizons frequently resemble each other so closely that the sharpest inspection cannot distinguish them. In mineral composition, indeed, there may be no difference whatever. Wherever the continuity of a sand-rock is lost, as in passing from one valley to another, it is an uncertain guide.

Coal seams are universally recognized as having great powers of service in this way. Generally, more reliance is placed on them than on any other element, in constructing the section of any portion of the Coal Measures. Wherever there are marked peculiarities of a seam, as contrasted with others with which it may be associated, in regard to quality as open-burning or caking, or in partings that are found persistent, or in less obvious points, as in the color of the ash, the seam can be trusted to a large extent, but it cannot be denied that the individuality required for identification is often wanting, and in many fields, two contiguous seams may agree so closely in character, structure, and volume, as to make it impossible to determine them except by their stratigraphical relations.

The same thing is true of beds of fire-clay. Occasionally a seam is so marked in quality or volume that it can be safely followed, but the same hill will often hold two or more seams that repeat each other in almost every particular.

Seams of ore are often very well characterized. No one can distinguish hand samples of the limestone ore of Lawrence county from specimens of the same seam in Perry and Hocking counties, where it is known as the Baird vein. Many other seams have locally such well marked peculiarities that wherever found they are confidently recognized.

It is, however, to the last of the elements named above, that we owe most in this respect. The strata of limestone that are distributed through the Ohio Coal Measures, have long been recognized as, on the whole, the most available guides to a knowledge of the stratigraphical order of the several separate districts and of the field as a whole. Every geologist who has worked in this series has been obliged to recognize and follow them, and practical men in search of ore and coal, have long since learned their value. The reasons for their selection are obvious. Limestones are more individualized than any other strata with which they are associated. They differ from each other in structure, in color, in the presence or absence of fossils, and to some extent in the kinds of fossils when any are present. They are generally slow to decay, and thus their outcrops are marked in all natural and artificial sections. When they chance to weather easily, they give rise to soils as characteristic and as easily recognized as the limestones themselves.

A. LIMESTONES OF THE HANGING ROCK DISTRICT.

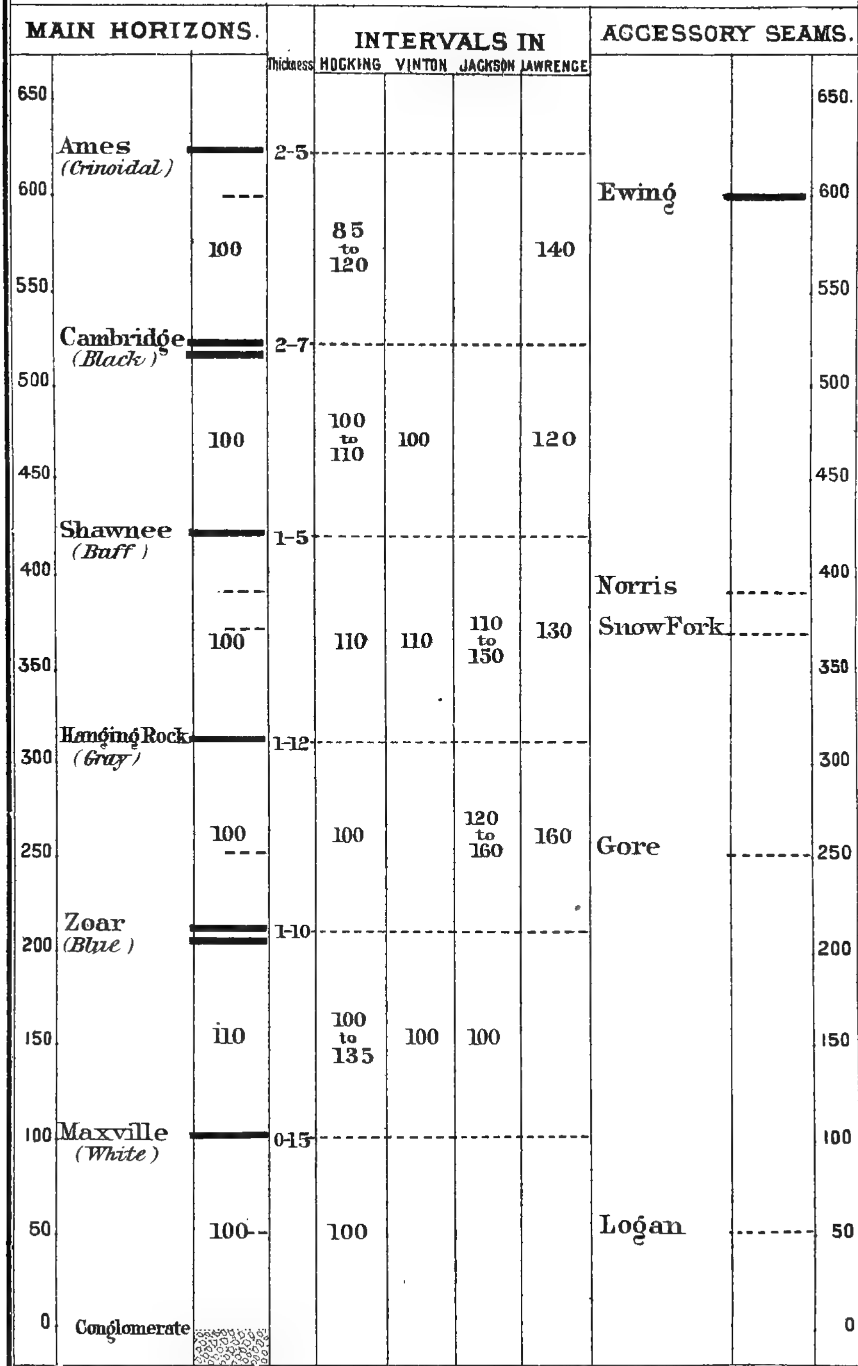
There are six principal limestone horizons in the Hanging Rock District. Five of them stretch through the whole field, and furnish the means of establishing the stratigraphical order of every portion of it. They are named as follows, being numbered in ascending order,

6. Ames or Crinoidal Limestone.
5. Cambridge or (locally) Black Limestone.
4. Shawnee or Buff Limestone.
3. Hanging Rock or Gray Limestone.
2. Zoar or Blue Limestone.
1. Maxville or (locally) White Limestone.

The lowermost stratum or the Maxville, is very much less extended than the rest. It is shown indeed only in isolated patches, and much remains to be learned of its development in the district. While it cannot be claimed as a conspicuous or steady horizon, yet in such portions of the field as it occupies, it serves a very useful purpose in establishing the true order and system of the Coal Measures.

These several limestone horizons are separated from each other by approximately equal intervals, which vary, however, in different parts of the field, being generally increased as they are followed southward. In the Hocking Valley, the intervals are about one hundred feet. Thus the distance from the Maxville Limestone to the Zoar, ranges from one hundred to one hundred and thirty-five feet. No better average can be given for the interval between the Blue Limestone and the Gray (Hanging Rock) Limestones than one hundred feet. Again, the Shawnee or Buff Limestone lies one hundred to one hundred and ten feet above the Gray. The Cambridge is about one hundred feet above the Shawnee and, finally, the Ames ranges between eighty-five and one hundred and twenty feet above the Cambridge. In southern Vinton county, the interval between the Maxville and the Blue Limestone is a little less than that already given —viz., ninety feet. From the Blue Limestone to the Gray, the distance has been increased to one hundred and twenty or one hundred and forty feet,

LIMESTONES OF THE HANGING ROCK DISTRICT.



Strobridge & Co. Lith. Cincinnati

while the distance from the Gray to the Buff Limestone is somewhat increased.

In Jackson and Scioto counties, there is an interval of about one hundred feet between the representative of the Maxville and the Zoar.

From the Zoar to the Gray Limestone, there is a still larger interval than in Vinton county, the distance now being one hundred and sixty feet.

In Lawrence county, the lowest horizon is not reached, but the interval last named, between the Blue and Gray Limestones, is repeated. The interval between the Gray Limestone and the Buff is also found the same as in Jackson county, the average distance being one hundred and thirty to one hundred and forty feet. From the Shawnee to the Cambridge, the distance ranges between one hundred and ten and one hundred and twenty feet. No measure from the Cambridge to the Ames was found in Lawrence county, but a single one taken in Gallia county showed the distance there to be one hundred and forty feet. These facts are represented in the appended diagram—(Limestones of the H. R. District.)

In the diagram are also shown the places of various other limestone horizons that occur in the series. There are none of them, however, that are equally persistent with those named above. Local patches of limestone are scattered through the district of which no account can be taken. Found in some single section, they may never be met with again, but the accessory seams to which reference is now made, have quite a wide distribution. One of them, particularly, the Gore Limestone of the section, is found at thirty to forty feet above the Zoar. It can be traced as a lime, or flint, or ore horizon, from the Hocking Valley quite to the Ohio River. It does not, however, make a continuous bed of limestone, for any large area.

At twenty-five feet below the Shawnee or Buff Limestone a lower Buff Limestone is often met. It is named in the section, the Norris Limestone. In Southern Ohio, if correctly identified, it becomes an important ore horizon. At a still lower level, the Snow Fork Limestone is found in the northern part of the district. It is better developed on the stream from which it takes its name than elsewhere. It, also, is a Buff Limestone. A local limestone of considerable extent is found in northern Gallia county, about midway between the Shawnee and the Cambridge Limestones. It is blue and fossiliferous, and has sometimes been mistaken for the Cambridge. It is found at the exact horizon of an important iron ore of that vicinity, viz., the Banda ore, which replaces it throughout several townships. It is named the Flag Spring Limestone, from a well known locality in Walnut township, Gallia county, where it is best developed. Finally, the Ewing

Limestone may be named as a very wide spread and persistent seam. It takes its name from Ewing Site, in the Sunday Creek Valley, where it is a ferruginous limstone, five feet in thickness, about eighty feet above the Cambridge and forty feet below the Ames. It holds its place throughout the counties southward to the Ohio River, and by its steadiness, indeed, almost deserves to be counted in the first list. It weathers easily and is so often hidden by the products of its own decomposition that it escapes general notice.

These, then, are the principal limestones at present known in the Hanging Rock District. They constitute a very orderly and symmetrical system. The suggestion of Croll, that the Coal Measures are the product of a glacial period, the coal seams themselves, and equally the limestones and ores with which they are associated, being interglacial growths, finds in this series its best illustration, and, perhaps, furnishes the best explanation of the astronomical regularity with which these horizons succeed each other.

Each of the limestones named will be briefly described.

1. *The Maxville or White Limestone.*—It is harder to characterize the Maxville limestone than any other in the series. The exposures of it are few in number, and even these few exhibit great diversity of composition. The most valuable and, on the whole, the most characteristic part of the stratum as seen at Maxville, Perry county, at Winona Furnace, and at Logan, Hocking county, consists of a light drab-colored limestone, very fine grained and homogeneous, generally poor in fossils, breaking with a conchoidal fracture and looking very like lithographic stone. Other portions of the stratum are blueish in color, and others still are colored green by silicate of iron. There is often a notable quantity of this substance in the clays that are found between the layers of the limestone. A light blue stone that is found at the Winona Furnace drifts, is equal in quality to the portion already described. It greatly resembles in appearance the famous Dayton Limestone of Upper Silurian Age. The drab or white limestone yields at its best over ninety per cent. of carbonate of lime, and is much esteemed as furnace flux. The darker beds are generally rejected by the furnaces as too silicious, but analysis shows that selection cannot properly be made on the ground of color.

It has already been stated that this formation is unsteady and irregular in its occurrence. The best guide in following it is the persistent and easily recognized horizon of the Zoar or Blue Limestone, which, with its block ores, is universally known throughout the district. The place of the Maxville is about one hundred feet below the Blue Limestone. The greatest measures found are one hundred and thirty-five feet in two instances in Hocking county.

With the clue above named, the horizon of the Maxville Limestone can apparently be followed in patches of gray or drab, sometimes, blueish limestones, generally sandy in composition, from the south line of Vinton county, through the townships of Lick, Franklin and Hamilton, of Jackson county, and through Harrison and townships, Scioto county, to the Ohio River. In other words, the Maxville Limestone constitutes a definite horizon in the Lower Coal Measures. It may be described as an *intra-conglomerate* limestone. The main body of the conglomerate, the Waverly conglomerate of Prof. Andrews, lies below it, but in the southern part of the district, it is also overlain in some instances by twenty or thirty feet of conglomerate.

Like all the other Coal Measure limestones, this ore is occasionally replaced by flint.

2. *The Zoar Limestone.*—This stratum takes its designation from the village of that name in Tuscarawas county, where it was first studied in its relations to the Ohio series. It is beyond question the best marked stratum in the Lower Coal Measures of the State, and, therefore, the most available guide in establishing the order of this varied series of deposits. It can be followed without interruption from the Pennsylvania line, through Mahoning county, Stark, Holmes, Tuscarawas, Coshocton, Muskingum, and Perry, to Hocking. From the north line of Hocking county, as far southward as the middle of Jackson county, its outcrop need scarcely be lost sight of for a mile. Though seen but infrequently from that point to the Ohio River, there is no uncertainty or obscurity as to its place in the series. Before it disappears, it has established connections with a group of strata that is everywhere developed and exposed in the furnace districts beyond. The lowest of these block ores that constitute so important a reliance of the western furnaces, rests upon the Zoar Limestone when it is present, and represents it when it is absent.

The color of the limestone is dark-blue, as indicated by the name that it usually bears. Along the line of its outcrop through the State, it is almost everywhere known as the *Blue Limestone*, the only exception being that it is occasionally styled the Black Limestone. In thickness it occasionally rises to ten feet, but it, as often, shrinks to ten inches. The usual measure for it in this district is from one to three feet. It is generally shaly in structure, at least for a part of the stratum. It does not lie in massive or even beds, and does not endure the weather well. For these reasons, it has comparatively little value as a building stone.

In composition, it is often quite impure, containing a notable quantity of silica, alumina, and iron, which generally forbids its profitable use as a furnace flux.

It is highly fossiliferous, being charged with common Coal Measure forms. The large stems of crinoids are specially noticeable in it. The solid portions of the stems have usually been replaced by calc spar, and their white, crystalline sections make a marked contrast to the dark and earthy rock in which they are imbedded. The center of the stem is often blue, like the mass of the rock. This peculiarity holds in every county of the State in which the limestone is shown, but in the counties eastward, it is shared with the two limestones next above it in the series.

This limestone is very often replaced by flint. Sometimes layers of flint are interstratified with the limestone layers, and sometimes the limestone entirely disappears for miles in succession. The flint holds the fossils of the limestone and maintains the same relations to overlying and underlying rocks. In color it is generally black or dark-blue, but there are often light-colored portions distributed through the mass. Where the interbedding of limestone and flint referred to above, occurs, there is sometimes a notable expansion of the series, its varied members filling fifteen or even twenty feet. The position of the Zoar Limestone in the series has been already plainly indicated. It lies about one hundred feet above the Maxville limestone, its limits as measured varying between ninety and one hundred and thirty-five feet. In the Hocking Valley it is from one hundred and sixty-five feet to two hundred feet above the lowest coal, and these are also common measures through Vinton and Jackson counties.

It has been spoken of as a single seam; but it must be distinctly added that two courses, separated by an interval of fifteen feet, belong to the horizon to the northward and eastward. In Vinton county, the interval expands to twenty-two feet. Each of these courses when present, is capped with iron ore, and underlain with a coal seam. The ores continue after the limestones fail, the lower becoming the one known as the Dresden, Junction City, and Union Furnace Block, in our section, and the upper being the Main Block or Hocking Furnace ore. This duplication of the limestone and its associated seams has led to some confusion where it has not been recognized. The upper layer is referred to in all measurements that follow, where the Zoar Limestone is involved, unless exception is expressly made.

The Hanging Rock Limestone—The Gray or Hanging Rock Limestone is the next one of the main series to be met in ascending the scale. It is the limestone named "Ferriferous," by Prof. Andrews, in the southern counties; but inasmuch as the Zoar or Blue Limestone, which is also found in this district, is equally with the Gray Limestone, *ferriferous*, this designation will be replaced here by a geographical name. As this limestone is everywhere developed and everywhere known throughout the Hanging Rock District, and is almost the sole reliance of all the southern furnaces for flux, it will be styled the *Hanging Rock Limestone.* It is ordinarily known as the Gray Limestone. It is the duplicate of the Gray Limestone of the eastern counties. This last seam, it will be remembered, received from Prof. Andrews the name of Putnam Hill Limestone, from a fine exposure opposite Zanesville. As the Putnam Hill Limestone is followed westward, it is found to grow thin and finally disappear. It is in good force as a flint and lime horizon at New Lexington, Perry county—being shown in a section of five feet in the railroad cut, just east of the station, but it cannot be followed, without change, far beyond this point. It seems to become an ore horizon to the southward. The "Limestone Kidney" ore of the southern counties lies very near its proper place. A bastard limestone is found associated with this ore seam at McCuneville and elsewhere. But just as the Putnam Hill Limestone fails, a new one makes its appearance. In the neighborhood of Bristol, Perry county, a horizon of lime, flint, and ore appears from fifteen to thirty feet above the Putnam Hill Limestone. Its usual distance is a little more than twenty feet. It, too, is a gray limestone, and it takes its place in a series of fifty or sixty feet of strata that repeat, in a remarkable way, the order of the strata found with the Putnam Hill Limestone. It will be remembered that the Zoar or Blue Limestone very often occurs in the district in two courses, from fourteen to twenty-two feet apart. As this interval is sometimes wholly filled with fossiliferous, calcareous shales, and as the limestones indicate the same conditions of growth, there can be no question as to their both belonging to the same epoch; and they are, therefore, distinguished as the Upper and Lower Zoar Limestones. It will be hereafter shown that the Cambridge Limestone is split in the same way, its two courses being separated by intervals varying from one to twenty-seven feet, and the separate courses being known as Upper and Lower Cambridge. There is almost equal warrant for counting these two gray limestones as belonging to one epoch, and giving them the same general name. The difference between the cases does not lie in the magnitude so much as in the character of the intervals. The Putnam Hill and Hanging Rock horizons are separated in the northern part of the field by sandstones which indicate a more complete break than is shown by the fire-clays and fossiliferous shales referred to above. The Hanging Rock Limestone will accordingly be treated by itself in the following review.

It is generally light gray in color and semi crystalline in structure, and is heavily charged with fossils, some of which may prove to be characteristic of the stratum. It is frequently a Crinoidal Limestone for limited areas. In composition it is pure enough to furnish an excellent furnace flux, for which purpose it is largely used along the whole line of its outcrop in this district. Though comparatively irregular and uncertain in the Hocking Valley, there has yet enough of it been raised in connection with the Baird ore to furnish many hundred tons of flux to the furnaces located here. Occasional exposures of it are darker colored than the main body of the rock, but it seldom acquires the dark shade of the underlying Blue or Zoar Limestone. There are phases, however, of the two that are liable to be confounded.

Like the limestones already described, the Gray Limestone is frequently replaced by flint. The accumulations of flint along this horizon and that of the Putnam Hill Limestone, indeed, are the heaviest that occur in the Coal Measures of the State. The best known of all is Flint Ridge of Licking county, which belongs to the last named horizon. For a large area here, the limestone is generally wanting, its place being taken by six to eight feet of fossiliferous flint. The flint is of an enduring nature, and so it happens that along the margins of the ridge great blocks of it, which have been undermined by the waste of ages, are left to cover the slopes quite widely.

There are flint ridges in Vinton county and also in Jackson, replacing the Gray Limestone, that are not at all inferior in thickness to the ridge of Licking county, just named. Their areas, however, are much less.

Many of these deposits were extensively worked, by the earlier races that occupied the country, for arrow-heads and spear-points, and in our own day mill-stones have been wrought from the stratum. Quite an important business was carried on in this manufacture fifty years ago. This stratum constitutes, in part, the "calcareo-silicious rock" of the First Geological Survey (First Annual Report, page 31).

The interval between the Blue Limestone and the Gray—counting from the Lower Zoar, or Lower Block ore—ranges in the Hocking Valley from one hundred and ten feet to one hundred and twenty feet. It increases gradually to the southward, becoming one hundred and twenty-five feet to one hundred and fifty feet in Vinton and northern Jackson, and as much as one hundred and sixty or one hundred and seventy feet in the southernmost portions of the district.

The Hanging Rock Limestone bears the famous limestone ore of the district, which is worked for the supply of fifty furnaces. It also covers one of the most available coal seams of Jackson and Vinton counties, and thus its horizon is by far the best known of any in our western

Coal Measures. It can be followed without the slightest uncertainty from the Ohio Valley as far at least as Bristol, Perry county.

4. *Shawnee Limestone.*—The Shawnee, or Buff Limestone, is the next of the main series to be reached in ascending the scale. Its average elevation above the Gray Limestone in the Hocking Valley is one hundred and ten feet, but the distance increases somewhat to the southward, becoming one hundred and thirty or one hundred and forty feet in Lawrence county. This limestone is a persistent, though not very conspicuous member of the geological scale of the Hanging Rock District. It takes its name from Shawnee, Perry county, where it is extensively worked for furnace flux. It is also largely worked for the same purpose in the Monday Creek and Snow Fork valleys. Its thickness varies between one and three feet, but it falls below two feet much oftener than it rises above this measure.

Its color is described by the name by which it is generally known, viz., the Buff Limestone. The best varieties of it carry ninety-three per cent. of carbonate of lime and only four or five per cent. of silica, but it genally contains ten or fifteen per cent. of silicious matter and not more than eighty to eighty-five per cent. of carbonate of lime. The amount of iron and alumina often rises to ten or fifteen per cent. and a small percentage of manganese is a constant element. The best varieties of it are not surpassed in purity by any limestone in the district, but it is unsteady in composition. It is commonly called non-fossiliferous, as it lacks the usual coal measure forms, but fragments of crustaceans are not of rare occurrence in it. It never passes into flint, as the limestones previously described so often do. On the whole, it is an excellent and reliable guide to the geology of the district to which it belongs. The only uncertainty in regard to it that is likely to occur, results from a duplication of this portion of the series in some parts of the district. From twelve to twenty feet above the Shawnee Limestone, and about the same distance below, two other Buff Limestones are sometimes found, but they are of more interest as ore beds than as limestones, and will be treated on a subsequent page under that head.

5. *The Cambridge Limestone.*—The fifth member of this orderly series of limestones is the stratum called the Cambridge Limestone by Prof. Andrews. The name is derived from the village of Cambridge, Guernsey county, where this limestone is said to be well developed.

The Cambridge Limestone has long been recognized as one of the most persistent of our Coal Measure limestones. It stretches through every county of Ohio in which its proper horizon is reached, and furnishes an invaluable guide in the determination of the order of the Lower and the Barren Coal Measures. The geologists of the first survey saw its availability, and made use of it to some extent, but greater stress has been laid upon it by Prof. Andrews and the other members of the present corps who have worked within its limits. In the district now under consideration it is especially serviceable, as it can be followed by a continuous line of outcrops from Nelsonville to the river hills above Ironton. The westernmost exposures of it pass through Starr township, Hocking county; through Brown, Madison, Vinton, and Wilkesville townships, Vinton county; through Huntington and Raccoon townships, Gallia county; through Madison township, Jackson county, and through Washington, Decatur, Elizabeth, and Upper townships, Lawrence county. It overhangs the Ohio River on the Monitor Furnace lands, above Ironton. It is found at an elevation of one hundred to one hundred and ten feet above the Shawnee Limestone in the Hocking Valley, and the interval increases slowly to the southward and eastward, being about one hundred and twenty feet in Lawrence county, and one hundred and fifty feet in Gallia county. It is seldom less than two feet in thickness, and is frequently found eight to ten feet thick through extensive tracts. It is highly fossiliferous in most of its outcrop, and, like the fossiliferous limestones below it in the scale, is very frequently replaced by flint. It constitutes flint ridges, indeed, scarcely inferior in thickness and extent to the deposits of this sort along the outcrop of the Putnam Hill Limestone. This phase is shown very distinctly in Lawrence county, on Mt. Vernon Furnace lands. Dr. Hildreth, of the first survey, supposed the Cambridge flint, the Putnam Hill flint, and the Hanging Rock flint, to be one stratum, to which he gave the name of the "calcareo-silicious stratum." It is possible that he counted in also one or two exposures of the Zoar flint. He clearly recognized, however, the differences in quality between the flints from these separate horizons. The buhr stone, which was manufactured into millstones quite extensively, thirty years ago, was derived from the Putnam Hill and Hanging Rock horizons, exclusively.

The formation generally gains in volume when flint takes the place of lime. This statement can be made, in fact, for all of the similar deposits that have here been described.

The limestone agrees in composition with the one last named, holding in its best phases from eighty to ninety per cent. of carbonate of lime, with very little magnesia. It contains, locally, a notable quantity of iron.

It is frequently a crinoidal limestone, and is generally fossiliferous. It is crystalline in structure for the most part. The prevailing shade of color is a grayish brown, which is quite characteristic. It is the same in Athens, Vinton, and Lawrence counties. In the Hocking Valley, however, the limestone is often black for considerable areas, and gets a local name from this fact. It is also sometimes reddish in tint, and sometimes blue. It occasionally resembles certain phases of the Putnam Hill Limestone very much, but its distance from this in the scale renders any confusion from this cause unnecessary. The only limestone with which it is really likely to be confounded is the Ames Limestone that lies about one hundred feet above it.

6. *The Ames Limestone.*—The last of the series is the stratum called the Ames Limestone by Prof. Andrews, from the township of this name in Athens county. It is a light gray, crystalline, highly fossiliferous limestone, often crinoidal, that is found in all of the Coal Measure counties of the State in which it is due. In the district under consideration, however, it is but seldom reached. Its altitude above the Cambridge Limestone, in the Hocking Valley, varies in the few sections measured, between eighty-five and one hundred and twenty-one feet. The interval in two sections in Gallia county was found to be one hundred and forty feet. It is often called the "fossil limestone," or the "crinoidal limestone." It will answer an excellent purpose for furnace flux. In this district, at least, it does not pass into flint.

The Ames Limestone forms the summit of the series to be considered here.

ACCESSORY SEAMS.

Between the Ames and the Cambridge Limestones, one of the accessory seams named on a preceding page is due, viz., the Ewing Limestone. It has not been seen where the interval between the limestones named above is shortest, but in the Sunday Creek Valley it is found at about eighty feet above the Cambridge. It does not vary ten feet from this interval throughout the field. It is quite heavily charged with iron, is non-fossiliferous, and weathers easily. It is often found in isolated bowlders in a seam of red earth along the line of outcrop. It is concealed by the products of its own decomposition, much more than any other limestone of the series.

Between the Hanging Rock and Shawnee Limestones, two seams of buff limestone are often found. Neither is steady in occurrence, but the upper one, named the Norris Limestone, marks an important horizon. A valuable ore seam is found at this level in the southern part of the district. The Norris Limestone, in the Hocking Valley, seldom reaches a thickness of two feet.

The lower of these two seams, called the Snow Fork Limestone, is found at comparatively few points. On the Snow Fork of Monday Creek, Hocking county, however, it is shown in numerous outcrops, and has been counted available in that region for possible furnace use. It lies only twenty or thirty feet above the great coal seam of the valley.

The Gore Limestone, which is found from thirty to forty feet above the Zoar, resembles the latter in some of its phases, and can easily be mistaken for it. Like the latter, too, it is underlain with a coal seam and overlain with iron ore. As a limestone, it is chiefly found in Hocking and Vinton counties. It is often replaced by flint, though seldom by as heavy deposits as the Zoar horizon shows. Like that limestone, it is dark blue in color, but it is not as heavily charged with fossils as the Zoar. In Sections 25 and 26, Starr township, Hocking county, however, it yields very perfectly preserved fossil shells. It has been used to some extent as furnace flux, but it is inferior to most of the limestones of the district for this purpose.

This, then, is the geological frame-work of the district. The main elements, already named, are persistent, and can readily be distinguished from each other. The accessory seams come in to facilitate the identification. A careful enough examination of these elements will, therefore, show the proper horizon of every portion of the field.

The fact that the limestones already described are closely associated with seams of both coal and iron ore, has already been incidentally mentioned. It is a point of so much importance that it deserves to be treated at more length.

There are four elements of the Coal Measures that are the products of life, viz., seams of coal and ore, and beds of limestone and flint. The last two have been found to be interchangeable to a high degree in the review already made. There are, in fact, but two limestones of the main series that are not very frequently replaced by flint. Both limestone and flint show their organic origin unmistakeably, being often filled with remains of the marine life of the periods in which they were formed.

It needs no argument to prove that coal is the product of ancient vegetable growths. The microscope shows in coal the various tissues that belong to plants, and even enables us to estimate the relative proportions of these several tissues that make up a coal seam.

A bed of iron ore is a less obvious sign of the former presence of vegetable matter than a coal seam, but it is not a less certain sign. Unlike coal, iron ore is not formed from the tissues themselves, but it is accumulated by means of such tissues. The iron that is diffused so generally through rock formations of all sorts, is rendered soluble by the presence and through the agency of organic matter, and by the same agency is gathered into seams of carbonate of iron.

These three or four elements are intimately associated in all our Coal Measure rocks. This association recurs again and again in the series under consideration. Coal, limestone or flint, and ore, mark vital nodes in the series, these nodes being separated from each other by beds of shale, sandstone, or conglomerate, in which the remains of animal or vegetable life are, for the most part, wanting. The presence of any one of these elements proves the existence of conditions favorable to life, but they separately mark the varying conditions of the surface upon which they were deposited. Coal, as has been pretty well established, accumulated in marshes near the sea level. Beds of fossiliferous limestone were formed upon the sea floor in warm and clear water, but no great depth could have been required. If the ore seams are contemporaneous with the rocks in which we find them, they must owe their origin to conditions very similar to those under which limestones grew; but one theory of their origin is that they have been formed by a segregation of their materials from adjacent beds since the original deposit.

When a coal seam, then, is overlain by a fossiliferous limestone, as happens again and again in the series under consideration, there is clear proof that a subsidence of the coal swamp took place, so that its former area came to be occupied by clear and warm sea water. When the limestone in turn is covered by a bed of iron ore, there is perhaps indicated an upward movement of the sea floor, by which a partial return to the conditions of the coal swamp was effected. The beds that intervene between the horizons of life, and especially the great sandstone ledges that occupy so large a portion of every section, indicate conditions very widely different from those already hinted at. They show apparently a greater depth of water, currents of considerable force and range for the transportation of the rock material from distant sources, and, through some causes, a very great diminution always, and sometimes the entire absence, of the former life of the seas.

These mutations that succeed each other so often in our scale, it tasks the imagination to follow and restore.

In filling up the series of the district under review, the frame work already pointed out will, of course, be used. The iron ores of the series will first be located and briefly described, and afterwards the coal seams will be treated in like manner.

B. IRON ORES OF THE HANGING ROCK DISTRICT.

Seams of iron ore are found at a multitude of horizons in the Hanging Rock District. Some of the deposits are altogether local in their occurrence. Found in a single section, they may never be met again. A few, however, extend through the whole field. Of the six limestones that constitute the main series, five are capped with iron ore, the Ames being the only one that is not so covered. The accessory limestones also for the most part, carry ore. It is this association of ores and limestones that makes the identification of the former possible in widely separated localities. But few of the ores have individuality enough to render identification safe when based on their qualities alone, but taken in connection with the other elements of the section, we may make ourselves sure of their continuity.

In the appended section (Iron Ores of the Hanging Rock District), the general order of the leading ore seams of the district is shown, and their relations to the limestones already named are indicated. Place is given, as a general thing, only to those seams that have been worked. The intervals between some of the limestones, it will be remembered, increase as the strata are followed southward. This fact renders the connections of some of the intermediate seams doubtful, but when the general and particular stratigraphical order of one section is observed in another, it is scarcely possible to avoid the identification of corresponding elements, though no continuity of outcrop exists. To all of these doubtful or uncertain cases attention will be distinctly called.

1. The lowest ore shown in the scale belongs to this division. A deposit of ore is often found near the level of the lowest coal seam. The best showing of this horizon occurs in Scioto county. An ore named the Guinea Fowl has here been worked for two or three furnaces to a small extent, and notably at Scioto Furnace. It is about fifteen feet above the conglomerate which occurs here. It is a heavy ore, of good thickness. Its appearance is quite promising, and trial has, once and again, been made of it, but it has never been approved. It is probably highly silicious, and is certainly poor in iron.

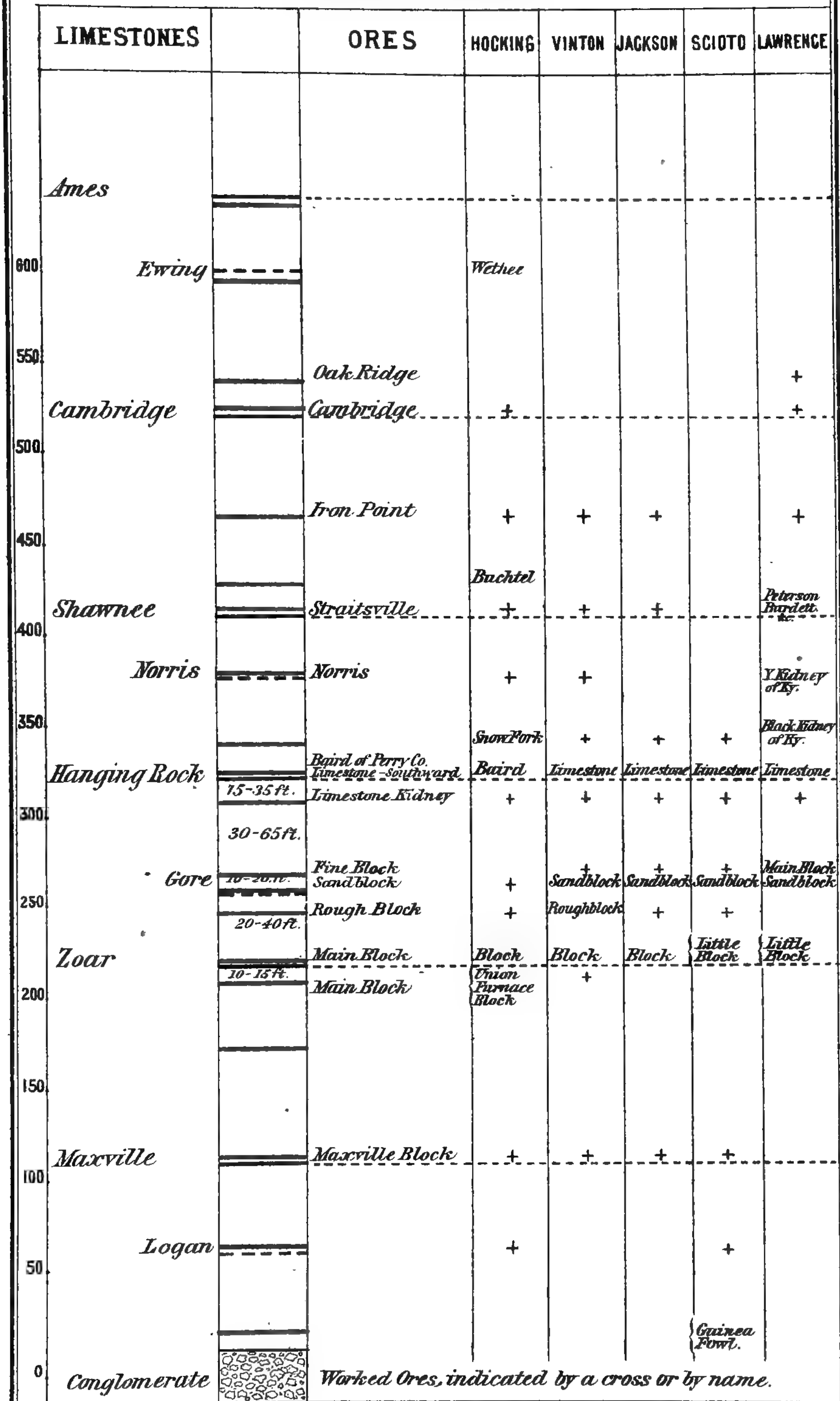
At the same horizon in Jackson county, and more particularly on Sections 19 and 20, Washington township, and in the northern sections of Hamilton township, considerable ore is shown in outcrop. In Vinton county, also, ore is seen at this level at various points. Most of the exposures noted lie in Richland township. Like a half dozen other ore seams of the Lower Coal Measures, this one is frequently replaced by a blue limestone.

This is an ore horizon rather than an ore seam. There is nothing to warrant the expectation that it will receive more attention in time to come than it has already received.

2. At an elevation of about fifty feet above the Waverly conglomerate, a thin limestone or flint, overlain with iron ore, sometimes occurs. The ore has been worked to a small extent on the Westenhaver farm, Section 31, Falls township, Hocking county, in connection with the fire-clay that covers it. The flint or lime overlies a thin seam of coal, and this in turn covers the fossiliferous beds of sandstone and shale that are included in the Logan sandstone of Prof. Andrews. The lime, flint, and ore may be marked by a similar designation, and are accordingly marked on the sec-

IRON ORES OF THE HANGING ROCK DISTRICT.

Scale 100 feet – 1 inch.



Strobridge & Co. Lith. Cincinnati.

tion as the Logan Lime and Ore. Through Vinton and Jackson counties there are many showings of ore at this horizon, but none of them are known to be worked.

3. The next ore found in ascending the scale is of somewhat more importance. Its place is forty or fifty feet above the Logan flint. It rests upon the Maxville Limestone when this is present, and gets its name from this association, being known in the northern part of the district as the Maxville Block Ore. The ore often retains its place when the limestone is wanting. The same thing can be observed in repeated instances in the other ores that are associated with limestones in the district, the ore seams being generally more persistent than the limestones.

An exception to this statement must be made in the case of some of the outcrops of this limestone in Vinton and Jackson counties. At Reed's Mills, near Hamden Junction, there is quite an exposure of the Maxville horizon, but the ore seen at this point is thin and worthless. Of the numerous outcrops of the limestone in Lick and Franklin townships, Jackson county, none has been found to hold the ore, but it appears again in Hamilton township, where it has been worked to a small extent.

In Monday Creek township, Perry county, and the adjoining township of Falls, in Hocking county, the Maxville Limestone is now quite extensively worked for furnace flux. The Logan fire-clay, one of the most valuable clay seams of Ohio, is also obtained from the same horizon, its place being immediately above the ore and limestone. A considerable quantity of ore is raised with the fire-clay and the limestone, accordingly, in this vicinity. In quite a number of instances, the ore alone is worked, the overlying clay being below the standard quality, and the limestone being wanting. The Sciotoville and Webster fire-clays, of Scioto county, probably belong to the same horizon.

In the vicinity of Logan, the Maxville Block Ore varies in thickness from an inch to a foot. It will probably average eight inches in the quarries that are most largely worked. It often lies in two courses, the heavier being the lower. It is a dark-colored limonite ore, of medium weight, and of good composition, yielding about forty per cent. of iron in the furnace.

4. Passing, at sixty-five to eighty-five feet above the Maxville Limestone, an horizon of ore, fire-clay and coal—none of which are worked, we come at an elevation above the same limestone of eighty-five to one hundred and fifteen feet, to a block ore of excellent quality, and quite extensive distribution. A good deal of it was taken out for Union Furnace in Starr township, Hocking county, and it is accordingly named in the section, the Union Furnace Block or Lower Main Block. It has also been worked to the east and north of Logan to quite an extent. It

is well developed at several points in Green township, Hocking county, and especially on Kitchen Run. In the vicinity of Junction City, many thousands of tons have been raised. It is also found in Vinton county, but has not been noticed south of the Marietta and Cincinnati road. Its position is easily remembered on account of its relation to the Blue or Zoar Limestone, the main seam of which it underlies by fifteen feet, and the lower seam of which it covers when the latter is present. It yields forty per cent. of iron and is in every respect a valuable element of our geological scale.

5. The next ore in ascending order is one of the most widely distributed and important of our whole series. It is the block ore which immediately covers the main Zoar Limestone, and is designated in the section as the Main Block. Situated thus in the most conspicuous horizon of our Lower Coal Measures, it is universally known and through considerable districts is styled *the block ore*, although it is never the only seam of this class. Under cover, it is often a close-grained, heavy blue carbonate, but along its outcrop, it is everywhere an easily worked and excellent limonite. It agrees in general character with the ore last described, like it yielding forty per cent. and over, of iron in the furnace. It seldom exceeds a foot in thicknes and eight inches will make a very satisfactory average wherever it is worked. Though ore is always shown at this horizon, it is by no means to be concluded that the ore is always valuable. There are very many areas in which it is too thin or too silicious to have any value. It shows its marine origin in some instances by containing fossil shells. Such a phase of it is seen at the old Hocking Furnace, at Haydonville. It shares this peculiarity with the seam next to be named.

It is co-extensive with the limits of the limestone but it does not disappear with that formation. The limestone is lost in Scioto county, a few miles north of the Ohio River, but the ore retains its place with perfect regularity and furnishes the means of identifying the various elements of the scale that are associated with it. It is the lowest of three block ores that are extensively worked among the southern furnaces, and when all three are worked on the same lands, this ore is generally known as the "little block" or "little red block." It must, however, be confessed that the same terms are sometimes applied to the other ores of the series.

6. Following the Upper Main Block Ore at an interval of twenty-five to forty feet, quite a persistent seam occurs, the most common designation of which is the *Rough Block Ore*. It is also called the *Sand-block*, but neither name is distinctive. It has been worked to a small extent

in Perry county, and also in Jackson county, but it is nowwhere very highly esteemed. It is easily traced and thus helps to connect the sections of quite distant localities.

7. From ten to twenty feet above the seam last named, another block ore occurs. Its place is made quite conspicuous by its association with the limestone and flint called Gore, in the present classification. The place of the ore is immediately above the limestone or flint. It is often wanting, but a good deal of iron is found at this horizon. The limestone itself is highly ferruginous. The ore is variously designated, its name changing with its quality. It is called *Sand-block* more frequently than anything else, but in many localities, it is counted valuable. It often resembles the main block ores so much as to be confounded with them.

Near Hamden, Vinton county, it is known as the Robbins ore. It is there fossiliferous, containing sometimes beautifully preserved brachiopod shells, thus proving its marine origin. Prof. Andrews called attention to this interesting fact in the Report of 1870.

There are in the Vinton county section two or three seams of block ore above the one now named, but it is not certain that they are persistent. In Scioto county, and in the western part of Lawrence, three block ores make a considerable contribution to the supply of the furnaces located there. The lower one of them is the Upper Main Block, that covers the Zoar or Blue Limestone. Whether the second, which is known as the Sand-block, agrees with the seam here described as the rough block No. 6, has not yet been determined. It is either this or the one now under consideration, No. 7. If it is the rough block, then the upper ore of the three which is locally known as the *red block* or *big red block* holds the place of the Gore limestone and ore. It lies from ten to fifteen feet above the middle block.

The intervals all expand somewhat as they are followed southward, and, unless frequent sections are taken, there is danger of confounding different elements of the scale.

The red block of Scioto county becomes the main block of the Ohio Valley. Its position is determined by its relation to the limestone ore which is everywhere known and worked. It is about one hundred feet below this horizon.

On its western outcrops, where it lies high in the hills and under light cover, it is often weathered into an excellent ore—quite as good as the ores of the same class just enumerated, but at many points, and notably in the neighborhood of Ironton, it is a very close-grained, dark blue carbonate, which has thus far proved intractable, having been tried only in charcoal furnaces. It is found here in fine volume, measuring two and a half feet in many sections. There is more iron at this horizon by far than at any other in the region, and it cannot be doubted that the resources of science are adequate to the utilization of such a seam, even though unfriendly elements are present in it. Such ores are made serviceable elsewhere by exposure to the weather for one or two years after they have been sharply roasted.

At McCuneville, Perry county, the limestone beneath the ore is found to be ferruginous enough to warrant it also to be ranked as ore. Portions of it contain over twenty per cent. of metallic iron.

8. At about thirty feet above the Gore Limestone and the Sand-block another ore horizon occurs in the Hocking Valley. The ore that is found here represents or replaces the Putnam Hill Limestone, or Gray Limestone of the eastern counties, in part, and possibly includes also a kidney seam that is found ten feet below the limestone at New Lexington. To this horizon belongs a ferruginous limestone found at the Moss and Marshall Furnace, and the heavy blue carbonate that is well shown at Haydenville.

The Dunkel ore of Vinton county appears to find its place just here, the intervals, however, varying a little from those given or implied above. The last named seam is, perhaps, the most important of Vinton county, the limestone or Baird ore alone being excepted. It ranges from one and a half to two feet in thickness, and holds a large scope of country to the north-east of McArthur. Many hundred tons of it have been worked in Vinton Furnace, where it came to be highly esteemed. It would seem to be a safe reliance for a furnace so located as to reach its area easily. Its place is about fifty feet below the limestone ore.

9. The next regular deposit to be found in ascending the scale is the seam known as the "Limestone Kidney Ore" in Vinton and Jackson counties. Its place in Vinton is about fifteen feet below the Gray or Hanging Rock Limestone which bears the limestone ore. The seam known by this name in Jackson is twice as far from the limestone, but it has the same character with the northern ore, and the workings of the seam are almost extensive enough to establish the connection suggested. The ore is of excellent quality, being esteemed by the furnaces as highly as the limestone ore, in connection with which it is generally worked.

In Perry and Hocking counties, ore is found at the same place in the series, but has not been largely worked. At McCuneville this seam is found in connection with a "bastard limestone." A heavy deposit of gray ore, identical in general character with the Baird ore, is found ten feet below the last named seam on the land of W. B. Brooks, Esq., at Nelsonville. It agrees in position approximately with the kidney vein.

10. The ore next to be named is, beyond all question, the most valuable of the Ohio series. It lies at the very center of what has been our largest and most successful iron manufacture therto. It is the chief element in the geological scale of a large section, all limestones, coals, and other ores being located as so much above or below this horizon. It is known in the southern counties as the *limestone ore*, and the use made of this designation suggests the importance of the seam. It is called the limestone ore because it generally rests directly upon a well known limestone, viz, the Gray or Hanging Rock Limestone; but there are two other ores, at least, that have an equal right to this name—being associated in the same way with limestones—yet both are ignored in common use, and this name is applied to the seam now under consideration, without uncertainty or ambiguity. The name, however, is in some ways a misleading one; it suggests composition rather than situation, but with the former it has nothing to do. Some lime enters into this seam as into so many others, but the proportion is not nearly as large as in other Ohio ores. Another designation is commonly given to this seam in Hocking and Perry counties. It is here known as the *Baird ore*. At Union Furnace, Hocking county, it is styled the *red ore*. The identity of these several ores has been fully established, and will be demonstrated in a subsequent part of this report.

Like the ores of the Coal Measures, the limestone ore is a carbonate or siderite under heavy cover and a hydrated sesquioxide or limonite on its outcrop. The varieties are known as gray or blue limestone ore and red limestone ore, respectively.

The gray variety is one of the best marked ores in Ohio, and is uniform in character through all the district which we are considering. Samples from Lawrence, Gallia, Scioto, Jackson, Vinton, Hocking, and Perry counties cannot be distinguished from each other. Metallurgical suites from the Hanging Rock Furnaces were collected during the progress of the survey, and specimens of the gray ore came in the sets of the following furnaces, viz.:

Hecla	Lawrence	county.
Monitor	"	"
Vesuvius	"	"
Ætna	"	"
Lawrence	"	"
Center	"	"
Mt. Vernon	"	"
Buckhorn	"	"
Olive	"	"
Howard	Scioto	county.

Gallia	Gallia county.
Star	Jackson county.
Vinton	Vinton county.
Union	Hocking county.

It is also known to be worked at all of the eastern furnaces of Jackson county. There is no characteristic by which the most experienced iron master of the district can distinguish a specimen from the Hecla Furnace from one taken from Nelsonville or Gore.

The gray ore consists of oölitic grains of carbonate of iron, which are each invested with a whitish covering of fire-clay and finely divided silica. It contains in this state about thirty to thirty-five per cent. of iron. The outcrop ore rises frequently to forty-five and fifty per cent., and yields in the furnace over forty per cent.

There is scarcely a trace of sulphur in the ore, and phosphorus, exists in very small proportions.

Its average thickness in Southern Ohio may be taken as ten inches, but north of Vinton county, the average does not exceed eight inches. Locally, however, it rises to several feet in thickness. From less than one-half acre near McArthur, on the "Speed farm" of Dr. Wolfe nine thousand tons of ore were taken.

The steadiness an constancy of the seam go far toward making amends for the scanty volume. It is found where it is due and can be followed under cover with confidence and success. Several of the older furnaces of Lawrence county obtain a large proportion of their ore by drifting. It is subject to cut-outs of course, but there are as few in this seam as in any other geological horizon of the district—a district by the way that is remarkable for the steadiness of its series.

More than sixty Ohio furnaces make this ore their chief supply, and the iron yielded by it is the standard of quality throughout the Ohio Valley.

11. At an interval varying from thirty feet in the northern counties to fifty feet in the southern counties, another very steady seam of ore occurs. In the Kentucky furnace district it is known as the "Black Kidney" and is there highly esteemed. It has no generally received name to the northward, but it will be recognized by all familiar with the geology of this district from its relation to Coal No. VI, with which it is closely associated, underlying it at an interval of two to ten feet. It is a very compact and close-grained, blue carbonate, lying in large blocks and kidneys, in the clays that support the coal. It is also characterized from the Hocking Valley to the Ohio River by holding beautifully preserved coal plants. Leaflets of ferns, bits of bark, and branches are

found throughout its substance, often in an exquisite state of preservation. Insect remains are to be expected here. The ore was first recognized with all of these peculiarities by the geologists of the First Survey. The locality at which they found it is one of the best known to-day, viz., the Whitmore farm on Snow Fork, a mile east of Bessemer. It is designated in the section as the *Snow Fork ore.*

It was mined to a small extent in the earlier iron making of Ohio on land now owned by Charles Robbins, opposite Nelsonville, and was worked in the old Mary Ann Furnace of Licking county. But the ore although sufficiently rich in iron is of a character that the charcoal furnaces avoid and has, therefore, been almost entirely neglected in Ohio.

The seam can be followed without interruption from the Hocking Valley to the Ohio River and beyond. Its average thickness can not be less than that of the limestone ore, but it is spread through more space and is much less reliable.

The so-called *Phosphorus ore* of Hamden Furnace lies very near this horizon—if it does not actually represent it. It is found in a heavy seam two to four feet in thickness, and the ore is promising in appearance—but no efforts to make marketable iron out of it have proved successful. Analysis shows as much as seven to eight per cent. of phosphate in some parts of the seam.

12. In reaching the next ore seam we pass one of the most marked geological horizons of this part of Ohio, viz., that of Coal No. VI—the Nelsonville coal, of the Hocking Valley; the Carbondale or Mineral City coal, of the Marietta and Cincinnati Railroad; the Webster or Lower Waterloo, of Gallia county; the Sheridan coal, of Lawrence county, and the Ashland or Coalton coal, of Kentucky. The identity of all these coals is now fully established, as will be shown on a subsequent page of this report.

Forty feet above Coal No. 6, in the Hocking Valley, a buff limestone is very frequently found which sometimes bears an iron ore—is sometimes indeed represented and replaced by an iron ore. The ore occurs either in massive nodules, or in a layer fifteen to eighteen inches thick. Analysis indicates an ore of good quality, but it has not yet been subjected to the test of the furnace in this part of the field. In Southern Ohio, and more particularly in Kentucky, there is a widely distributed ore at about forty feet elevation above the Sheridan coal, which is known as the *Yellow Kidney*. It is an excellent ore, and is welcomed by every furnace manager.

Identity of sections in such widely removed localities as Nelsonville and Ironton would be proof of difference of age rather than of equivalence, in most parts of the Coal Measures, but there is such unusual steadiness in this district that there is reason for believing these horizons to be the same. The question can be settled by a little more work in Vinton and Jackson county.

No limestone is found at this horizon south of Jackson county. It will be remembered that the limestone where it does occur is called the *Norris limestone* from its contiguity to the coal of that name. The ore seam for the same reason is termed the *Norris ore* and is so represented in the section.

13. An ascent of twenty-five to thirty feet above the Norris limestone and ore—or of sixty-five to seventy feet above the Great Vein Coal (No. VI) brings us to another buff limestone and an accompanying ore, the latter of which has been worked to some extent in Perry county. The limestone is largely used for flux in the new furnaces at Shawnee and has, therefore, been named in this report the *Shawnee Limestone.* The ore would naturally be called from its association the Shawnee ore but confusion would be sure to result from such a designation, the ore seam which is the sole reliance of the Shawnee furnaces belonging to a distinct horizon.

This seam has been worked for ore at various points in the Hocking Valley, notably at Straitsville, within the last few months, where several thousand tons have been raised. Its best designation, then, will be the *Straitsville Ore.* It is so named in the general section.

The volume of the ore is large, and the percentage of iron in the outcrop is generally satisfactory, but its association with the limestone that bears it is somewhat different from that observed in the lower ores. It will be noticed that *buff* limestones occur again and again in the one hundred and fifty feet of strata that overlie Coal No. VI, while in the same number of feet below this coal seam, the limestones are all *blue* in color. These upper ores pass by gradations into the limestones, so that while the outcrop is an ore of excellent character, it may soon change under cover to a ferruginous limestone, containing possibly but ten or fifteen per cent. of iron. This is true of the Straitsville Ore throughout the Hanging Rock district. While the blue limestones are often ferruginous, there is a much better distinction between them and the ores which they bear, than is found in the case of the buff limestones now referred to. Complete substitution of the blue limestones by ore can often be noticed.

This seam has been quite largely worked in the southern furnaces under a variety of names, as "Top Hill Ore" in Gallia Furnace, and also in Vesuvius; as the "Burdett Ore" on the Monitor Furnace lands. It is esteemed as highly as the Limestone Ore at several points, its uncertainty always excepted It has been worked by itself to a small extent in Gallia Furnace, making an iron of the best quality.

It is seldom worked where it has a thickness of less than eighteen inches. It is estimated to yield thirty-eight per cent. of iron in the furnaces where it has been tried. This yield, it will be remembered, is from outcrop ore.

14. An entirely similar association of buff limestone and ore is met, for the third time, at ten to fifteen feet elevation above the last named bed, or at about seventy-five to eighty-five feet above Coal No. VI.

The similarity of these three deposits (Nos. 12, 13, and 14) has led some observers to hastily class them as one, and to explain their differences of level by "slips" of the strata. No such explanations, however, are tenable, for two at least of these three horizons stretch without a break through many hundreds of square miles, and the section at Nelsonville, in the Hocking Valley, is repeated at Ironton, on the Ohio River, with surprising agreement.

The ore now to be considered is better known than either of the others which it resembles so closely. It has had, heretofore, a very unfortunate designation, viz : the *Bessemer Ore*, the name being derived from the site of the Akron Furnace Company on Monday Creek, in the Hocking Valley. It can well be substituted by the name of the enterprising head of the Akron Company, and the ore will be here known as the *Buchtel Ore.* It is quite probable that some of the various horizons known in Perry county as the *Sour Apple Ore*, will find a place here. This last name is supposed to belong to the horizon of the Straitsville Ore by the best right, but its uncertainty makes it safer to discard it.

Except the Great Coal Seam, no other stratum of the Hocking Valley has awakened so much interest and excitement as the Buchtel Ore. Its outcrops in the vicinity of Akron Furnace show a wall from three to six feet in thickness, and it is evident that the ore may be quite lean and yet make a valuable contribution to the iron manufacture of the State. The ore contains from twenty to thirty per cent. of iron under cover, the average of many analyses being about twenty-four per cent. The percentage of silica varies, being sometimes, though rarely, as low as eight per cent., but the usual figures varying between twelve and twenty per cent. The average is not less than fifteen. It is to be remembered, however, that in the lime of which the ore carries a notable percentage, a part of the flux is contained, and the percentage of silica can accordingly be looked on as the double one of ore and flux.

The results obtained from Akron Furnace have been watched with great interest, as widely different views have been held in regard to the character and availability of the seam. On the whole, it can be said that a considerable value has been shown to belong to the seam in this immediate locality.

In passing southward this stratum holds as a limestone rather than an ore. Throughout Vinton and Jackson counties, this is generally the case, but in Lawrence county, ore is again found at about the same point in the scale that the Buchtel ore holds. The seam is there known as the *Little Yellow Kidney.* Though distinct from No. 13 in the Hocking Valley, this ore may still be counted with it. It affords another instance of the local duplication of lime and ore horizons, such as have been already named in connection with the Blue Limestone and the Gray Limestone.

15. One other bed of ore remains to be named, viz., the remarkable deposit that is either immediately associated with Coal No. VI, or that overlies it by a few feet. When the ore is found at the horizon of the coal, it becomes either a blackband or a clayband, being a distinctly stratified deposit. When it is found above the coal, it generally takes a rough, ungainly form, consisting of large nodules imbedded in white and red clays. There is a large amount of iron at this horizon in either shape, but the latter condition has not yet encouraged any trials. The blackband form is well known to be a very valuable deposit. In Stark, Tuscarawas, and Guernsey counties, it is well developed, constituting there a basis of iron manufacture second only to that of the Limestone ore in the Ohio Series. It is comparatively of recent date that the stratum has been recognized in the district now under review. It was first opened at "Iron Point," a hill near Shawnee, Perry county. It here lies from one hundred and five to one hundred and fifteen feet above the Great Vein Coal, (Coal No. VI) or at one hundred and forty to one hundred and fifty feet above the Baird Ore, which is associated with it. North of this point it has been opened on the Clark farm, near Bristol, where the extraordinary thickness of thirteen feet is claimed for it. A thickness of three to five feet is not unusual in the localities named, and often, enough coal goes with the ore, both underlying and covering it, to effect its calcination. The *Hone Bank* and also the *Whitlock Bank* are found farther to the eastward. Both of these were discovered, as well as the *Clark Bank* last named, under the energetic and sagacious management of the Moxahala Furnace Company. Found as these deposits all are, within easy reach of the Great Vein Coal, if not immediately associated with it, they make the foundation of a new iron manufacture in Ohio that threatens to revolutionize the whole business of iron making in the State. When all the advantages of this district come to be utilized, it will be found

that a certain grade of iron can be made here cheaper than anywhere else in the northern coal field. The iron made from the ore is very fusible and somewhat deficient in strength, but still it is of a kind for which there is a large demand.

Throughout the southern counties this horizon is always conspicuous as an ore or limestone horizon. It lies a little higher above Coal No. 6 than at the northward, its average height being about one hundred and thirty feet. It yields an ore of large volume at Gallia Furnace, which has been worked to a considerable extent under the name of the *Banda Ore.* At Hecla Furnace it is known as *top hill ore.* In the vicinity of Flag Spring, Gallia county, a blue, fossiliferous limestone takes its place. This limestone has been sometimes confounded with the Cambridge Limestone, to the great confusion of the true geological order. In Vinton county and in Jackson, both ore and lime are generally found. The ore has been worked to a small extent on lands belonging to the Iron Valley Furnace. Coal has not been found in association with the ore at any point south of the Hocking Valley. All the trials made of the ore southward seem to indicate an undue percentage of phosphorus in it.

In the accompanying chart of the iron ores of the district, the places of four other ores are indicated that lie still higher in the series than the Iron Point Ore. Wherever the Cambridge Limestone is worked, more or less ore is found with it, but the seam is never heavy enough to warrant the working of it for its own sake.

About twenty feet above the Cambridge Limestone, in Aid township, Lawrence county, quite a heavy deposit of ore occurs. It was the main reliance of Oak Ridge Furnace for the short time that it was in blast.

The Ewing Limestone, in Trimble township, Athens county, carries with it a considerable volume of ore, the quality of which is, however, doubtful.

It will be seen, then, that the valuable deposits of ore in this series occur chiefly at three horizons, viz., that of the Zoar or Blue Limestone, that of the Hanging Rock or Gray Limestone and in connection with or near the place of Coal No. 7.

C. COAL SEAMS OF THE HANGING ROCK DISTRICT.

The places and general relations of such of the leading coal seams of the district as fall within the limits of the section now under consideration, will next be discussed. The facts are represented to the eye in the accompanying engraved section, viz., *Coal Seams of the Hanging Rock District.*

1. The Jackson Shaft Coal, so widely and so favorably known, is cer-

tainly one of the lowest coal seams of Southern Ohio. It has not been established that the various exposures of low coal found on the western side of Jackson and Vinton counties, and on the eastern side of Pike, all belong to the same horizon, but it seems probable that they are to be so referred. The westernmost of these exposures are all *intra-conglomerate coals.* They rest directly, or with the interposition of a few feet of shale and fire-clay, upon conglomerate rock, and they are covered with heavy ledges of conglomerate. On sections 21, 22, 27, 28, of Jackson township, Jackson county, not less than forty feet of pebble rock are shown above the coal. On the east side of section 25, same township, on the land of J. Wilson Case, a seam, measuring three feet in thickness, is overlain by a ledge of very coarse conglomerate, the pebbles of which are cemented with iron ore. The overlying conglomerate is also shown in full force on sections 19, 22, and 31 of Jackson township, Pike county, and also in Union and Marion townships of the same county.

The underlying conglomerate in all these cases is the first main seam that is reached in the ascending scale of the State. The Pike county sections furnish the means of connecting the coal seams directly with well-known and definitely-marked horizons of the lower rocks. The coal is not more than five hundred and seventy feet above the Huron Shale, and not more than four hundred and fifty feet above the Waverly Black Shale.

2. About one hundred feet above the Shaft Coal a second seam occurs, which, like the one already named, is locally of great economical importance. It is known as the Petrea Coal, the Wellston Coal, and the Hill Coal of Jackson county.

No discussion of these lower seams is in place here, and no correlation of them with the lower coals of other sections of the State has been attempted. Numbers have not been assigned to them in the engraved chart of the Coal Measures, but their Sub-carboniferous age is there asserted in the place that is given them, viz , below the Maxville Limestone.

The position of two other seams above the Wellston Coal, but below the Zoar Limestone, is also indicated in the chart, but no mention of them will be made here.

3. We come now to a horizon that is everywhere conspicuous for the presence of the characteristic elements of the Coal Measure rocks, viz., fire-clay, coal, limestone, and iron ore. It is the horizon of the Blue or Zoar Limestone, and of the Main Block ores. The coal seams associated with the limestone can be traced with perfect distinctness through all of the marginal counties of the coal field from Pennsylvania to the Ohio

COAL SEAMS OF THE HANGING ROCK DISTRICT.

Scale 100 feet – 1 inch.

	LIMESTONES		COAL SEAMS	HOCKING	VINTON	JACKSON	SCIOTO	LAWRENCE
			(when present indicated by cross or by name.)					
	Ames							
	Ewing							
600								
550								
	Cambridge		Coal Nº VII B.	+				+
500			Coal Nº VII A.	+				
450			Coal Nº VII	Bayley's Run.	+	+		Upper Monitor Furnace
	Shawnee							
	Norris		Coal Nº VI B.	Norris				Hatcher U. Waterloo
400			Coal Nº VI A.	+	+	+		
350			Coal Nº VI.	Nelsonville	Mineral City.	Sheridan		Sheridan Ashland L. Waterloo.
		25–35.						
			Coal Nº V	+	+	+		New Castle
	Hanging Rock	10–35.	Coal Nº IV A.	+	Limestone	Limestone		Limestone
300			Coal Nº IV?		Flint			Conway?
			Coal Nº III B.	+	Vinton Furnace	+	+	
	Gore		Coal Nº III A.	+	Slate Seam	+	+	Hunnewell (Cannel)
250								
	Zoar		Coal Nº III	+	Dowd Seam Wilbur Coal Ely Coal.	+	+	
200								
			Coal	+	+			
150								
			Coal					
100	Maxville		Wellston Coal	Webb Summit? Lower Gould?	Elk Fork	Wellston Petrea.		
50	Logan		Coal (Thin)	+	+	+		
0			Jackson Shaft Coal			Shaft Seam	+	
	Conglomerate							

Intervals in Lawrence County greater than indicated in section.)

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River. There are sometimes two in the series, though more frequently but one. It has the name of Coal No. III in Dr. Newberry's classification. As it is followed through the State, it acquires various local names derived from points where it is worked. At Flint Ridge, in Licking county, it is the best cannel coal of the State, and it is accordingly quite widely known in this region as the *Flint Ridge Cannel*. In the Hocking Valley it no where attains importance, though its presence is almost always to be recognized. Near Logan it was mined some years ago for the manufacture of coal oil for distillation. The seam is here a cannel, but of poor quality. In Vinton county it furnishes far more coal than in any other division of the Hanging Rock District. Two seams, underlying or representing the two divisions of the limestone, are found here from fifteen to twenty-two feet apart, each of which attains a fair thickness, though the quality of the coal is no where such as to warrant its use for anything more than local supplies. It is called the *Dowd seam* at Zaleski. In the vicinity of Hamden Junction the seams have been worked to a small extent as the *Ely Coal* and *Wilbur Coal*.

South of Vinton county the place of the seam is generally kept by a bed of black slate or impure coal; but it is not known to furnish any fuel throughout this region. When at its best the seam exhibits frequent changes of quality. There is always more or less cannel coal in any large development of it, and it is rare to find a workable thickness of the seam that does not contain a large proportion of worthless *bone coal*.

The coal of this horizon, then, makes a comparatively unimportant addition to the supply of the Hanging Rock District. It is not known to be brought into the market at the present time by any line of railroad. All the attempts to establish a coal business upon this seam in the district have so far failed, the product being unable to maintain itself in competition with the excellent seams that are found below it, as well as above it, in the geological scale.

Coal No. III is often underlain by heavy and locally valuable beds of fire-clay and potter's clay.

4. The seam next to be named, Coal No. III*a*, is deserving of a full number, certainly in Southern Ohio. It is a steadier and more important seam throughout this field than Coal No. III. Though it is no where worked for the general market, it supplies a considerable amount of fuel, locally. It is separated by an interval of thirty to forty feet from Coal No. III, being associated with the Gore Limestone, one of the accessory seams of the general section. It bears the same relation to this limestone that the seam below it does to the Zoar, each being roofed with the limestone. It is to be remarked that a thin coal is frequently found di-

rectly *above* the limestone. This is counted in under the number given above, for, though differing in age, it belongs to the same vital node.

Coal No. III*a* seldom reaches thirty inches in thickness, and seldom falls below twelve inches. In some neighborhoods it is known as the sixteen-inch seam. It is found of this thickness at McCuneville, at Baird's Furnace, and at Haydenville; while in Vinton county it makes a showing of four feet, from the fact that it includes a bed of black slate in the middle of the coal. To the east of McArthur it is, on this account, known as the *slate seam.* For a short distance south of the Marietta Railroad, it is a chief dependence for local supply, especially in Madison township. It is there called, locally, the *Kelly Coal.* It is thin through the southern part of Vinton and the northern part of Jackson; but in Jefferson township, Jackson county, it again reaches a thickness of sixteen to twenty inches. It holds these dimensions southward through Scioto county. It has been worked for neighborhood use on Monroe Furnace, and also on Scioto Furnace lands. It seems probable that it makes the *Hunnewell Cannel* of Northern Kentucky.

5. Coal No. III*b*, the next reliable seam to be reached in ascending the scale, lies twenty or thirty feet above the last named horizon. It is the most valuable seam thus far found above the Wellston Coal, and is vastly more extensive and steady than it. It is known to have been worked for the general market but in one instance, viz., at Vinton Furnace. The commercial seam opened there is the one now under discussion. The seam at that point measures five feet, partings included. The quality is fair. The same seam, holding the same thickness and quality, is found in the tunnel of the Columbus and Gallipolis road, at Eagle Furnace. On the general section, the Tunnel Coal is wrongly identified as No. III*c*. For local supply this seam is largely depended on. It is a thirty inch seam in the neighborhood of Union Furnace, Hocking county, being here overlain by two feet of highly bituminous shale. It holds through southern Hocking and northern Vinton, attaining its maximum near the line of the Marietta Railroad, as already described. Southward it keeps its place quite steadily, though it is generally less than twenty inches in thickness. There is a greater multiplicity of coal seams through the southern part of Vinton county than in any other part of this district. The exact equivalent of Coal No. III*b* in this region can not be certainly given here but it is probable that the *Wortman Coal*, which lies about fifty feet below the Gray Limestone, is the seam sought for. If it is not, the thin seam ten feet below represents it.

On the lands of Monroe Furnace, this seam has a thickness of three and one-half feet, slate parting included. It has been worked here to some extent. The seam grows thinner to the southward, but can be traced in its own place to the river. Its association with the block ore series helps to identify it, the ores having been quite largely worked in Scioto county.

6. About twenty feet above No. III*b* another seam is often found in the same section. Near McArthur, Vinton county, it is well developed, and has there a very conspicuous mark in the fact of a layer of flint being interposed between the two bodies of the coal. From this fact it acquires the local name of the *Flint Vein.* This coal lies very near to the horizon of the true No. IV, which latter seam underlies in eastern Ohio the Putnam Hill or Gray Limestone. That limestone disappears in Hocking county, but its place is very near the seam of coal now under discussion. Accordingly the seam is marked No. IV, with a question. There is also uncertainty in regard to the southern extension of this coal. It is marked in the chart as the *Conway Coal* of Lawrence county, and this determination is quite probable.

This seam is incorrectly identified in the general section as the Tunnel Coal, at Eagle Furnace, on the line of the Columbus and Gallipolis road. It was so named on the authority of Dr. L. W. Baker, but a re-examination of the section at that point made by Mr. Thomas Kelly, of Vinton Furnace, proves the Tunnel Coal to be the Vinton Furnace Coal, or No. III*b*.

7. The next seam is the steadiest and most important of Vinton and Jackson counties. It is the "Limestone Coal" of this region, so named from the fact that it underlies at a short interval the Gray or Hanging Rock Limestone, that has been already described as the chief geological feature of the district. This seam in the counties named is as reliable as the limestone and holds a thickness of about four feet through a large district. It affords the main dependence of all those parts of this region where the *limestone ore* is worked. It has been mined for the general market along the line of the Portsmouth Branch of the M. & C. R. R. to some extent. It is always quite high in sulphur, but it is a bright, open-burning coal that is fitted to supply very important demands. There is probably twice as much coal at this horizon as at any other that has been thus far named. The seam has never been found pure enough to warrant its use in the blast furnace, and it is too open-burning to make a good quality of coke. Southward from Jackson county it soon disappears, not being found at all in the main part of the Lawrence county field. North of the Marietta Railroad, it also grows unsteady. It is, however, found in good development on the Reasoner farm, Section 29, Brown township. The northernmost development noted is on the McKinney hill, near

Logan. Here it shows quite a heavy blossom in the road near M. Keigley's house.

This seam is the exact counterpart of the true No. IV, underlying the southern Gray Limestone just as Coal No. IV underlies the northern Gray Limestone. The name assigned to it in the scale is Coal No. IV*a*.

8. It is to be noted that the part of the series which we have now reached is, by far, the most crowded of the Lower Coal Measures. The barren intervals are here greatly reduced, and a rise of more than twenty feet is seldom required in order to reach a new horizon of coal or ore.

The four last named seams belong to this crowded series, as do the four that follow.

In regard to the numbers of the coals that follow, no responsibility is here assumed. The Upper New Lexington Coal has been pronounced by the geologists who have worked in that district as No. VI of Dr. Newberry's classification, and the Lower New Lexington Coal has been made No. V of the same scheme. A connection is claimed to have been made between the Upper New Lexington coal and the Straitsville seam. That connection is not called in question, but in numbering the coals that follow No. V, No. VI, etc., no reference is made to the eastern extensions of these numbers; but in speaking of No. VI the Straitsville or Nelsonville seam is referred to, and No. V is applied to the first general seam below it.

With this qualification, then, it may be added that Coal No. V is the seam next met. Its position is about ten feet above the limestone or Baird ore at the northward, and about twenty to twenty-five feet above the same horizon, south of Vinton county. In working the Baird ore the place of the coal is almost always shown. Another seam is frequently found from ten to fifteen feet above it, which is often confounded with it. Both are shown on Washington Furnace lands and at many points in Vinton county in the same hills. The lower of the two is the main seam. It is called the *New Castle Coal* in Lawrence county, where it yields a large amount of fuel, being extensively worked in the vicinity of Ironton. It is here a coal of fair quality, but not adapted to iron manufacture. Coal No. V is not worked elsewhere in the district to any extent. At Nelsonville it holds a thickness of between two and three feet, and, as tradition says, was the first coal ever opened there. It is at present so entirely overshadowed by the great coal seam above it—No. VI—that its presence is quite lost sight of. It may be added that it is a remarkably constant geological feature of the whole field. It is scarcely necessary to lose sight of it between Perry county and the Ohio River.

9. The coal that comes next in order is, by far, the most important of Ohio coals, viz., No. VI, of Newberry's classification. It is found at a

height of twenty to forty-five feet above Coal No. V. This former measure is observed in the northern part of the district; the latter in the southern. A better known horizon with which to associate it is found, however, in the Gray Limestone and the ore that accompanies it. Coal No. VI lies from thirty to fifty feet above the Baird ore in Hocking county. The single measure that will best represent the facts is forty-two feet. This measure is held almost, without wavering, through Hocking, Vinton, and northern Jackson counties. The interval begins to expand in Milton township, Jackson county, at Keystone Furnace. In Bloomfield township it has become fifty-five feet. In the next ten miles another gain of ten feet is made, and from this point on the best measure of the interval is sixty five feet. South of Keystone Furnace the seam is known as the Sheridan Coal, while to the northward any one of a half dozen names can be used to designate it. The most common designations are derived from the great mining centers, Nelsonville and Straitsville. Along the line of the Marietta and Cincinnati Railroad it is styled the Carbondale Coal or the Mineral City Coal.

It is not necessary at this point to go into any detailed description of Coal No. VI. Full accounts of its quantity and quality in the Hocking Valley, have been already given in the present volume. West of the Hocking River, it is gradually reduced in volume. A few mines are opened in Starr and York townships which hold six or even seven feet of coal, but the common measure of three and one-half to five feet is soon reached, and that is held through the townships of Brown, Swan, Madison and a part of Elk, in Vinton county. In all of these townships the coal everywhere holds its place and its quality is, in the main, excellent.

It will be remembered that the seam, in the region of its greatest development, occurs in not less than three benches. In following it southward, the lower one of these divisions, shrinks rapidly, being found but six inches thick along the line of the Marietta road, (Carbondale and Mineral City Coals). In Clinton township, Vinton county, the lower bench is altogether lost and the upper division is also much reduced, the main thickness of the seam (three feet) being found in the middle bench. A mark here comes in by which the seam can be followed without the slightest difficulty or uncertainty to the southward. The uppermost bench is separated from the middle bench by four to six inches of hard fire-clay. The seam holds this peculiarity until it comes to be known by a new name, viz., the Sheridan Coal, of Gallia county. In Jackson county, the upper bench is found only as soft coal and is not mined, the middle bench being all that remains of the great vein of the Hocking

Valley. It is not largely worked even for neighborhood use in Clinton township, nor in Vinton and Bloomfield townships, Jackson county, because of the fact that the next seam above it, No. VI*a*, is a heavier and better seam in this district.

In Madison and Jefferson townships, Jackson county, and in adjacent townships of Gallia county, the coal remains thin, seldom at least measureing three feet, but its quality is almost always good and is often excellent. This is the seam worked at Washington Furnace for smelting purposes. It is here but twenty-six inches thick, but, its quality is good and it is giving satisfactory results in the furnace. It is charred before use. In Walnut township, Gallia county, it makes the Lower Waterloo coal, a seam which yields over five feet of as good coal as is mined from this great horizon at any point in Ohio.

Through the central part of Lawrence county, Coal No. VI is less conspicuous than coal No. V, though its place is generally shown and the seam frequently becomes workable, but in Perry township again, and in the region south of the Ohio River, it shows a thickness of four to five feet and yields a great deal of excellent coal. As the *Coalton* or *Ashland Coal*, it has a high reputation, being used in iron manufacture to a considerable extent. The Perry township coal is called the *Sheridan seam*, and this name holds, as has been already stated, as far north as Jackson county. It may be remarked in passing that there is not the slightest uncertainty in regard to the equivalence of the Sheridan and Coalton Coals. No opposite sides of a river agree more perfectly than the Sheridan and Ashland sections. The sections indeed are identical.

10. The next seam to be met, Coal No. VI*a*, has never yet received the attention that it really deserves. It has been confounded generally either with No. VI, or with No. VI*b*. Its position is about half way between these two coals. In the Hocking Valley, the usual measure is twenty-eight to thirty feet above Coal No. VI. This measure is maintained with surprising steadiness through Vinton and Jackson counties. Thus, on the Cawthorn tract, Monday Creek, the interval is twenty-eight feet. It is the same on the Whitmore farm, just beyond Akron Furnace, and also on J. L. Gill's land, on Meeker Run, west of the Hocking River. On the Ogan Hill, in Elk township, Vinton county, it is thirty-three feet. At Eagle Furnace, it is twenty seven feet; at Hamden Furnace, thirty feet; at Iron Valley, the same, and also at Buckeye Furnace, and twenty-eight feet at Keystone Furnace and at Hartley's Mills, Wilkesville township, Vinton county, where it is known as the seven feet seam. It will be remembered that Coal No. VI is increasing its distance from the Gray Limestone slowly, but steadily, throughout this last named region; but the

interval between the two coals holds unchanged from Nelsonville to the southern side of Jackson county. Beyond this point, the seam has not been certainly identified. It is probable that it becomes the *Hatcher Coal*, which is found on the river at fifty feet above the Sheridan Seam. As there is another coal due at that point, viz., Coal No. VI*b*, the Hatcher Coal was identified in the section under this head, but subsequent examinations render it probable that it is in reality No. VI*a*. If this shall be established, a change will be required in the naming of one or two other elements of the scale, but chiefly in the Yellow Kidney Ore, which has been doubtfully recognized as the southern extension of the Norris Limestone. A little time spent in the field can settle these questions.

Like the great seam below it, this coal is everywhere found in three divisions. It is cubical and lustrous, and approaches a cementing coal in character, being much richer in bituminous matter than No. VI. It is nowhere made of as much account as from Hamden Furnace southward for a few miles. At the furnace, it has been opened and analyzed with reference to its employment as an iron-making coal. This analysis will be found on a subsequent page. It was shown to be of fair quality, as as the average of No. VI in this region, perhaps, but not good enough to base an extensive iron manufacture upon. It was considered to be the Nelsonville seam when it was opened. It is named the *Hamden Furnace coal* in the general section. It is quite uniform in thickness, measuring three or three and one-half feet in almost every section where it is found. Both No. V and No. VI*a* would be highly esteemed in many localities, if found as good as these seams are at Nelsonville and vicinity, but the presence of the great seam here, within thirty feet of each, robs them of all present recognition and interest.

11. Coal No. VI*b* is identified in the section as the *Norris coal*. There may be a question in regard to this identification, but there is none whatever as to the fact that about fifty feet above No. VI, a very persistent seam occurs that sometimes has volume enough to warrant its being worked. On the Whitmore farm, already referred to, near Akron Furnace, the three seams, Nos. VI, VI*a*, and VI*b*, are shown in full development in the same hill. All the seams are opened here. On an adjoining farm, known as the Lefever farm, now owned by W. W. Poston, Esq., this last named seam is well opened, and shows a thickness of more than five feet. The coal has very much the character of that last described, and makes a very desirable household fuel. Experiments have been made in coking it, which seem to promise some success. The seam, however, is capricious in its development. Its mark is seldom missed, but it shrinks from five feet to as many inches, with very rapid alternations. West of the Hocking River, and to the southward, it is always thin

where certainly recognized. In Vinton county, indeed, it has not been clearly identified. There are several thin seams near its proper horizon. As to its identification with the Hatcher Coal, nothing need be added to the statements already made under the previous head.

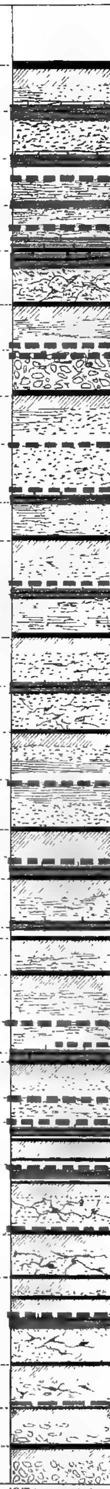
12. The next coal seam is one of Dr. Newberry's main numbers in Eastern Ohio, viz., Coal No. VII. It is a well-developed and well-known seam in the Hocking Valley, being here styled the *Bayley's Run Coal.* It lies at eighty to one hundred feet above Coal No. VI, with an average elevation, say, of ninety feet. It takes its name from the Sunday Creek region, where its distance from No. VI is a little below eighty feet. It is shown in good force on Meeker's Run, in York township, Athens county, on the land of J. L Gill, Esq. It is here eighty-seven feet above the Nelsonville Coal. It has a thickness of four feet, and agrees in character with the two seams next below it. It is held by many to be a coking coal and some good results have been obtained in this way, but it is doubtful whether it is rich enough in bituminous matter to make the process possible in the ordinary ovens. This latter test is always understood in claiming it as a coking coal. There is little doubt that the driest burning coals of our series can be coked by proper or possible management; but it seems improbable that any coal now known in the Hocking Valley will use its slack in the process of coking, in ovens of the ordinary type. There is no extended seam, at any rate, of which this is true. The product of single mines may possibly give such a result.

All through the southern counties, at one hundred to one hundred and twenty feet above Coal No. VI, a coal horizon is found, which is identified in a general way with No. VII. It is not known to be worked except on the Monitor Furnace lands, opposite Ashland, Kentucky. The seam measures there three feet, and lies one hundred and two feet above the Sheridan coal.

13. A coal seam that is nowhere very valuable, but that is as steady throughout a wide area as any other geological element, is next met with. It is named Coal No. VII*a* on the section. It lies about sixty or seventy feet above Coal No. VII. It seldom exceeds thirty inches in thickness, and is opened but infrequently. The coal is said to be of fair quality. It is a northern seam principally. At least it has not been indentified south of the Hocking Valley, but this may result from a lack of sufficient work upon its proper horizon.

14. Coal No. VII*b* is, on the contrary, found only to the southward. Through Lawrence and Gallia counties a thin seam of coal is often found associated with the Cambridge Limestone. Lying well up in the Barren

GENERAL SECTION
SHOWING ORDER OF SUCCESSION OF COALS, ORES AND LIMESTONES IN THE HANGING ROCK DISTRICT.



COALS.	ORES.	LIMESTONES.	Approximate elevations above Jackson Shaft Coal
Coal N° VIII { Pittsburg, Pomeroy, Federal Creek }			870
		Pittsburg	850
		Ames	730
		Ewing	690
Coal N° VII B	Oak Ridge	Cambridge { Upper, Lower }	610
Coal N° VII A			595
	Iron Point Black Band		545
Coal N° VII { Bayley's Run }			510
	Buchtel		505
	Straitsville	Shawnee Buff	495
Coal N° VI B { Norris, Hatcher }			480
	Norris Yellow Kidney	Norris	470
Coal N° VI A Hamden Furnace			460
		Snow Fork	450
Coal N° VI { Nelsonville, Mineral City, Sheridan, Ashland, Ky. }			430
	Black Kidney Snow Fork		420
Coal N° V { Newcastle }			385
Coal N° IV A { Limestone Coal }	Limestone Baird	Hanging Rock Gray	365
Coal N° IV? { Eagle Furnace }	Limestone Kidney	Putnam Hill Place of	340
Coal N° III B { Vinton Furnace }			310
	Fine Block		300
Coal N° III A	Sand Block	Gore	270
	Rough Block		260
	Main Block	Zoar { Upper	240
Coal N° III { Flint Ridge Cannel, Dowd Seam, Zaleski }	Main Block	Zoar Blue { Lower	225
Coal { Sometimes workable }			180
Coal			150
Coal	Maxville Block	Maxville White	120
Coal			100
Coal Thin		Logan Flint	50
Jackson Shaft Seam			0

Conglomerate or Sandstone.

Measures it has been opened at many points for local use, on account of the scarcity of coal at this horizon.

15. The seam next to be named is the most valuable of the Appalachian coal field, viz., the *Pittsburgh Coal*, or No. VIII of Newberry's classification. It lies at the base of the upper productive Coal Measures, and only reaches this district in isolated outliers. Its position is about four hundred and forty feet above Coal No. VI, though the maxmium intervals measured give over five hundred feet. No discussion of the seam is in place at this time.

The formal enumeration of the extended coal seams of the district has now been completed. The number given is large, but it is in no wise in excess of the facts. Several additions could be made, indeed, of seams that have a considerable distribution, but none has been discussed here that can not be traced through more than a single county.

It will be seen that there are many points in regard to which uncertainty prevails. Attention is called to them in order that the facts may be noted by those who have the opportunity. It is only by connecting the several subdivisions of the field, on the basis of a minute and individual knowledge of each one that is possible to none but actual residents, that the facts can be combined in the truth of nature.

D. GENERAL SECTION.

A general section to which reference has already been repeatedly made, is here introduced, showing the order of succession of all the elements thus far described. It will be seen that the absolute elevations above the *Jackson Shaft Coal* are generally put at a higher figure here than in the preceding diagrams. This arises from the fact that maximum intervals must be used in the general section in order to find the proper room for all the elements. No interval between conspicuous horizons, however, is introduced that is not guaranteed by some actual and carefully measured section.

The interval between the Gray Limestone and Coal No. VI is put in the diagram at sixty-five feet. This is a true measure for a wide scope of country, viz, Southern Jackson, Gallia, and Lawrence counties, but from the middle of Jackson county northward but little more than half of it is required.

By an oversight in reading proof, the elevation of Bayley's Run Coal (No. VII) is given as five hundred and ten feet, where it was designed to read five hundred and twenty feet.

The elevation given to the Iron Point Ore is the maximum elevation above Coal No. VI. As a rule, the ore and Coal No. VII lies nearer each other than the measures here given would imply.

E. CONNECTIONS BETWEEN THE SEVERAL PORTIONS OF THE FIELD.

The foregoing statements as to the stratigraphical order of the rocks of the Hanging Rock District embraces the main result already reached. The results have been stated as facts, and no proofs of the correctness of the interpretations by which they have been reached have been given, except incidentally. Inasmuch as a new place is here assigned to the two most important horizons of the district, viz., to Coal No. VI and to the Gray or Hanging Rock Limestone, with the ore that covers it, the grounds on which these changes are made will properly be demanded. A brief statement of the facts which establish the order here claimed, will, therefore, now be given.

The Gray, or Hanging Rock Limestone, (Ferriferous of Andrews) which constitutes, by far, the best known stratum of the district now under review, was followed by Prof. Andrews as far north as Elk and Madison townships, Vinton county. The Nelsonville seam (Coal No. VI) was traced southward by him to the same townships. No exact connection was established between these two important horizons, but the conclusion was announced that the Nelsonville coal found its place immediately *below* the Gray Limestone, constituting the *Limestone Coal*, or No IV*a*, of our present series, and that "an entire change in the deposits" began here and continued throughout the whole range of the Nelsonville coal, (pages 61, 72, 115,) Report of Progress, 1870) A mistake in the identification of the Blue or Zoar Limestone, with the Putnam Hill Limestone, which prevailed in the work of the district for the first two years of the survey, but which was corrected by Prof. Andrews in Vol. I. of the Final Report, increased the confusion.

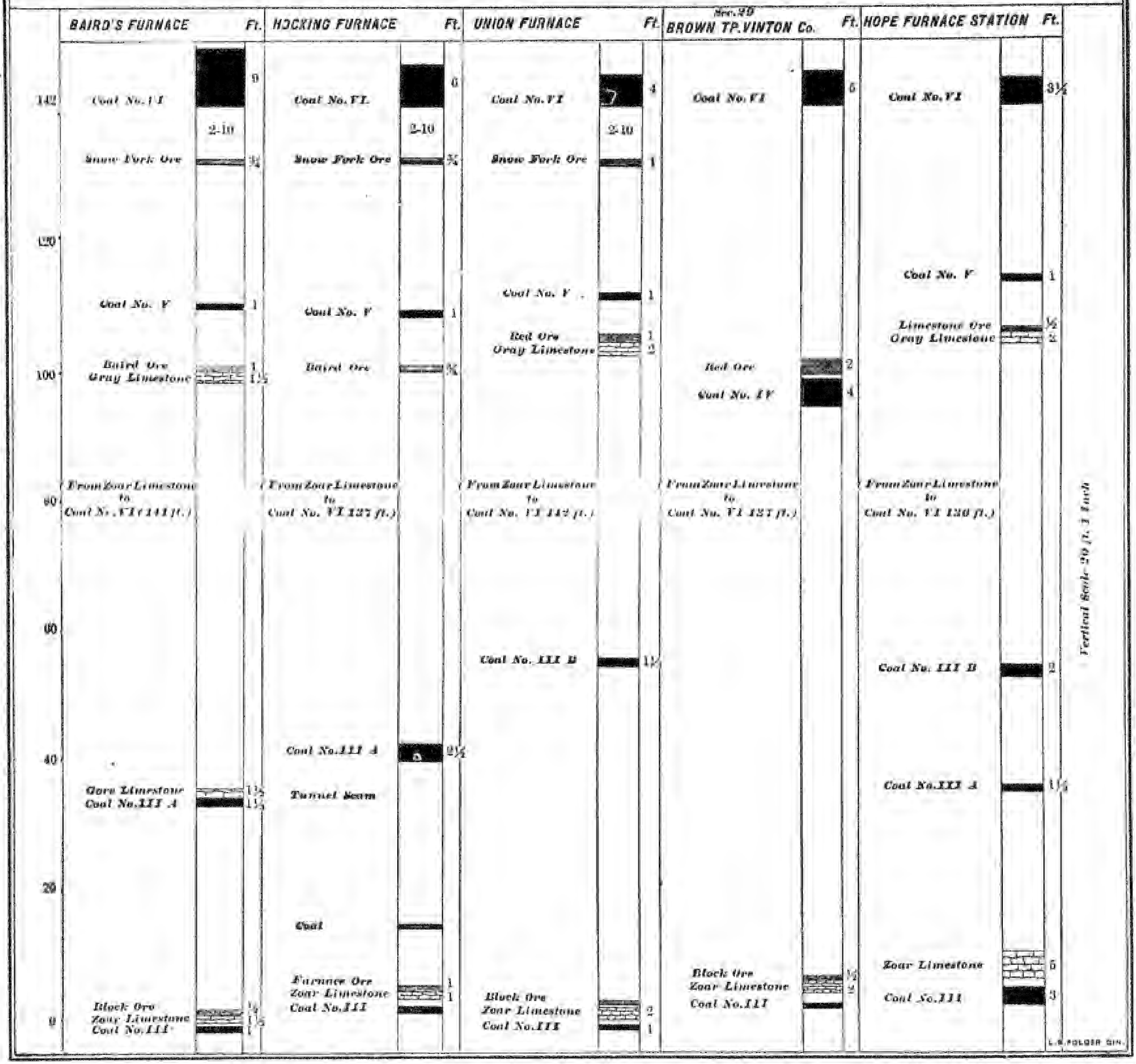
The correctness of Prof. Andrews's view was publicly called in question by Andrew Roy, Esq., State Mine Inspector, in his Third Annual Report, (report for 1876, page 153) Mr. Roy asserts the true place of the Gray (Ferriferous) Limestone to be between Coals No. IV and No. V, and frequently directly over Coal No. V, instead of over Coal No. VI. He also declares this limestone to be the equivalent of the Putnam Hill Limestone.

On page 157 he also makes the New Castle Coal, of Lawrence county, Coal No. V, and the Sheridan Coal, Coal No. VI, instead of No. VII, as it had been previously counted. Either of these changes would go far toward carrying the other with it.

The result of the examination here recorded shows that Mr. Roy was entirely right as to the last point and substantially right as to the first.

For the purpose of determining the true order through this unsettled portion of the field, a line was selected which connected the Nelsonville

SECTIONS SHOWING IDENTITY OF "BAIRD ORE" OF PERRY Co. WITH "LIMESTONE ORE" OF VINTON Co.



Coal and associated strata at Baird's Furnace, Monday Creek township, Perry county, with one of the nearest unequivocal and unquestioned exposures of the Gray Limestone, with its overlying ore, viz., at Hope Furnace Station, Brown township, Vinton county. The limestone ore has been worked almost continuously from this point, westward and southward. Along this line, which traverses Green and Starr townships, Hocking county, in the direction of the strike of the strata, sections were measured at short intervals. The Zoar Limestone was taken as the lower limit of the section and the Nelsonville coal as the upper. The whole series embraced in these limits was carefully measured at the point of beginning, its thickness there being one hundred and forty feet. It was then followed bodily to the southward. Measurements were taken at all available localities, generally with the hand level, but enough sections were re-measured with the engineer's level to give assurance that the results were entirely reliable.

From all the sections measured, five that are strictly representative of the districts in which they occur, are given in the accompanying diagram. They are as follows:

1. * Baird's Furnace—Monday Creek township, Perry county.
2. * Haydenville—Hocking county.
3. Union Furnace—(Section 35, Starr township), Hocking county.
4. P. Reasoner's—(Section 29, Brown township), Vinton county.
5. * Hope Furnace—(Section 19, Brown township), Vinton county.

Those marked with a star were measured with an engineer's level.

No extended explanation of these sections is required. The main question to be raised will be as to the certainty of the limits of the sections, but in regard to this, there is no ground of difficulty. The Blue, or Zoar Limestone, which is the base, is throughout all this region very persistent, and very well marked. It is found wherever it is due, almost without exception. Its place is rendered all the more conspicuous by the block ores and coals that are associated with it, and which have been worked at many points. The same certainty exists as to the Nelsonville coal. There is, in fact, no question as to the identity of the Mineral City and Nelsonville seams. The Cambridge and Shawnee Limestones stretch in unbroken beds from one field to the other, furnishing elements that cannot be mistaken in sections that prove identical. Prof. Andrews traced the coal, by way of Carbondale, to the Marietta road, and the outcrop is scarcely interrupted throughout the whole region. It can also be followed with but very little interruption by way of Five Mile Creek to Carbondale.

The sections are practically identical. In those that are given, differences of a few feet are recorded, but as much range is found in the sections of any one neighborhood as these show throughout the extent of the line.

The result is plain to be seen. The Baird Ore of Perry county is the Red Ore of Union Furnace and the Limestone Ore of Hope Furnace and southward. The Gray Limestone which is thin and uncertain in Perry county increases in volume in Hocking county, and is found steady and well developed in Vinton county. It gains this steadiness, indeed, in Washington township, Hocking county, ten miles west of Nelsonville.

The Nelsonville Coal instead of underlying the Gray Limestone, ranges from thirty five to forty-five feet above it in Perry, Hocking, and Vinton counties. This interval is observed until Bloomfield township, Jackson county is reached, where an increase of ten feet in the interval is made, the coal at Keystone Furnace being fifty-five feet above the limestone and being here known by its southern name, viz., the Sheridan seam. In the next six miles a further gain of ten feet occurs, and from that point to the Ohio River, a very reliable average of sixty-five feet is maintained. The country between Zaleski and Keystone Furnace has been repeatedly traversed in this interest, and hundreds of sections have been measured. No obscurity or doubt remains as to the general order.

The usual interval between the Gray Limestone and the Sheridan Coal in the southern counties has been shown to be sixty-five feet. Prof. Andrews traced the seam northwards until the interval was reduced to fifty five feet. In the Report of Progress for 1870, page 179, he gives a section near Keystone Furnace in which he notes the fact that a coal which "is doubtless the the Sheridan seam," "is nearer the limestone than usual."

In Volume I, Geology, page 233, he quotes the section referred to above and adds the following sentence, viz, "If the coal given in the above section is the Sheridan coal, there was probably a mistake in the measurement of tne space between it and the limestone." There is no mistake, however, in the identification or the measurement. The coal is the Sheridan coal and the measure is fifty-five feet.

On the other hand, the Mineral City seam (Nelsonville) has been followed southward from Zaleski until at Keystone Furnace it is found to be fifty five feet above the limestone. There is no room for doubt or question as to this fact, that the upper coal at Zaleski is the coal fifty five feet above the Gray Limestone at Keystone. The whole series has been followed without a break from the first point to the last. The fire clay parting by which No. VI is characterized through all this region, makes its identification easy and certain. A few of the intervals between the limestone and the coal in this district will be given here.

In Section twenty-two and twenty-five, Elk township, the intervals are respectively forty-two and forty feet. The coal is here know as the Carbondale seam. In Section twenty-five, Madison township (Vinton

Furnace), the interval is forty-two feet. In Section twenty-five, Clinton township (Eagle Furnace), it is forty five feet. In Section sixteen, Clinton township (Hamden Furnace), it is forty-six feet. In Section two, Milton township (Lincoln Furnace), it is forty-two feet. In Section twelve, Bloomfield township, (Keystone Furnace), it is fifty-five feet. In Section four, Madison township (Madison Furnace), it is fifty-one feet. In Section thirty, same township (Oak Hill), it is sixty-three feet, and in Section six, (Washington Furnace), it is sixty-six feet. At the last four stations the coal is known as the Sheridan seam.

A geological connection cannot be made stronger than this. There is room for an argument as to the identity of the upper New Lexington Coal and the Nelsonville seam, though this identity is highly probable, but there is no room for argument as to the equivalence of the Sheridan and Nelsonville seam. It is demonstrated.

The same line of facts, of course, holds for the limestone ore. It is certain that the limestone ore of Jackson county is the limestone ore of Vinton county, though a difference of interval of twenty-five feet occurs between it and the next best known horizon, viz., Coal No. VI within this area, but not a foot of difference between these two horizons occurs to the northward, where the limestone ore is known by different names as Baird ore and red ore. The outcrop of the ore is continous as far as the nature of the ground allows, and the measures are indentical. The structure and character of the ore also is the same through all the different exposures.

The Gray Limestone gradually loses its volume as it is followed northward from Vinton county. It is found in full force in Section eighteen, Elk township, Vinton county, but northward from that point *there is no ground high enough to hold it* until the north side of Swan township is reached. In the neighborhood of Mt. Pleasant it is struck at many points. The next point to the northward with elevation great enough to catch the limestone is Ilesboro, in Washington township, Hocking county. The limestone paves the roads of Ilesboro. It is here at least two feet thick, with characteristic fossils and appearance, and is overlain with a fine showing of the limestone ore. Thousands of tons of ore have been taken out here and carried to the nearest furnaces. The limestone underlies much of the east side of Washington and the west side of Starr townships, but is not more than a foot thick in this district. Going northward from Ilesboro, no other land is high enough to hold it until Schultz's Hill, two miles south of Logan, Section twenty-five, Falls township, is reached. Here the ore at least is found with about the usual interval (one hundred and seven feet) between it and the Zoar Limestone, the outcrops of which are well shown around the hill. In illustration of the fact that the points last named are the only ones high enough to reach this horizon, it may be added that these two localities, viz., Schultz's Hill and Ilesboro were among those selected by the United States Coast Survey for signal stations in their recent operations in this part of the State. The fact that they overtop the country around them is thus attested.

From Schultz's Hill eastward and northward, the ore and lime have been extensively worked, the ore here being known as the Baird ore.

The report now published is founded on sections accurately measured and connected as closely as possible through the several divisions of the field. The plan has been, after becoming acquainted with any locality and after measuring as many sections as possible with the hand level, to select some one representative section and to re-measure this with the engineer's level. These representative sections have been taken in every county of the district. Two or three of them are introduced here to show the detailed structure of the regions to which they belong more fully than it has been thus far given.

The first of these sections was taken on the land of John L. Gill, Esq., on Meeker's Run, below Nelsonville. It is a thoroughly representative section, embracing every valuable element but one that is due in a vertical range of two hundred feet at the very heart of the Lower Coal Measures. The single exception is the Baird ore with its accompanying limestone, which is not to be recognized in its proper place in the series as far as shown. The section is unusually complete, the openings being made so frequent and so extended that it is scarcely an exaggreation to say that the hill from which it was taken is *faced* from top to bottom. The intervals in almost all cases are those usually found in this part of the district. The Cambridge Limestone is, however, ten or fifteen feet nearer to Coal No. VI than in most sections.

The intervals above the Nelsonville coal are measured from it, according to the custom throughout the region in which the seam is so largely developed.

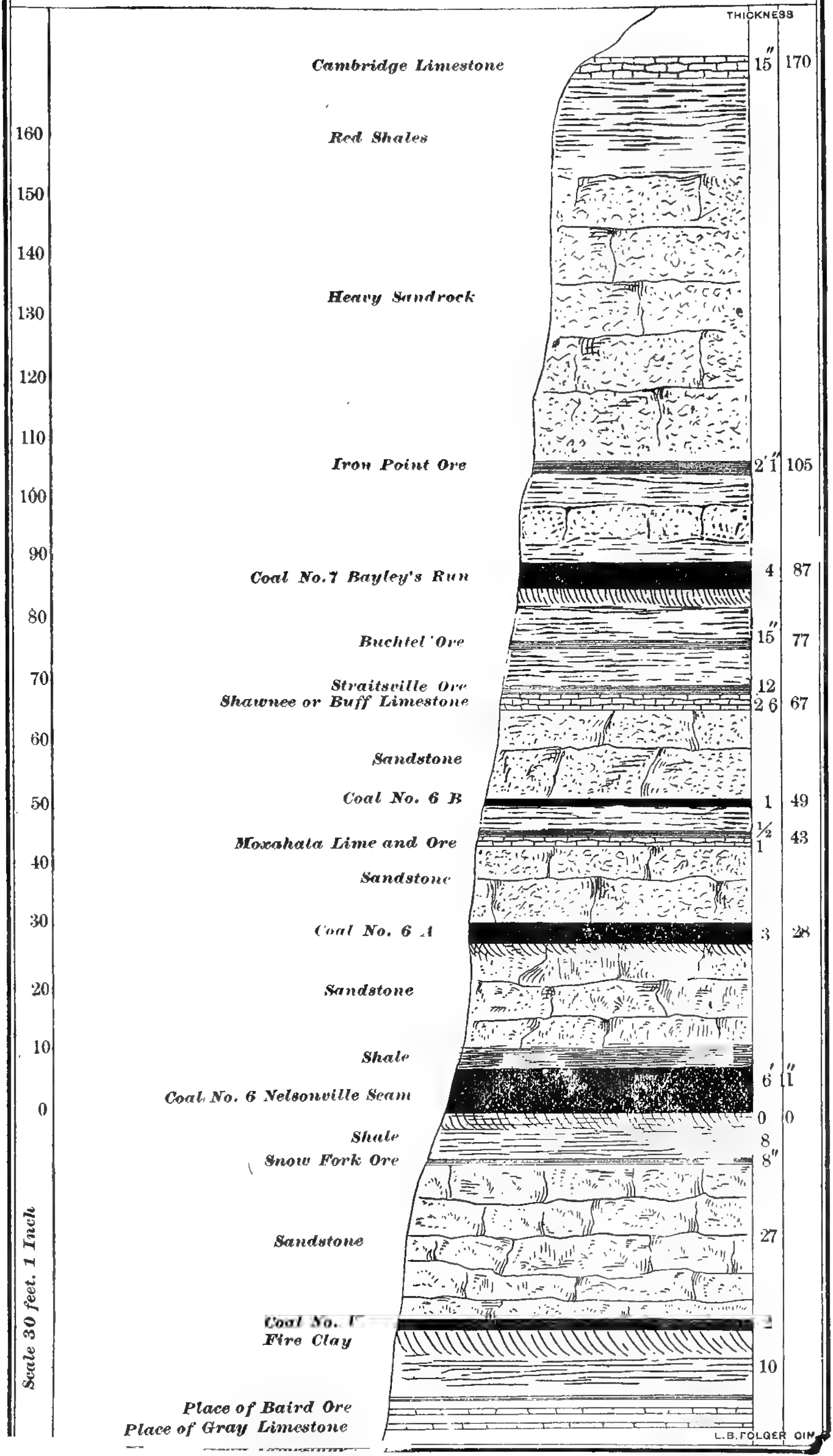
The lowest element of value in the section is Coal No. V. It is here shown with a thickness of two feet, underlain with the usual white clay and shales, but, as already remarked, while the horizon of the Baird ore and the Gray Limestone is reached, neither of them appears at this particular point.

The distance between Coals No. V and No. VI is found to be greater than in many sections by a few feet. The interval is filled with a soft sandstone for most of the space.

The Snow Fork ore is seen a few feet below the Nelsonville coal, the bed of the run being filled with the massive nodules that have been

SECTION ON LAND OF JOHN L.GILL ESQ.,

MEEKER'S RUN NEAR NELSONVILLE.



gradually undermined and accumulated here. The ores shows the impressions of fern leaves and other vegetable tissues by which it is so widely characterized. A thickness of shale and fire-clay varying from two to ten feet underlies the great coal seam.

The coal has a thickness of six feet and eleven inches. It has the usual partings and is, in every respect, an excellent representative of the great seam in its best estate. It is overlain by a few feet of shale which is in turn succeeded by a sandstone ledge about twenty feet in thickness.

Coal No. VI*a*, with a thickness of three feet is next met with, at a height of twenty-eight feet above the great seam. It is a coal of fair quality and would attract attention in many other fields. Its steadiness cannot be relied upon.

The Lower Buff Limestone and its associated ore are found at an elevation of forty three feet above Coal No. VI. They are styled in the section the Moxahala lime and ore, but in the body of the report they have been connected in name with the coal seam above them, viz., the Norris Coal, and have been described as the Norris Lime and Ore. The latter name is to be preferred. There are twelve inches of limestone and six of ore in the openings shown.

The very variable and inconstant seam known in this report as Coal VI*b*, is found at an elevation of forty-nine feet above the base. The seam is here but one foot thick. Three miles north-east, on the Lefever farm of W. W. Poston, Esq., the same seam has a thickness of over five feet.

The Shawnee or Buff Limestone holds its usual place at sixty-five feet above the Nelsonville Coal. It is thirty inches thick in the section here shown, and twelve inches of the ore that accompanies or replaces the limestone is shown above it. The ore seems to have the usual character of the Straitsville seam.

This is one of the few sections of this region that distinctly shows the Buchtel ore in its relations to the other elements of the section. Fifteen inches of ore of fair quality are shown ten feet above the limestone last named.

Another ascent of ten feet brings us to Coal No. VII, or the Bayley's Run Coal. There is a fine showing of this seam, four feet in thickness, in the section under review. The coal has all the best characters of this seam in this vicinity. Like the two coals next below it in the section, it is much more bituminous and melting than the great seam. Whether it will prove a valuable coking coal remains to be demonstrated, the experiments thus far made not having complied with all the necessary conditions.

Eighteen feet above Coal No. VII a stratified ore, two feet and one inch in thickness, occurs. It is named in the section the Iron Point ore. This identification is not beyond question, but the interval, and the character of the ore, and its outcrop, seem to make it probable.

An interval of sixty-five feet filled with sandstone and with reddish shales next succeeds, without any recognized elements of economical value, above which the Cambridge Limestone finds place, completing the section. The limestone is one hundred and seventy feet above Coal No. VI, which is a smaller interval by ten or fifteen feet than is generally found.

The section is thus seen to be very full and satisfactory. It answers, without change, for all of the leading elements of the scale throughout the western part of York township and the eastern part of Starr, and through Brown and Madison townships, or, in other words, to the line of the Marietta and Cincinnati Railroad. It is repeated with almost identical measurements in Rich Hollow Hill, three miles south-east of Zaleski (Section 30, Madison township), where the westernmost exposure of the Cambridge Limestone in that vicinity is found.

Two sections, taken respectively at Ironton and on the river hills of the Monitor Furnace lands, opposite Ashland, Kentucky, will next be presented. These sections faithfully represent the lower Coal Measures of this part of the Ohio Valley. An average of many sections would scarcely change the measurements found by the engineer's level in the hills which were selected for this purpose.

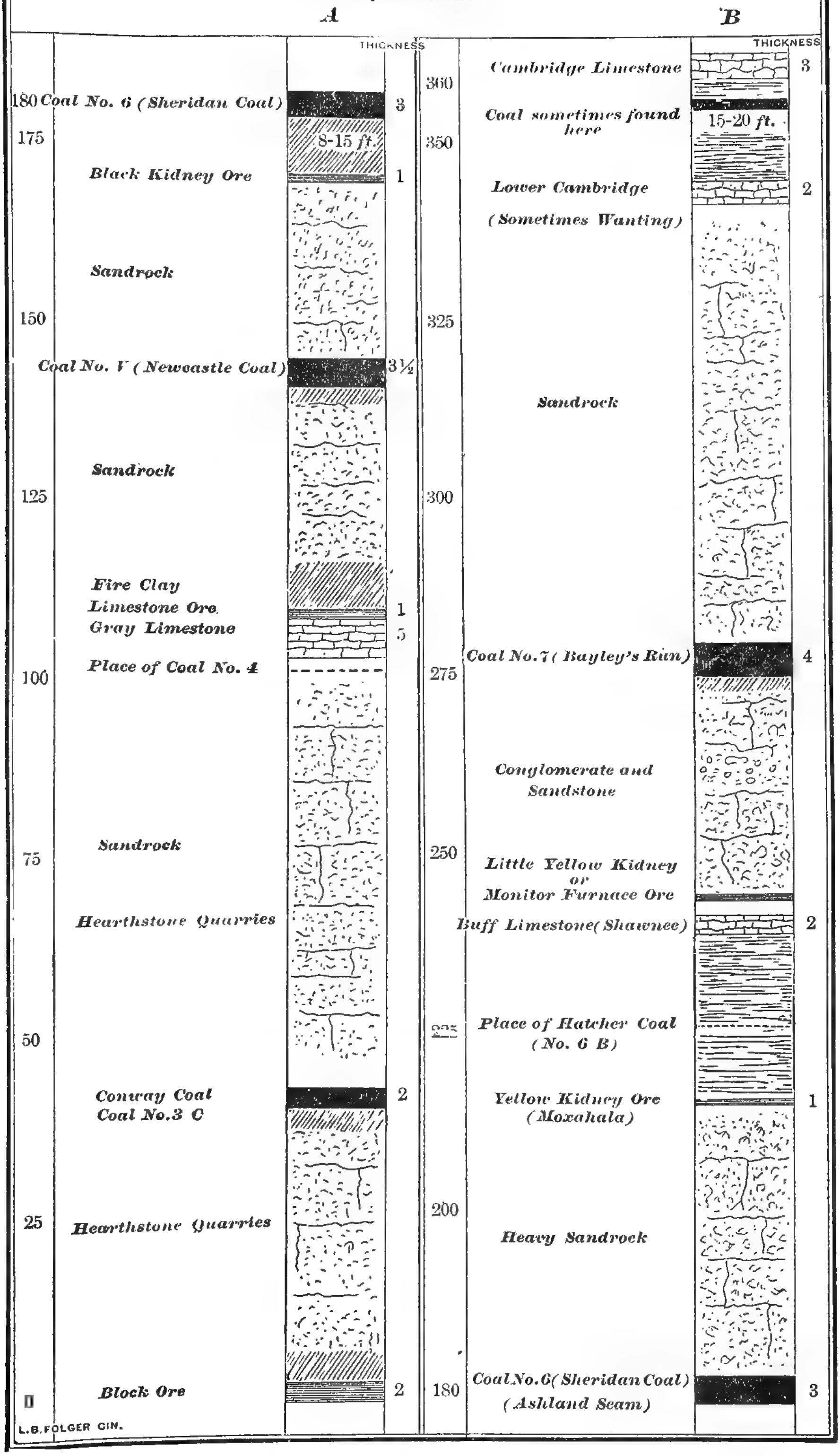
The section in the right hand column was taken immediately back of Ironton. The block ore, which is made the base, lies sixty feet or more above low water. It is the highest of the three seams of block ore that constitute so important an element in the supply of the western furnaces of the district. It is well shown at Kronnacher's spring house, just above the Iron Railroad. It is here two feet in thickness, and is rich in iron, but it is also highly charged with sulphur, and it has, therefore, after repeated trials, been rejected as worthless for the blast furnace. Its character has been discussed on preceding pages, and nothing need be added here.

The heavy ledge of sandstone that covers it has been worked in the neighborhood for furnace hearth-stones. On the Kentucky side of the river, especially, stone from this horizon has a very good name in connection with this use. The Belfont hearth-stone quarries belong here.

A coal seam, locally known as the Conway coal, is found forty feet above the Block ore. It has here a thickness of two feet, and has been worked, in the small way, for neighborhood supply. It is through this coal, and the rocks associated with it, that the tunnel of the Hecla Furnace turnpike has been carried. A prostrate tree is finely shown in

SECTIONS FROM IRONTON AND VICINITY.

Scale 25 feet, 1 Inch.



the roof of the tunnel. It can be traced distinctly for more than thirty feet.

The seam is numbered III*c* in the section, but it will be remembered that the identification is not positive in the general review.

The ledge of sandstone that lies next above is the most marked of all the deposits of this order in the Lower Coal Measures of the district. It is finely shown on Hecla Furnace lands, and yields there furnace hearth-stones that are well approved. It can be followed through Lawrence and Jackson counties into Vinton county, holding everywhere a thickness of not less than twenty-five feet, and sometimes rising to forty feet. It is no where shown better than in Bloomfield township, Jackson county. Its relation to the Gray Limestone renders it very easy of identification throughout the field. It may very appropriately be termed the Hecla Sandstone.

We reach, now, the horizon of the Gray Limestone. It is five feet thick at the point where the measurement was taken, but a heavier body of it is found in some of the sections of the neighborhood. The place of the coal seam that is so generally found below it, Coal No. IV*a*, is indicated in the section, but there is not even a black line to stand for the seam in the actual section. As in the Hocking Valley, so in the Ohio Valley, the coal is wanting, while from the northern part of Lawrence county to the north line of Vinton county, the seam is on the whole the most stable and valuable of all the series.

Over the limestone, one foot of ore is found, and over the ore, eight feet of fire-clay. The clay is of the plastic variety, and has been largely employed in pottery in past years. Its white color makes it everywhere conspicuous in the sections of the region.

Over it, about fifty feet of sandstone is found in two great ledges, which are generally separated, however, by Coal No. V, the New Castle seam. The upper ledge lies immediately over the coal, and the lower one approaches the coal very closely, also. Vertical sections, in which the country abounds, often show the sandstone continuous, the coal being entirely cut out. The New Castle Coal is, in the Ironton hills, three and one-half feet thick. Its quality can be judged in part by the fact already noted, that it has a sandstone roof. Such a cover is almost always associated with a sulphurous coal.

Above the upper ledge, the "Black Kidney" ore, as it is named in some of the Kentucky furnaces, is found. It lies from eight to fifteen feet below the Sheridan Coal (No. VI) and is without doubt identical with the Snow Fork Ore of the Hocking Valley. Like it, it frequently contains impressions of fern leaves and other vegetable tissues.

The Sheridan Coal, which completes the section, is found at an elevation of seventy feet above the Gray Limestone. It is less steady as a seam than the New Castle Coal. It is, however, quite well shown in the section under consideration. It is opened in W. D. Kelly's orchard, where it has a thickness of three feet. The coal gets its southern name, viz., the Sheridan seam, in this vicinity. The mines of Hon. E. Nigh, which are located about seven miles above Ironton, have received this designation, but no new name would have been affixed to the seam if it had been distinctly understood that the Sheridan Coal and the Ashland Coal were the same. The latter coal is widely and favorably known. No question in regard to these coals being one and the same seam can now be raised. The sections on opposite sides of the river are identical through at least three hundred and fifty feet of strata. The character of a coal can not be inferred from the name by which it is known. Coal No. VI, the Nelsonville seam, is certainly the most valuable coal of the district, but portions of it are to be found of sulphurous and otherwise inferior quality. It seems to contain a larger measure of sulphur in the Ohio Valley than at the northward, but there are in this general region large areas in which it displays its greatest excellence. The Walnut township Coal, of Gallia county (lower seam), according to all investigations thus far made, compares well with the best showing of the Hocking Valley Coal, except in thickness. It yields at least five feet of coal for a large area. The seam at Sheridan, as at Coalton, Kentucky, shows in places a large percentage of sulphur, but there is a great deal of excellent coal at each of these localities. Experiments have been lately made in coking the coal at the Sheridan mines, but the result has not been learned. None of the trials thus far reported in coking Coal No. VI in this district has been entirely successful. The coal can be charred, but its slack has never yet been taken up.

The characteristic features of the section just given are apparent. Nowhere else in the district is there such a development of sandstones as in the southern part of Lawrence county. Four great ledges, no one of them less than twenty feet in thickness, have been found in the one hundred and eighty feet already traversed; and the sandstone next to be named, is quite as massive and conspicuous as any thus far described.

The section now described does not terminate with the Sheridan Coal, but one hundred feet of strata overlie this horizon in the hill belonging to W. D. Kelly, Esq., and also in the adjoining land of John Campbell, Esq. It has been found more convenient, however, to break the section at this point, as just about the same number of feet remain to be described.

The section on the left hand side of the page embraces a part of the measurements obtained on the Monitor Furnace lands, directly opposite Ashland, Kentucky. Repeated mention has been made of this section in the preceding pages, and it will now be described with necessary detail. The whole section obtained in this hill is the most complete yet found in the district. A large number of the best known elements can be identified, and the hill rises so abruptly that most satisfactory and reliable measurements can be obtained. It embraces all that the two sections represented in the diagram contain. The block ore, which is the base of the Ironton section, is found near the level of low water in the river. The several elements agree with the descriptions already given as far as they extend. The part that remains to be described is the interval between Coal No. VI and the Cambridge Limestone.

In regard to the Sheridan Coal, which makes the base of the second section, nothing needs to be added.

It is overlain, sometimes with the interposition of a few feet of shale and oftener without, by a heavy ledge of sand-rock. This is one of the well marked strata of the valley for ten or fifteen miles. It is the "hanging rock" that overlooks the village of this name, and so has come to give a designation to the entire district.

At forty feet above the coal, a seam of ore, well known throughout the furnace district on both sides of the river, is found. It is designated in the section as the "Yellow Kidney" Ore, but no such name can be depended on without proper verification of the seam, for it will be found that the "Yellow Kidney" of one furnace is the "Red Kidney" of the next, and the "Black Kidney" of still another. The name most frequently applied in the immediate vicinity has been adopted here. This is a mellow and excellent ore that is welcomed by every furnace of the region. The seam is about one foot thick in its development, and is quite persistent. A few feet of shale intervene between it and the sandstone that supports it and it is also overlain by shale and shaly sandstone.

The Hatcher Coal was not opened in the Monitor Furnace hill, but its place is indicated in the section. It is found in the immediate neighborhood at an elevation of forty-five to fifty feet above the Sheridan seam.

At sixty-six feet above the last named coal a Buff Limestone, two feet thick, is met. It is an element in almost every section of this region. It is overlain very often by a seam of ore. The ore is shown in the section at seventy feet above Coal No. VI. It has been quite extensively worked on the furnace lands, and a good report is always given of it where it has been used. It seems to be the same seam that is known in this part of the district as the "Little Yellow Kidney." If not identical with it, both belong very near together.

The ledge of sandstone that comes next in the section is a marked and characteristic element in the geology of the region. It is a Conglomerate, the first well defined rock of this kind that has been found in the three or four hundred feet of strata that are now being reviewed. It contains quartz pebbles, for the most part, but occasionally coarse pebbles of non-fossiliferous limestone and of Coal Measure sandstones occupy the series for several feet of thickness. This phase is well shown at Buzzard's Roost, on the old road leading from Ironton to Hecla Furnace. The limestone pebbles seem to be derived from the Buff Limestone last named. This Conglomerate stratum is found to be an excellent and reliable guide throughout the southern and eastern portions of Lawrence county.

At about one hundred feet above Coal No. VI another coal seam is shown in this same hill. The measurement was not in this instance, however, direct, and the distance may be somewhat less than has been given. The coal is worked on the furnace lands. It is four feet thick and of fair quality.

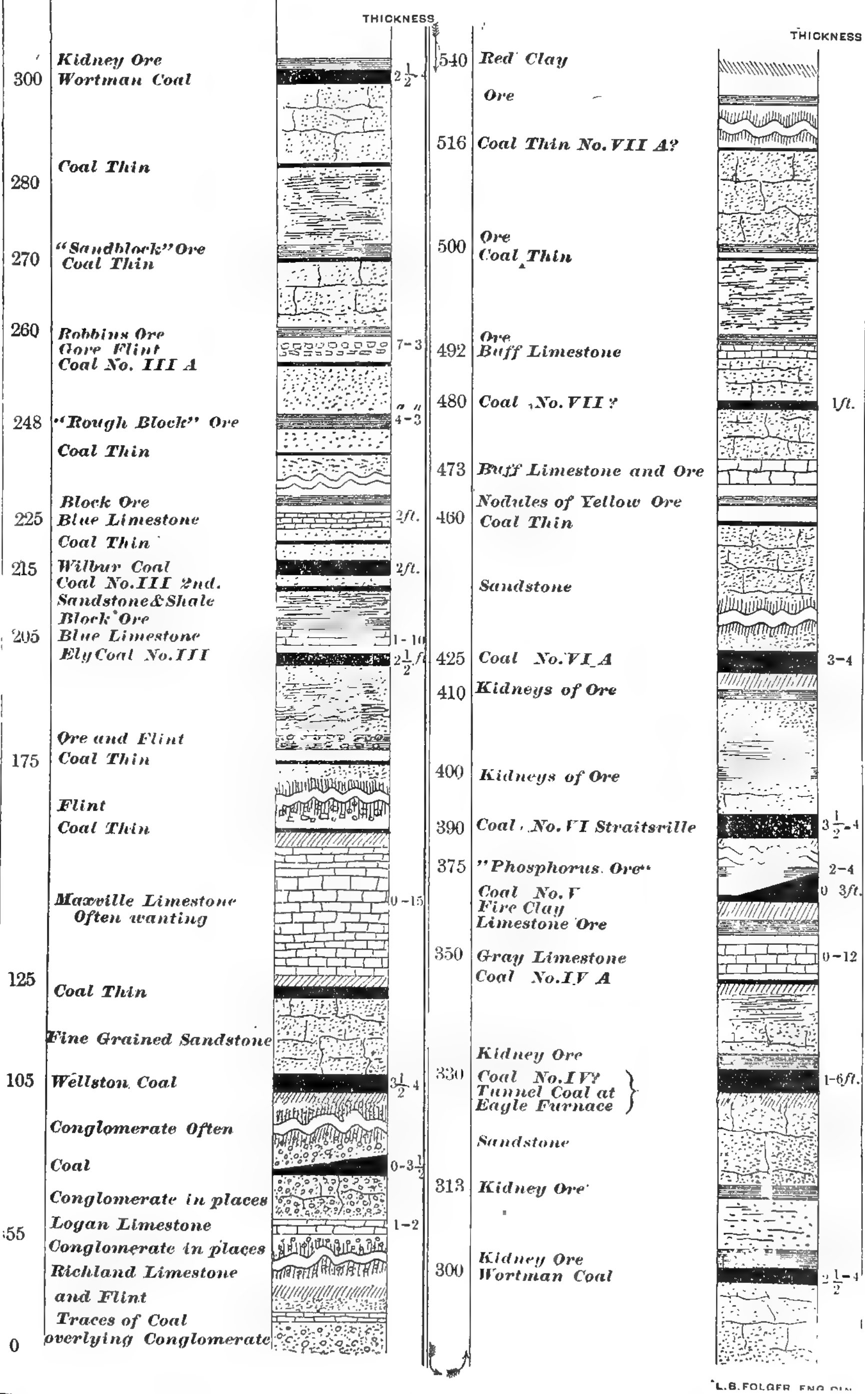
A barren reach of eighty-seven feet—mainly sandstone, intervenes between this coal seam and the Cambridge Limestone. This well marked stratum is frequently found in two courses from one to twenty feet apart. It seems to be so divided here. At one hundred and sixty-seven feet, the lower stratum seems to be met. Seventeen feet higher the main layer is found, at a height of one hundred and eighty-four feet above the Sheridan coal. This limestone completes the section.

On comparing this section with the one measured in the Hocking Valley—page 926, a remarkable agreement will be observed. The boundaries of the Meeker's Run and Monitor Furnace sections are certainly the same. Both the coal and the limestone that constitute these boundaries have been followed from township to township, through the whole district, until the identity of each throughout its various exposures has been completely established. The interval in the first section between these two horizons is one hundred and seventy feet; in the second, it is one hundred and eighty-four feet. But it was remarked that the interval in the Meeker's Run section was ten or fifteen feet shorter than the usual interval. In other words the usual interval between these horizons in the Hocking Valley is exactly the same that we find in the Ohio Valley. This agreement is certainly surprising. As has been already remarked such identity of measure in sections so remote from each other would constitute proof of difference rather than of equality of age, but here we are obliged to believe that the same number of feet of strati-

COMBINED SECTIONS FROM
VICINITY OF HAMDEN JUNCTION, VINTON CO.

BY

Dr. L. W. BAKER.



fied deposits, shales, sandstones, fire-clays, coals, etc., accumulated in these separate localities in the vast lapse of years that one hundred and eighty feet of strata require for their growth. Equality of measure is not, however, to be inferred for other portions of the district. In Greenfield township, Gallia county, the same interval expands to two hundred and twenty feet. Both horizons here are perfectly distinct and certain, and the interval was carefully measured with the engineer's level.

It will be observed that the whole intervals in the two sections are divided in very nearly the same way. Especially a Buff Limestone is found in each at a height of about sixty-five feet above the base. The connections of this last named horizon are numerous, and it seems almost certain that the Buff Limestone of the Hocking Valley is one and the same with the Buff Limestone of Monitor Furnace. There are, however, several limestones of this general character in this part of the series to the northward, and inasmuch as no direct continuity of the stratum has been proved, the identification is not positive.

This steadiness is all the more surprising when the difference of materials that fill the intervals is considered. There are much heavier sandstones to the southward than in the Hocking Valley.

A third section is here introduced that represents with great fidelity and minuteness the general stratigraphical order of the series in the southern part of Vinton and the northern part of Jackson counties. This section was furnished by Dr. L. W. Baker, of Hamden Junction, to whose untimely death, reference was made in the letter that introduces this Report. This section stands for a great amount of labor, and a more thorough and accurate knowledge of the field than any other man has ever had. The section was made on entirely independent measurements from those already reported, but it is in substantial agreement with them. In regard to the lowermost two hundred feet, it must be granted that there is less certainty than in the other portions. This part of the series has not yet received the attention that it merits.

This report will be concluded with the publication of a number of chemical analyses that have been made in the laboratories of the Ohio State University during the last two years, of the economical minerals of the Hanging Rock District. These analyses will be seen to embrace many points of interest and importance both as regards quantity and quality. They have been made without expense to the Survey or to the State. The analysis of a few limestones outside of the district is also introduced here, because they are in process of trial as flux among the furnaces of the Hocking Valley. All of these analyses were executed by Curtis C. Howard, B. S., now Assistant Professor of Chemistry in Starling Medical College, Columbus.

The tables of analyses will be arranged in the following order

A. Limestones.
B. Iron ores.
C. Pig irons.
D. Coals.

The limestones and ores will also be taken in geological order.

A. LIMESTONES.

A. MAXVILLE LIMESTONE.

1. Winona Furnace Drift—white variety.
2. Culver and Stotler's—white variety—Webb Summit.
3. Culver and Stotler's buff variety—Webb Summit.
4. Culver and Stotler's blue variety—Webb Summit.
5. Glenford, Perry county.

MAXVILLE LIMESTONE.

	1.	2.	3.	4.	5.
Calcium carbonate	89.31	82.88	79.18	88.71	93.08
Magnesium carbonate	1.52	2.23	1.96	.54	1.59
Iron and alumina	2.99	2.68	16.09	1.18	1.60
Silicious matter	5.91	11.58	4.28	9.01	3.02
Moisture	....	....	....	....	.40
Totals	99.63	99.37	99.51	99.44	99.69
Phosphoric acid	....	....	....	....	.12

NOTE.—No. 4 was refused by the furnaces at the time these samples were selected; while No. 3 was accepted. This preference is not justified by the analyses.

B. BLUE OR ZOAR LIMESTONE.

A single analysis of the Zoar Limestone is given here. The specimen came from the vicinity of Jackson Court House, where this stratum has been, and is still extensively used for flux. The sample analyzed represents the better grade of the rock from the Young America Furnace lands.

Calcium carbonate	82.47
Magnesium carbonate	1.25
Iron and alumina	7.47
Silicious matter	6.46
Organic matter	1.66
Totals	99.31

C. SHAWNEE OR BUFF LIMESTONE.

1. Ogden Furnace—Ward township, Hocking county.
2. XX Furnace—Shawnee.
3. Fannie Furnace—Shawnee.
4. Fannie Furnace—Shawnee.
5. W. W. Poston's—Nelsonville.
6. W. B. Brooks's—Nelsonville.
7. George W. Gill's—Meeker's Run.

	Ogden Furnace.	XX Furnace.	Fannie Furnace.	Fannie Furnace.	W. W. Poston—Nelsonsonville.	W. B. Brooks—Nelsonsonville.	G. W. Gill—Hocking Valley.
Calcium carbonate	92.62	81.65	87.86	73.15	85.32	72.08	76.00
Magnesium carbonote	.96	1.96	1.16	2.07	Trace.	Trace.	*
Iron alumina and manganese	3.63	4.99	7.27	6.81	2.99		
Silicious matter	2.91	10.42	3.57	11.81	10.12	22.23	19.85
Moisture		.65	.38	.61			
Organic matter					.86		
Oxide of iron						3.91	
Phosphate of alumina							1.35
Iron							2.40
Magnesia							Trace.
Totals	100.12	99.57	100.24	99.45	99.29	99.22	99.60
Phosphoric acid		.34					
Manganese oxide	1.39						

NOTE.—The Ogden Furnace sample is exceptionally good, and cannot be assumed to represent any large part of the stratum.

D. CAMBRIDGE LIMESTONE.

A single analysis of the Cambridge Limestone is given here. The sample analyzed was taken from the stock pile of Ogden Furnace. It represents the best grades of the stratum in Hocking county.

Calcium carbonate	90.30
Magnesium carbonate	.92
Iron and alumina	4.42
Silicious matter	3.67
Organic matter	Trace.
Total	99.31

E. AMES LIMESTONE.

Two analyses of this excellent limestone are given. The first sample was taken from the stock pile of Ogden Furnace, and the second from the outcrop of the stratum on the land of L. D. Linscott, Trimble township, Athens county. The analyses fairly represent this stratum. It is certainly the purest in composition of the limestones of the Hocking Valley.

	1.	2.
Calcium carbonate	94.18	91.71
Magnesium carbonate	1.02	.72
Iron and alumina	1.26	....
Manganese oxide	1.18	....
Silicious matter	2.23	4.51
Iron, alumina, and manganese	....	2.67
Totals	99.87	99.61

F. CORNIFEROUS LIMESTONE.

Two analyses of the Columbus or Corniferous Limestone are introduced here. The samples were both taken from Smith and Price's quarries, two miles west of the city, and from the particular course called the "smooth rock." The first analysis represents the best grade of the limestone, and shows this variety to be equal in purity to any limestone of the State. The second sample represents courses that lie at a lower level in the quarry:

	Smith & Price's quarries, "smooth rock."	Same quarries, but lower layer.
Calcium carbonate	93.28	81.14
Magnesium carbonate	2.69	16.00
Aluminic and ferric oxides	2.10	1.08
Silicious matter	1.41	1.94
Totals	99.56	100.16

B. IRON ORES.

A. GRAY LIMESTONE ORE—(BAIRD ORE).

1. Gallia Furnace, Gallia county.
2. Howard Furnace, Scioto county.
3. W. B. Brooks, Nelsonville.

	1.	2.	3.
Silicious matter	22.97	22.45	11.58
Aluminic oxide	1.69	1.91	1.78
Phosphoric acid	.48	.74	.60
Manganic oxide	1.12	1.32	1.55
Calcic oxide	2.95	2.77	4.47
Magnesic oxide	1.19	1.08	1.23
Carbonic acid	26.28	26.22	28.86
Sulphur	.79	.48	.54
Combined water	2.63	1.72	2.43
Metallic iron	30.26	31.65	35.37

These analyses all represent the Gray Ore, and the samples analyzed could not be distinguished from each other in appearance. The gray variety has never had a good name at Gallia Furnace. The amount of silicious matter is shown to be excessive. The Nelsonville sample from W. B. Brooks's land is fully up to the best standard of the Gray Ore in the southern counties.

B. BUCHTEL ORE.

Of the ore that lies eighty-four feet above Coal No. VI, on land of Akron Furnace Company, Bessemer, Athens county, the following analysis was obtained :

Ferric oxide	54.52
Aluminic oxide	1.52
Manganese oxide	1.69
Calcic oxide	11.06
Magnesic oxide	.84
Calcic phosphate	1.15
Silicious matter	28.21
Sulphur	.27
	99.26
Metallic iron	38.16
Phosphorus	.34

The above analysis represents the best grade of the outcrop ore. The results of seven analyses, in which only the metallic iron and the silicious matter were determined, are given below. The samples were taken from the stock pile of the furnace during the first month of its operation. A more careful selection of ores has doubtless since been made, by which the yield would be increased. The samples were all calcined ore.

	1.	2.	3.	4.	5.	6.	7.
Metallic iron	21.19	26.19	22.41	14.95	28.45	24.00	19.02
Silicious matter	17.61	17.97	8.88	7.03	4.08	16.77	17.15

C. IRON POINT ORE.

Five analyses of the ore from this valuable seam are given below. Most of the samples come from beyond the field considered in the present report, but the horizon is well marked in the Hanging Rock District. The analyses are not equally complete.

1. Fannie Furnace, Shawnee—one hundred and five to one hundred and twenty feet above Coal No. VI, calcined ore.
2. Gould and Moore's lands, Carbon Hill—Ward township, Hocking county, one hundred and thirty feet above Coal No. VI. From weathered outcrop of seam.
3. Moxahala Furnace, Whitlock Bank.
4. " " " "
5. " " " "

	1.	2.	3.	4.	5.
Ferrous carbonate			74.66	75.17	76.56
Alumina	8.30		6.69	3.80	4.82
Manganese oxide	2.33		4.49	2.33	2.95
Magnesic carbonate		23.15	.60	1.82	1.87
Calcic carbonate			2.35	8.10	3.86
Phosphoric acid	.67		.58	.67	.83
Sulphur	.39		.13	.39	.52
Silicious matter	2.43	19.65	10.60	2.43	2.73
Organic matter					2.63
Water					3.80
Sesquioxide of iron	75.17	57.23			
Magnesic oxide	1.82				
Calcic oxide	8.10				
Metallic iron	52.67	40.06	36.04	36.28	36.96

C. PIG IRONS.

The results of four analyses of the iron made by Star Furnace, Jackson county, will be found below. This furnace uses native ores solely and Jackson Shaft coal for fuel. There is no other furnace district of the State in which all the materials that go into the stack are derived from the immediate neighborhood. Some use Lake Superior or Missouri ores, and some use Connellsville coke in connection with the native supply, but no foreign materials are here employed.

	No. 1 Foundry pig.	No. 2 Foundry pig.	No. 3 Foundry pig.	Mill iron.
Silica	3.73	3.59	3.81	3.66
Graphitic carbon	2.62	3.23	2.65	2.49
Combined carbon	.40	.29	.38	.20
Phosphorus	.53	.40	.63	.56
Sulphur	.08	.12	.11	.14

D. COALS.

The analyses of two seams of coal from the district will conclude this list. The first one is Coal No. VI*a*, from lands of the Hamden Furnace Company, Vinton county. The coal lies in three benches, as does Coal No. VI. At the time of the analysis this seam was supposed to be the Nelsonville coal. It lies seventy-three feet above the Gray Limestone. It was afterwards shown, however, that the Nelsonville coal was present in the section, though in rather small volume, at forty-three feet above the limestone and the Hamden Furnace coal, as the present seam may be designated, was proved beyond question to be No. VI*a*. It will be remembered that for a large area here the last named coal is much more important than the Nelsonville seam.

1. Top bench.
2. Middle bench.
3. Bottom bench.

	1.	2.	3.
Moisture	5.29	5.19	5.87
Volatile matter	31.24	31.95	35.63
Fixed carbon	48.03	54.03	45.89
Ash	15.44	8.83	2.61
Totals	100.	100.	100.
Sulphur	2.58	1.93	.94
Specific gravity	1.47	1.44	1.31

The second series of analyses is of the great seam (No. VI) in its best development at Straitsville. The samples were furnished by Moss and Marshall, proprietors of Bessie Furnace. They were taken from the mines of the Straitsville Mining Company—J. S. Doe and Co., lessees, upon the coal of which the furnace was then running. A diagram is appended to show the general structure of the seam. The samples were taken at intervals of about one foot, and are numbered from the top downward.

STRUCTURE OF THE GREAT SEAM AT STRAITSVILLE.

		FT.	IN.
1.	Coal	2	..
2.	Parting	..	2
3.	Coal	2	..
4.	Parting	..	4
5.	Coal	4	..
6.	Clay parting	..	6
7.	Coal	2	..

The analyses are as follows:

	1.	2.	3.	4.	5.	6.	7.	8.
Moisture	5.62	4.56	5.50	5.98	6.01	3.90	4.15	4.52
Volatile matter	33.99	31.66	30,05	31.37	31.12	35.03	35.51	36 08
Fixed carbon	58.35	61.22	57.70	59.61	53.04	56.94	54.15	52.60
Ash	2.04	2.56	6.75	3.04	9.83	4.13	6.19	6.80
	100.00	100.00	100.00	100.00	100.00	100 00	100.00	100.00
Sulphur	1.02	.62	.94	.98	.71	1.04	2.21	1.32
Specific gravity	1.28	1.27	1.32	1.27	1.27	1.30	1.33	1.32

The average percentage of sulphur is 1.12.

A few words will be added in regard to the determination of the dip of the strata. Many determinations of direction and amount have been made in different parts of the district during the progress of this examination, but the want of space excludes them from the present report.

A graphic method of determining this important factor in geological exploration, has been kindly furnished by Prof. R. W. McFarland, of the Ohio State University. It has been found so intelligible and so serviceable, and is so simple and beautiful withal, that it is appended here. It is a valuable contribution to stratigraphical geology. By the aid of a map on which the elevations of definite horizons, like coal seams or limestones, are marked, the direction and amount of dip can be readily determined. The excellent map of the Hocking Valley coal field, by W. H. Jennings, Esq., of Columbus, gives numerous elevations of the great seam above Lake Erie, which can be used in these calculations.

A GRAPHIC METHOD OF DETERMINING THE DIRECTION AND AMOUNT OF DIP IN COAL AND ROCK STRATA.

"Join on the map three points in some stratum, the elevation of these points above a given base (e. g. Lake Erie, or tide-water) being known, or make a triangle similar to that on the map. Find the elevation of each of the two higher points above the lowest; at right angles to the line joining the two higher points, set off their respective heights above the lowest point (using any convenient scale); join the upper extremities of these lines and extend this connecting line till it meets the line passing through the feet of the perpendiculars; from the point of intersection, draw a line to the lowest station; from the highest station draw a perpendicular to the last mentioned line, and call this line A; draw a meridian through the highest point, then the angle between this meridian and the line A will be the *direction* of the dip.

"To find the angle of the dip, make a right angled triangle, with the line A for a base and the difference between the highest and lowest points, for the perpendicular; then the angle at the base is the *amount* of the dip. All this is to be done by simple measurement. If the dip *per mile* is required, divide the difference between the highest and lowest points *in feet* by the number of *miles* in A. But in all cases where the dip is but slight, it is better to divide the perpendicular of the last named triangle by the base, both *in feet;* the quotient is the natural tangent of the angle of the dip."

CHAPTER XC.

GEOLOGY OF BROWN COUNTY.

BY H. HERZER.

[NOTE.—The survey of Brown county was executed in 1871 by Rev. H. Herzer, and some of the facts transmitted by him are embodied in the present report.—E. O.]

Brown county is bounded on the north by Clinton and Highland counties, on the east by Highland and Adams, on the south by the Ohio River, and on the west by Clermont county.

Its geology agrees almost exactly with that of the last named county. All the general statements made in regard to Clermont county can be applied, without change, to Brown. Both of them agree in containing, beside the deposits of the Drift period, but a single geological formation, viz., the Cincinnati Group. In range they vary slightly, the very summit of the series being attained in Eagle township, Brown county, in the north-eastern corner. At a few points in this township, there is evidence of the former presence of the cliff limestone, in the characteristic red clays that result from its decomposition. It is possible that the cliff limestone (Upper Silurian) will yet be found in place in the highest lands east of Fincastle. The ground is certainly very nearly high enough to catch it. It is found in force as soon as the Adams county line is reached, but thus far no bedded rocks have been discovered of Upper Silurian age in Brown.

The upper beds of the Cincinnati Group, on the east side of the county, are distinguished from the middle and lower portions of the series by a change of name. Instead of being counted with them as *Blue Limestone*, they are called *Gray Limestone*, their color being decidedly lighter than that of the typical beds. There is no doubt that with this change of color appreciable changes of chemical constitution are associated. It is held by some that the soils of the Gray Limestone lands are somewhat more productive than those derived from the lower portions of the series.

The upper limit of the rocks of the county has been found, in the base of the Upper Silurian formation. The lower limit almost exactly coincides with the geological horizon of Cincinnati. The trilobite *Trinucleus* *concentricus* that is so characteristic of the lower beds of the Cincinnati formation, is found abundantly at the base of the river hills at Higginsport and at Ripley, and extends upward from that level through the usual interval. The section, in fact, at these points, duplicates the Cincinnati section almost exactly. The same fossils are found, and in the same abundance. *Orthis lynx* and *Orthis sinuata* are no where better developed than at the summits of these sections.

The horizon of *Orthis retrorsa* Salter (*Orthis Carleyi*, Hall) is reached at Arnheim, in the banks of Straight Creek. From this point the dip is quite rapid to the eastward. All the characteristic fossils of the Lebanon beds are found in the neighborhood of Fayetteville as well as upon the eastern side of the county.

The Drift deposits of the county are the same as those already described in Clermont and Highland counties. The most characteristic feature is the compact white clay that covers the flat lands in the northern townships of the county. It is six to ten feet in thickness, and contains a great many scratched and glacially polished fragments of Blue Limestone rock, as well as representatives of the granitic series of the north. There are but very few large bowlders in the county. One of the most conspicuous is found in the immediate neighborhood of Fayetteville. Under the white clay is the seam of iron ore described in the reports already referred to. It seems to mark the epoch of the forest bed of the Drift. We are certain that there was an advance of glaciers over this region, for we find the limestone well polished in place in the adjoining townships of Highland county. No bank gravel is found in the county except in the main valleys. It is, of course, abundant there in the usual terraces. It is often cemented in immense blocks through the agency of the lime water that percolates it. An example of this Drift Conglomerate is seen in the massive and striking cliffs at the mouth of White Oak Creek, near Higginsport.

The soils of the county are of the usual character for these areas. The flat lands already referred to, are covered with a considerable depth of clays, rich in all the elements of vegetable growth, except organic matter. They are, of course, stubborn and intractable in certain seasons and under certain management; but they are rich in agricultural possibilities, and will, under a wise culture, some day be transformed into gardens. What these possibilities are, is often hinted at in the insulated portions of these white clay flats, where organic matter has accumulated. We find in such spots soils of the highest excellence and durability. As the Ohio Valley is approached, the native soils formed from the decomposition of the Cincinnati shales and limestones are quite largely represented in the slopes of the hills. These slopes have all the excellence that belong to such an origin. They constitute some of the strongest and most durable tobacco lands of the State. This crop is limited, so far as successful culture is concerned, to limestone lands. Sometimes the proper soils are found in decomposed limestone gravels, but oftener in the weathered outcrops of rocks *in situ.*

As in the other counties of this range, the water supply is not wholly satisfactory, but the condition in this respect is somewhat better than in Clermont. In the flat lands the only safe and sufficient supply must be derived from cisterns.

The surface of the county, through its central and southern townships, is highly diversified. Several tributaries of the Ohio have cut deep valleys, and descend them with a comparatively rapid fall.

The most considerable topographical feature of the county is the valley of White Oak Creek. Straight Creek and Eagle Creek rank next in size and importance.

INDEX.

ILLUSTRATIONS OF VOLUME III, GEOLOGY.

LIST OF MAPS AND CHARTS.

LIST OF ILLUSTRATIONS PRINTED WITH THE TEXT.

ERRATA.

NOTE.—It was found impossible to submit proofs of the reports, in which the following typographical and other errors occur, to their respective authors for revision.

Page 292, seventeenth line from top, for "finely," read "firmly."
" 296, fifth line from bottom, for "top," read "tap."
" 297, fourth line from top, for "top," read "tap."
" 297, sixth line from top, for "swamps," read "stumps."
" 300, sixth line from bottom, for "roads," read "road."
" 300, ninth line from bottom, for "north," read "south."
" 305, seventh line from bottom, for "their," read "thin."
" 306, fifteenth line from top, for "brands," read "bands."
" 308, fourth line from top, between "feet" and "above," insert "commencing."
" 308, seventeenth line from bottom, for "distribution," read "distillation."
" 309, thirteenth line from top, for "contributes," read "constitutes."
" 314, second line from top, for "level," read "local."
" 315, fifteenth line from top, for "transposing," read "transporting."
" 318, eighth line from top, for "center," read "county."
" 318, sixteenth line from top, for "northeast," read "southeast."
" 319, sixth line from bottom, for "northward," read "southward."
" 321, ninteenth line from top, for "thirty," read "three hundred."
" 324, ninth line from top, for "northeast," read "southeast."
" 325, third line from bottom, for "northward," read "southward."
" 325, ninth line from bottom, for "space," read "spur."
" 326, eleventh line from top, for "north," read "south."
" 326, twelth line from top, for "northward," read southward."
" 328, tenth line from bottom, for "pigments," read "fragments."
" 328, eleventh line from bottom, for "irregular," "angular."
" 330, third line from top, for "northward," read "southward."
" 331, third line from bottom, for "elevation," read "relations."
" 333, third line from bottom, for "where," read "when."
" 337, bottom line, between "here" and "in," insert "as."
" 337, seventh line from bottom, for "covered," read "cause."
" 337, tenth line from bottom, for "covered," read "caused."
" 338, eleventh line from bottom, for "Folbs," read "Fobe's."
" 339, ninth line from top, for "limestone," read "sandstone."
" 339, seventh line from bottom for "hills," read "wells."
" 340, tenth line from top, for "Bedford," read "Cleveland."
" 340, eighteenth line from bottom, for "advance," read "absence."
" 344, thirteenth line from bottom, for "well has," read "wells have."
" 344, eleventh line from bottom, for "eighty," read "forty."
" 345, second line from top, for "well," read "wells."
" 345, eighth line from top, for "Genoa," read "Gann."

Page 345, ninteenth line from top, for "Genoa," read "Gann."
" 346, eighth line from top, for "eighty-eight," read "eight."
" 346, thirteenth line from top, for "Hard," read "Hurd."
" 346, twenty-second line from top, for "covered," read "caused."
" 349, ninteenth line from top, for "northern," read "northwestern."
" 351, eleventh line from top, for "north," read "south."
" 352, fifteenth line from top, for "foundation," read "formation."
" 484, seventeenth line from top, for "where," read "whose."
" 520, sixth line from top, for "working," read "resting."
" 521, sixth line from top for "north," read "south."
" 525, ninth line from bottom, for "third," read "thin."
" 528, fifth line from top, for "forming the," read "form of."
" 529, ninth line from top, for "northward," read "southward."
" 533, eighteenth line from top, for "subdivision," read "subsidence."
" 533, fourteenth line from bottom, for "combination," read "continuation."
" 534, sixteenth line from bottom, for "north," read "south."
" 537, second line from top, for "abrasion," read "absence."
" 537, second line from bottom, for "north," read "south."
" 548, twenty-first line from bottom, for "Shopter," read "Shipler."
" 548, nineteenth line from bottom, for "fine," read "fair."
" 549, second line from bottom, for "separated," read "represented."
" 551, third line from top, for "Mort's," read "Mott's."
" 551, tenth line from bottom, for "Dagger," read "Daggen."
" 553, sixth line from bottom, for "represented," read "separated."
" 554, twelfth line from top, for "remarkable," read "workable."
" 555, fifth line from top, for "recovering," read "securing."
" 555, fourteenth line from top, for "probably," read "possibly."
" 560, thirteenth line from top, for "buried," read "burned."
" 561, nineteenth line from top, for "disappearance," read "appearance.
" 567, sixteenth line from bottom, for "their," read "thin."
" 571, thirteenth line from top, for "thick vein," read "thickness."
" 571, sixteenth line from bottom, for "Imley," read "Insley."
" 667, twenty-third line from top, for "interspersed," read "interposed;" for "same stem," read "sandstone."
" 669, thirteenth line, for "7," read "3."
" 677, second table, transpose "22.90," and ".10," and for "iron phosphate," read "lime phosphate."
" 690, first line, for "firmly," read "finely."
" 690, sixth line from top, for "round," read "sand."
" 694, twenty-second line from top, for "north," read "south."
" 695, second line, for "west," read "east."
" 699, twenty-third line from top, for "north," read "south."
" 699, thirty-first line from top, for "northward," read "southward."
" 708, third line from bottom, for "nominal," read "normal."
" 710, twelfth line from bottom, for "north," read "south."
" 714, twenty-second line from bottom, for "villages," read "valleys."