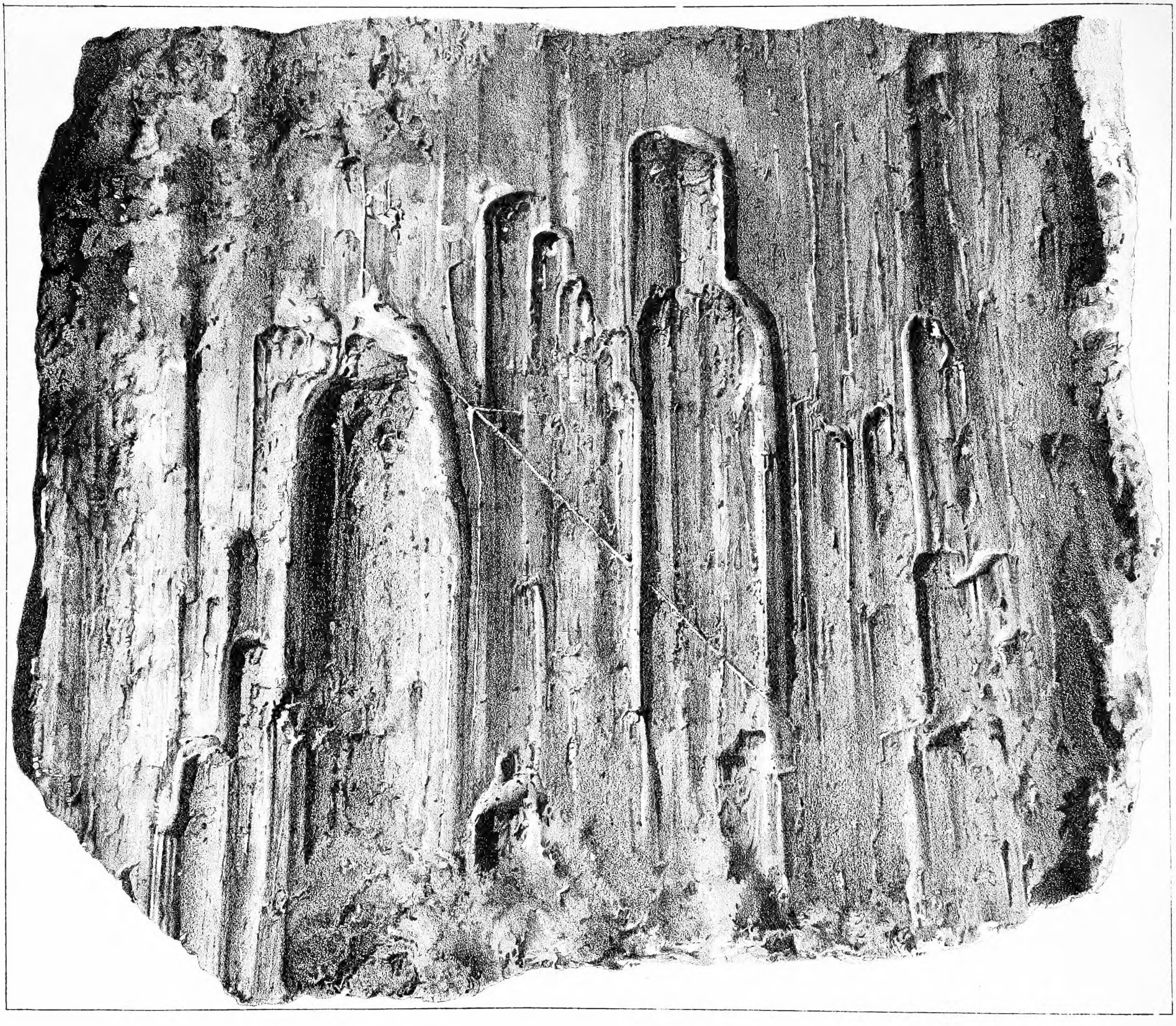
GEOLOGICAL SURVEY OF OHIO.

GLACIAL MARKINGS, WEST SISTER ISLAND, O.

(Half natural size.)



Grooves and trails leading south west from concretions of chert.

See page 76

Strobridge & Co Lith Cin. O

REPORT

OF THE

GEOLOGICAL SURVEY OF OHIO.

VOLUME II.

GEOLOGY AND PALÆONTOLOGY.

PART I. GEOLOGY.

OFFICERS OF THE SURVEY.

J. S. NEWBERRY, ...	CHIEF GEOLOGIST.
E. B. ANDREWS, ...	ASSISTANT GEOLOGIST.
EDWARD ORTON, ...	ASSISTANT GEOLOGIST.
T. G. WORMLEY, ...	CHEMIST.
F. B. MEEK, ...	PALÆONTOLOGIST.

PUBLISHED BY AUTHORITY OF THE LEGISLATURE OF OHIO.

COLUMBUS, OHIO:
NEVINS & MYERS, STATE PRINTERS.
1874.

MEMBERS OF THE GEOLOGICAL BOARD.

His Excellency WILLIAM ALLEN, ... Governor of Ohio.
Hon. ISAAC WELSH, ... Treasurer of State.
Hon. T. W. HARVEY, ... Commissioner Com. Schools.

MEMBERS OF THE GEOLOGICAL CORPS.

1872–1874.

J. S. NEWBERRY, ... Chief Geologist.
E. B. ANDREWS, ... Assistant Geologist.
EDWARD ORTON, ... Assistant Geologist.
T. G. WORMLEY, ... Chemist.
F. B. MEEK, ... Palæontologist.

LOCAL AND SPECIAL ASSISTANTS.

1872–1874.

J. Y. BERGEN, Jr.,
E. B. COPE,
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C. M. GALLOWAY,
JAMES HALL,
H. HERTZER,
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N. H. WINCHELL.

TABLE OF CONTENTS.

PART I.—GEOLOGY.

PREFACE.

The plan for the publication of the Final Report of the Geological Survey submitted by the Chief Geologist to the Geological Board, and adopted by them, provided for two volumes on Geology, two on Palæontology, one on Economic Geology, and one on Zoölogy, Botany, and Agriculture. It also contemplated the preparation of a general geological map of the State. In framing this plan, the requirements of the organic law of the Survey, as construed by the Geological committees in the Legislature, the Geological Board, and the Geological Corps, were carefully complied with.

Section 5 of the act authorizing the Geological Survey provides that "when the said survey shall be fully completed, the Chief Geologist shall make to the Governor a final report, including the results of the entire survey, accompanied by such drawings and topographical maps as may be necessary to illustrate the same, and by a simple geological map showing by colors and other appropriate means the stratification of the rocks, the character of the soil, the localities of the beds of mineral deposits, and the character and extent of the different geological formations." In obedience to this requirement, but before the completion of the field and office work of the Survey, the Chief Geologist submitted to the Governor sufficient material to form two of the volumes specified in his plan for the Final Report. The publication of this material was authorized by the Legislature as Volume I. of the Final Report of the Geological Survey, and twenty thousand copies of this volume were ordered to be printed. The quantity of material presented was, however, so large that it could not be conveniently included in a single cover; and it was, therefore, thought by the Geological Board best to publish the volume in two parts, one of which should be devoted to Geology, and the other to Palæontology. In the very generous provision made for the publication of this volume, it was specified that it should be published on paper of superior quality, and that, in all respects, the work should be done in the best possible style. No special provision was made, however, for securing the publication of the report in the style contemplated by the Legislature, and when the matter was placed in the hands of the printer it was found that no authority had been conveyed to the Geological Board, or any other officer of the State, to purchase and use any other paper than that supplied under the general contracts made by the Secretary of State. As a consequence, Part I. of the volume was printed on paper similar in quality to that used for other State documents; and the volume, in size and finish, was hardly in keeping with the magnitude and value of the work of which it constituted the record, and was less creditable to the Geological Corps and to the State than it would have been if the Legislature had conveyed full authority to carry its intentions into execution.

Before the publication of Part II. of this volume the Legislature convened, and immediately authorized the Secretary of State to purchase in open market larger and better paper. Part II., therefore, appeared in much more creditabte style than Part I. Although the want of uniformity in the size of these volumes and the inelegant appearance of Part I. are universally regretted, and are causes of special mortification to the members of the Geological Corps, some compensation may be found in the fact that the cost of the volume has been diminished just in the ratio of its defects of style in publication. It will be noticed that the numerous engravings which illustrate the volume are executed in a manner that leaves very little to desire, and that Part II. was printed on paper of a size and quality not inappropriate to the importance of a document which will not only have permanent value at home, but will be widely distributed, and be, to some extent, an exponent of the culture of our people; and yet the entire cost of twenty thousand copies—eighteen thousand in English and two thousand in German—of the two volumes comprising Parts I. and II. of Volume I., was $69,381.94, or $3.47 per copy. This is exclusive of the cost of the bound atlas of Prof. Andrews's maps, which cost $12,400. The very large edition published of each of the reports of the Geological Survey has been regarded by some persons as an extravagance, and one for which the Geological Corps is responsible. This is, however, an undeserved imputation. The selfish interests of the Geological Corps would have been much better consulted by the publication, in more elegant style, of a very much smaller number of these reports. They would then have been more highly prized, and would have reflected greater honor on their authors, since geological reports, like other things, are valued very much in the ratio of their rarity. They have been reconciled, however, to the possibility that their publications would be contemned because so common, by the consideration that, in issuing them in large but cheap editions, the Legislature had best carried out the wholesome democratic principle of "the greatest good to the greatest numbers." It is but just to all concerned, however, that the credit or discredit of these large editions should be given to the Legislature, and not to the Geological Corps. It should also be said that the propriety of publishing large editions of the geological reports has been attested by the eagerness with which they have been sought by our people, and the rapidity with which the entire editions have been exhausted. Already thousands of applications remain in the hands of the members of the Legislature, State officers, and the Geological Corps, which can not be supplied.

The history of the publication of Volume II. of our Final Report, now given to the public, is in many respects similar to that of the first. It was submitted to the Legislature at its last session, and was then ordered to be printed in an edition of twenty thousand copies. An appropriation of $60,000 was made to cover the cost of such publication, a sum which, owing to a considerable reduction in the cost of publication during the past year, and a very careful economy on the part of those who have had charge of the expenditure, has proved sufficient for the purpose. An effort was also made by the Legislature to secure the publication of this volume in a style fully equal to that of Part II. of Volume I. This was done by authorizing the Secretary of State to have paper of the requisite size and quality manufactured expressly for the geological report. It unfortunately happened, however, that the paper supplied on the contract proved inferior to the samples offered when the contract was awarded, and it was consequently rejected.

The alternative now presented itself of a delay of several months, or the use of inferior paper then in the hands of the Secretary of State. The latter was chosen, and consequently Part I. of Volume II. is printed in the same style as the corresponding part of Volume I., while larger and better paper was supplied for Part II., making this to correspond with Part II. of Volume I. The result of these accidents has been that we have two volumes on Geology in which the page is smaller and the paper lighter than was desirable, and yet the cost has thereby been considerably reduced. At the same time we have two volumes on Palæontology in which the page is larger—necessitated by the size of the plates—and the paper is of better quality. This want of uniformity in the entire series of volumes will be generally deplored, but it has been inevitable in the circumstances of their publication.

In framing the original plan for the Final Report of the Geological Survey, it was supposed that all the matter descriptive of the general and local geology of the State could be included in two volumes devoted to Geology; but when the detailed reports on all the eighty-eight counties we were specifically required to examine and describe were completed, it was found that abundant matter had been supplied for three volumes. A third volume on Geology has, therefore, been prepared, and now awaits the action of the Legislature. This volume includes reports on the following counties:

Of the First District—Ashland, Belmont (north half), Carroll, Columbiana, Coshocton, Guernsey (north half), Harrison, Holmes, Huron, Jefferson, Knox, Licking, Mahoning, Medina, Muskingum (north half), Portage, Richland, Stark, Tuscarawas, Wayne.

Of the Third District—Butler, Clinton, Darke, Fayette, Franklin, Miami, Preble, Warren.

Of the Fourth District—Champaign, Logan, Shelby.

It will be seen that the above list includes some of the richest and most populous agricultural and mining counties in the State, and it would be a great injustice to their inhabitants if, after paying their portion of the general expenses of the Survey and for the publication of reports on other portions of the State, they were denied their share of the benefits of the Survey. The matter for the third volume has been, to a considerable extent, prepared since the appropriations for the salaries of the Geological Corps were discontinued; much of it is, therefore, a gratuitous contribution, with which the Corps should be credited when a comparison is made between the value of their services and the compensation they have received. Some of the maps and other illustrations of this volume are already engraved, so that the cost of its publication will be something less than that of either of its predecessors; in other words, from seventy-five cents to one dollar a copy, according to the size of the edition published.

A large amount of new palæontological material has been gathered during the last year, which, with that crowded out of previous reports by the necessary limitation of space and expense, would, if fully described, go far toward forming a third volume on Palæontology; but no such volume has been had in contemplation, and it may very well remain as a subject for farther legislation, when the financial condition of the country shall better justify the expenditure of the money necessary for its publication.

As the value of the palæontological portion of our report is still underestimated in some quarters, it may not be out of place to repeat here what has been said on this subject in some of our former reports, viz., that the fossils found in our rocks are not mere objects for idle curiosity, but are of the highest practical importance, since they, in fact, constitute the only reliable guides in the study of our sedimentary rocks. The whole system of classification in modern geology is based upon them, and it is not too much to say that no man can be a good geologist who has not considerable familiarity with them. Figures and descriptions of the characteristic fossils of our formations will, therefore, prove of great utility to our students and teachers of geology; and it is, indeed, difficult to see how they can make much progress in the study of the geology of the districts in which they live without the assistance they afford. It is also true that the wealth and power of any community consist quite as much in the ideas in their heads as the dollars in their pockets; and it is even probable that the revelations which have been made through the Geological Survey, of the strange and varied extinct forms of life with which our rocks are crowded, will prove a source of as much pleasure and profit to our people as the facts that have been gathered in regard to the mineral resources of the State. In the geological surveys which have been organized by the most enlightened communities of our own and other countries, the fossils found have uniformly been the subjects of careful study and profuse illustration. This has not been the result of a vain craving for notoriety on the part of the palæontologists, but has been a response to a demand created by an interest in such subjects which pervades every cultivated population. That such an interest exists among our own people is shown by the avidity with which our palæontological reports have been sought, and by the value attached to them by those who possess them.

In the plan proposed for the Final Report of the Geological Survey, in addition to the reports on Geology and Palæontology, it was suggested that there should be one volume devoted to Economic Geology, and another to Zoölogy, Botany, and Agriculture. Of these volumes, the first was intended to include an exhaustive and accurate review of all our mineral staples—coal, iron, peat, clay, salt, oil, building material, etc.—both as regards their geology and technology. A large amount of labor has been expended in the preparation of this volume, and it may be said to be more than half done. But the investigations of which this report was to embody the results had not been finished when, in February, 1874, the appropriations for the field and office work of the Survey were exhausted. An attempt has been made in the preparation of this volume to determine the quality, uses, and best methods of manufacture of our mineral staples, not only by means of the ordinary chemical analyses, but by carefully gathering the results of all the trials to which they have been subjected in real life, and by original experiments made with an amount of material and under such conditions as would afford a practical and "working" test of each. For the completion of this volume six months' time and an expenditure of $4,000 to $5,000 would be necessary.

The volume on Zoölogy and Botany has been nearly completed, and at a very small expense to the State. The Botanical report was prepared by Dr. C. H. Beardsley, of Painesville, who has given a large part of two seasons to it, with no other compensation than his expenses.

Dr. J. M. Wheaton, of Columbus, has charged himself with the preparation of the report on Birds. This is nearly or quite ready for publication, and is very full and accurate. In the execution of his work Dr. Wheaton has received no other compensation than the payment of his expenses in visiting the museums at Washington, Philadelphia, and other eastern cities, where he had an opportunity of comparing his material with all that collected in other portions of our country.

The reports on Mammals, Fishes, Mollusks, and Insects are not yet completed, but could be finished in a few months, with an expenditure of not more than $500.

For the preparation of the Geological Map specified in the act authorizing the Geological Survey, an expenditure of perhaps $1,500 would be necessary. This would be consumed in making a review, in the field, of the ground gone over by the various assistants on the Survey, in order to secure accuracy and consistency in the general results, and also to put the facts gathered from all sources on paper in a creditable style.

From the foregoing statements it will be seen that—

1st. The field work of the Geological Survey is all done.

2d. Reports have been prepared on the physical geography and general geological structure of the State; also upon each of the eighty-eight counties into which the State is divided, and upon the principal fossil forms found in our rocks.

3d. Of these reports—in addition to three reports of progress (1869, 1870, and 1871)—two volumes on Geology, two on Palæontology, and two portfolios of maps and charts have been already published.

4th. Of the complete series of the reports of the Survey, three volumes yet remain to be published, viz., one on Geology (already completed), one on Economic Geology, and another on Zoölogy, Botany, etc.—the two latter requiring some months of time and an appropriation of $5,000 before they can be finished. As these three unpublished volumes are without expensive illustrations, they can be issued in the same style with the volumes on Geology, at a cost not exceeding one dollar per copy.

5th. A general Geological Map of the State, five by six feet in dimensions, can be prepared at a cost not greater than $1,500.

A few additional facts in regard to the Geological Survey may be of general interest. The survey began June 1, 1869, and it may be said to have continued to June 1, 1874, although the salaries of the officers were paid only to February 15 of that year. The total amount expended by the State on the Geological Survey has been $256,017.66, of which sum $86,764.17 were expended on the survey proper, and $169,253.49 on publication.

The publications of the Survey, including the volume now issued, consist of 116,000 volumes 8vo, in part re-published in German, containing numerous engraved plates, maps and sections, and three portfolios of charts.

Although the aggregate cost of the Survey may seem to be large, it should be remembered that all the expenditure except that for field and office work ($86,764.17) was returned to the people of Ohio in books which cost far less than similar volumes would be published for by private parties. As regards the practical benefits of the

Survey, it would probably not be difficult to prove that the increase in the value of property in a single township consequent upon the development of its coal mines—a development prompted and directed by the Geological Survey—has exceeded ten-fold its entire cost. Yet the benefits which will follow an accurate knowledge of the geological structure and mineral resources of the State have only just begun to be felt, and they will continue to operate for centuries.

As compared with similar surveys made in other States, it is believed that it will be difficult to point to any one which has been brought to a completion within as short a time, and with so small an expenditure of money, and yet in which as much and as good work has been done.

That the geology of the State is exhausted, that all desirable facts are gathered in reference to our useful minerals, that no errors have been committed—none of these things are claimed; but it is asserted that an honest and energetic use was made of the time and money expended on the Survey, and that its fruits will be worth much more than their cost to the people of Ohio. An *exhaustive* survey of the State, with its area of 39,964 square miles, its varied geology, its innumerable fossils, and its great and diversified mineral wealth, would require many years of time, and would cost perhaps a million of dollars. The present Survey was originally limited in time to three years, and though it was said by those who initiated it that it could not and should not be finished in less than ten years, and it was continued by special enactments more than a year and a half beyond the term first prescribed, the financial condition of the country at the close of 1873 prompted the Legislature to instruct the Geological Corps to bring the work to an end.

In these circumstances it has been impossible for the Geological Corps to accomplish all they had hoped to do in the commencement of the Survey; and if it should be found that the reports of the Survey do not supply all the information desired on the subjects of which they treat, it should be remembered that the work has been under such restrictions of time and money that greater perfection was not attainable. In view of all the embarrassments and uncertainties under which the Survey has been carried on, it may be a matter of congratulation to all who have been interested in its progress that it has attained the degree of symmetry and completeness it now presents, and that in the scale of expenditure and measure of detail adopted it has been brought so nearly to a successful close.

GEOLOGY OF OHIO.

CHAPTER XXX.

SURFACE GEOLOGY.

In Ohio we have no geological formations intervening between the Carboniferous and the Quaternary, and have, therefore, no representatives of the Permian, Triassic, Cretaceous, or Tertiary systems. The reason of this is simply, that about the close of the Carboniferous age the Alleghany Mountains were raised, carrying up all the area lying between the Mississippi and the Atlantic. From that time to the Quaternary no part of this region, with the exception of the southern margin, was ever submerged, and, therefore, no deposits were made on it during the ages I have enumerated. West of the Mississippi the land has been often and long below the ocean level since the epoch of the Coal Measures, and there all the newer formations are well represented. The materials which accumulated during the Quaternary are beds of clay, sand, gravel, and bowlders, which have received the name of *Drift*, because they are generally foreign to the localities where they are found, and have been transported (drifted) sometimes hundreds of miles from their places of origin.

The Drift phenomena of Ohio constitute a marked feature in its geology; one, indeed, more apparent and conspicuous to the superficial observer than any other, inasmuch as the Drift deposits cover nearly all parts of the State, and frequently conceal the underlying rocks so as to completely mask the fundamental geological structure. Perhaps no other State has so complete a series of these deposits, or a more legible record of the remarkable sequence of events which gave character to this chapter in geological history. The Quaternary system deserves, therefore, and will receive in this report, as full and thorough an exposition as our limitation of space will permit. Like most of the formations enumerated in the preceding chapters, the Quaternary has already been briefly discussed; but while the other groups are so simple that a few words may suffice to convey a clear idea of them, or at least of the new things we have learned about them, the Drift phenomena are too complicated, too little understood, and too interesting to be so summarily dismissed. It is true, also, that the causes that produced such marked effects in Ohio during the Quaternary age, covered in their action a much wider field than any one state or county; and for a proper understanding of the facts observed here, it is necessary that the record made elsewhere should be consulted. Although the last formed of all the geological series, and for this reason presenting the fullest and freshest record, the deposits of the Quaternary age have been the most difficult of all to decipher. The significance of facts observed in one locality becomes apparent only by comparing them with those seen in other and distant places; and it is by this process alone that any intelligent idea has been gained of the remarkable sequence of events which took place in the Quaternary age. I have, therefore, thought it best to include in this sketch of the Drift of Ohio brief notices of the observations made on similar phenomena outside of our State limits, and such as constitute the basis of the theories which have been proposed for the solution of the problems of the Quaternary. We shall thus be able to estimate more justly the import of our observations, and shall see how far they confirm or controvert the views that have been heretofore advanced. The most important facts which the study of the Drift has brought to light are, briefly, as follows:

1st. Over the northern half of North Amercia, and down as low as the fortieth parallel of latitude, we find, not every where, but in most localities where the nature of the underlying rocks is such as to retain inscriptions made upon them, the upper surface of these rocks ground or planed off, or furrowed and striated in a peculiar and striking manner, evidently by the action of one great denuding agent. It is now agreed by all geologists that this agent was *ice*. There has been some difference of opinion as to whether this ice rested upon land, or floated upon water; in other words, whether it formed glaciers or icebergs; but no one who has seen glaciers, and has observed the effect they produce on the rocks over which they move, and who examines good exposures of the markings to which I have reference, will fail to pronounce them the products of glacial action. The track of a glacier is as unmistakable as that of a man or a bear, and is as significant and trustworthy as any other legible inscription.

Though having a general north and south direction, locally the glacial scratches have very different bearings, conforming in a rude way to the present topography, and following the directions of the great lines of drainage. In Canada, and in our Eastern and Middle States, these ice-marks are universal. In the Mississippi valley, on certain uplands, like those of the Wisconsin lead-region, no glacial furrows have been discovered; but on most of the highlands, and in all the lowlands, lake-basins, and great valleys, they are distinctly discernible down to the limits specified, if the underlying rock has been such as to retain them.

2d. Some of the valleys and channels which bear the marks of glacial action—evidently formed by ice, and dating from the ice period, or an earlier epoch—are excavated far below the present lakes and water-courses which occupy them. These valleys seem to form connected lines of drainage at a lower level than the present river systems, and in part lower than the present sea level; such, indeed, as could not now be produced without a continental elevation of several hundred feet. The evidence on which this assertion is based will be cited farther on.

3d. Upon the glaciated surface we find a series of unconsolidated materials, generally stratified, called *Drift deposits.* Of these, the first and lowest, though not always present, is a tough, blue, unstratified clay, generally thickly set with small stones; more rarely containing those of larger size, ground and scratched. From this character it is called the *bowlder clay.* In the Eastern States, and near outcrops of crystalline rocks, sheets or heaps of gravel and bowlders are frequently found resting upon the glaciated surface.

4th. In certain localities the pebbly "hard-pan," or bowlder clay, is overlaid by a greater or less thickness of fine, laminated clay, without pebbles. This laminated clay corresponds closely with the "Saugeen clay" of Sir William Logan, but it shades into the bowlder clay below in such a way that it is impossible to draw any distinctly marked line between them. Both the laminated and pebbly clays are, therefore, regarded as parts of one formation, and the name *Erie clay* is retained for that, since it was coined by Sir William Logan to designate its exact equivalent on the north shore of Lake Erie.

5th. On the surface of the clays I have mentioned there is found, over a large area in Ohio and other Western States, a layer of carbonaceous matter, with logs and stumps, and sometimes upright trees. This carbonaceous layer I have termed the *Forest Bed*, since it is apparently an ancient soil which sustained a growth of vegetation that covered a large part of the area previously occupied by the ice-sheet. In some parts of southern Ohio this horizon is marked by deposits of peat now deeply buried under the later-formed deposits of the Drift. The remains of the elephant, mastodon, and giant beaver are found in and above the Forest Bed, but nowhere yet below it.

6th. Above the old soil which has been described we find a series of stratified deposits, sometimes of considerable thickness, evidently the product of a submergence by which a large land area was deeply buried beneath a mass of transported material. In southern Ohio these later Drift deposits consist of white, laminated brick-clay, yellow and blue clays, the latter containing bowlders, and sometimes heavy beds of gravel and sand. In the northern counties of Ohio the upper strata of the Drift, and the equivalents of those last mentioned, are laminated, usually somewhat sandy clays, and locally beds of sand and gravel, which, from the fact that they have been washed down from the watershed, and have been transported by the draining streams, have been sometimes referred to as the *Delta sand deposit.* In western Ohio, Indiana, Illinois, etc., the uppermost stratum of the Drift is called the Loess or Bluff formation. All the deposits enumerated in this note are the products of the last submergence, and I have termed them the *Lacustrine Drift.* They will be described in detail in another place.

7th. Upon the clays, sands, gravels, etc., last mentioned are scattered bowlders and blocks of all sizes of granite, greenstone, silicious and mica slates, etc., etc., generally traceable to some locality in the Eozoic area north of the lakes. Among these have been found many masses of native copper, which were plainly derived from the copper district of Lake Superior. These bowlders are found on nearly all the drift-covered area of the State; being scattered over the summit of the watershed, and reaching south nearly or quite to the Ohio. The margin of the bowlder area seems to mark the outline of the great ice-sheet at the period of its greatest development, but most of the bowlders strewed over this area appear to have been deposited by another agency, at a much later date. The greater part of them lie on or near the surface, and in many instances they rest on beds of purely laminated clay, and hence could never have reached their present positions through the agency of glaciers or powerful currents of water. They must, therefore, have been *floated* to their present resting places. The evidence is conclusive that they were transported by icebergs, and hence I have called them the *Iceberg Drift.*

8th. The highlands of Ohio, as well as in Michigan, New York, Wisconsin, etc., are locally occupied by hills, ridges, and banks of well rounded gravel and sand, with some bowlders which correspond closely with the "Kames" and "Eskers" of the Old-World Drift. These peculiar accumulations of drifted material were evidently produced by special and local causes, and do not hold a definite place in the sequence of Drift phenomena, but much interest attaches to them, and they will be described somewhat in detail in another part of this chapter.

9th. Above all the drift deposits of the lake basin, and more recent than any of them, are the "Lake Ridges;" embankments of sand, gravel, and clay, which run imperfectly parallel with the present margin of Lake Erie. Of these the lowest is about 100 feet, the highest some 250 feet, above the present level of the lake. In New York, Canada, Indiana, and Michigan a similar series of ridges has been discovered on the slopes of the basin of the great lakes; and they have every where been accepted as evidence that the water of the lakes once reached the level of the highest ridge, and that the lower ones mark successive periods of rest in its descent.

In the southern half of the Mississippi valley the evidences of glacial action are entirely wanting, and there is nothing among the superficial deposits corresponding to the wide-spread Drift of the north. We there find, however, proofs of erosion on a stupendous scale—such as the valley of East Tennessee, which has been formed by the washing out of all the broken strata between the ridges of the Alleghanies and the massive tables of the Cumberland Mountains, the canons of the Tennessee, 1600 feet deep, etc. Here, also, as in the lake-basin, the channels of excavation pass below the deep and quiet waters of the lower rivers, proving by their depth that they must have been cut when the fall of these rivers was much greater than now.

The history which I deduce from the facts cited above is briefly this:

1st. At a period probably synchronous with the glacial epoch of Europe—at least corresponding to it in sequence of events—the northern half of the continent of North America had an arctic climate; so cold, indeed, that wherever there was a copious precipitation of moisture from oceanic evaporation, that moisture fell as snow; and this, when consolidated, formed glaciers which flowed by various routes toward the sea. These glaciers, in the approach and retirement of the period of greatest cold, were local. During the prevalence of the extremest arctic conditions they were general, so far as this, that a great ice-sheet moving from the north north-west covered all New England, and other great glaciers occupied the region east of the Mississippi and north of the Ohio.

2d. The courses of these ancient local glaciers correspond in a general way with the present channels of drainage, and we owe to them some of the most striking features of the topography of the Western States, where the geological structure is simple, and the topography was once exceedingly monotonous. By local glaciers, flowing down from the Canadian highlands on to the plain which bordered them toward the south and west, all the basins of our great lakes were excavated; the ice in each case moving in the line of the major axis of the lake, from the north and east toward the south and west.

3d. At the commencement of this ice period this continent must have stood several hundred feet higher than now. This is proved by the great system of buried river channels, and by the deeply excavated troughs of the Hudson, Mississippi, Columbia, the Golden Gate, etc., etc., which could never have been cut by the streams that now occupy them, unless when flowing with greater rapidity and at a lower level than they now do.

4th. The ice period—the period of the greatest cold and of the most extensive glaciers, also a period of continental elevation and of active erosion—was followed by a water period, a period of ameliorating climate, of retreating glaciers, of subsidence, and of deposition. In the culminating epoch of this period the climate was much warmer than before, the continent was depressed 500 feet or more below its present level, the glaciers had retreated northward, and were replaced in the basin of the great lakes by an inland sea of fresh water. The first deposit of this period was that of the *bowlder clay.* This represents the fine material excavated and ground up by the glacier. It is most abundant where glaciers move over soft sedimentary rock, such as shale and limestone, and as such rocks filled most of the great excavated basin north of Ohio, the bowlder clay is naturally the most conspicuous of our Drift deposits. In New England and other countries where granite and other hard and silicious metamorphic rocks abound, the product of glacial erosion is sand, gravel, and bowlders. As the great ice-sheet retreated northward it thrust out and left behind it a succession of heaps of bowlder clay, which now form a nearly continuous sheet over the glaciated surface.

5th. When the retreating ice-sheet had passed the great watershed of Ohio, basins of water began to form along its margin, and in these the finer portion of the flour ground by it, for a time suspended, was ultimately deposited as the laminated clays, which succeed the bowlder clay, and form the upper subdivision of the Erie clay. This, in Ohio, is usually stratified in thin leaves, or lamellæ, and contains no bowlders.

6th. After the retreat of the ice-sheet from Ohio, Indiana, and Illinois, a considerable portion of the surface it had occupied and had left covered with debris was overgrown with a forest, composed largely of coniferous trees. This forest growth continued long enough to form a carbonaceous soil, and in many places beds of peat many feet in thickness. In this peat the remains of the mammoth, mastodon, and the giant beaver have been found, and we thus learn that they inhabited the forests which slowly followed and occupied the place of the retreating glacier to the rim of the lake basin, beyond which extensive bodies of water and ice prevented their advance northward.

7th. When the forest growth had spread over most of the Drift area south of the lakes, and had occupied it for hundreds and perhaps thousands of years, a submergence of the continent took place, which brought the waters of the Gulf of Mexico up the valley of the Mississippi until this formed an arm of the sea, which reached and covered all the lower half of our State. In this submergence the clays, sand, and gravel overlying the peat beds in southern Ohio, the lacustrine clays of northern Ohio, and finally the Loess of the Mississippi valley were deposited. These filled and obliterated many of the valleys of the Forest Bed era, as the Erie clay had done those of the pre-glacial date.

8th. During the submergence that covered the Forest Bed with clay, sand, and gravel, icebergs floated from the Canadian highlands, bringing with them gravel, bowlders, and blocks of granite, greenstone, mica slate, silicious slate, etc., and scattered them broadcast over all the submerged area. Some of these icebergs seem to have stranded at various points on the northern slope of the watershed, especially near its summit, and, melting there, to have left large accumulations of bowlders and gravel.

9th. In this last submergence, portions of the highlands of Ohio were low islands and shallows, exposed to the full action of shore waves, by which the drift accumulations were assorted, the clay washed out, the gravel and bowlders well rounded, and many of the gravel hills and sand banks (kames) of the summit of the watershed were produced.

10th. With the subsidence of the waters of the last submergence of the Drift period, certain great waste-wéirs, or lines of drainage, were established in the gaps in the watershed, which ultimately separated the river systems of the St. Lawrence and the Ohio. Through these waste-weirs strong currents of water poured, which transported and deposited vast quantities of gravel and bowlders in certain lines or belts leading to the Ohio valley. These great drainage lines were through the valleys of the Wabash, Miami, Scioto, Muskingum, and the Beaver.

11th. The retirement of the sea at the close of the Drift period took place very gradually, with intervals of rest and recession. In these intervals the terraces of our river valleys were formed, by the arrest of their flow and the deposition of the materials they transported in the dead water which partially filled these valleys. Hence this is denominated the *Terrace epoch*, the last chapter in the Drift history.

12th. The Ohio valley was nearly emptied, while the lake-basin was yet filled with water. This water drained off gradually through various outlets opened by the removal of the great ice-dam formed by the retreating glaciers, by the cutting away of barriers, or the warping of the earth's crust. The older outlets in Ohio have been enumerated. There are others which lead from Lake Michigan to the Mississippi. The descent of the water level in the lake-basins took place very slowly, and it remained for long intervals stationary at various points. These are distinctly marked by old shore lines which traverse the slopes that surround all the lakes. Along these shore lines we now find terraces where the shore was abrupt and hard; lake-ridges, where it was sloping, and composed of soft material.

In the Old World distinct traces are found of a return of arctic conditions after the first great glaciers had melted away, and a milder climate had supervened. In this country we have not yet detected any certain proof of the return of the glaciers to the area which they had before occupied and abandoned, although in southern Ohio the sheet of pebbly clay which overlies the Forest Bed seems to indicate a return in that region of something like the condition in which the first bowlder clay was deposited. Before this point in our Drift history can be considered as settled, many additional and careful observations will need to be made.

The preceding synopsis of the phenomena and history of the Drift has been made as brief and concise as possible, in order that the whole subject might be considered at one view, and thus the relations of its parts be made more apparent than would be otherwise possible. A fuller presentation of the facts, and of the deductions drawn from them, will be found grouped under different heads on the succeeding pages.

GLACIATED AREA IN OHIO.

The area over which glacial scratches and grooves occur is, for several reasons, not so well defined as that of the distribution of the Drift. In many of the rock exposures more or less decomposition and atmospheric erosion have taken place, and the traces of glaciers have been removed, where they once undoubtedly existed; and also over much the largest part of the territory once occupied by an ice-sheet, the Drift deposits cover and conceal the surface of the rock. The number of localities where glacial scratches are visible is, however, so great that we can trace with a good degree of certainty the reach of the ancient glaciers by the inscriptions which they have themselves made. From these we learn that the space covered with ice-marks coincides in a general way with that covered by the Drift deposits. The coincidence is not, however, entire, as will be shown hereafter, for other agents have been in action since the melting away of the glaciers, to distribute still further the materials which they ground up and transported. It may be said in a general way, that the glacial scratches are found over all but the south-eastern third of the State of Ohio; the limiting line running along the north side of Columbiana county, thence through the center of Stark, crossing the corner of Wayne, and passing diagonally through Holmes, Knox, Licking, Fairfield, Pickaway, and Ross; thence westerly through the northern part of Highland, Clermont, and Hamilton, into Indiana. North and west of this line glacial marks may be detected in nearly every county. A great number of observations have been made upon the bearing of the glacial striæ by Col. Whittlesey, the members of the Geological Corps, and others. From these it appears that they constitute two systems, one of which belongs to the highlands of the water-shed and the glaciated area south of this, of which the prevailing direction is S. 20° to 30° E., or, more accurately, from N. to S. 45° E. In some exceptional cases there is locally a marked deviation from the normal bearing of this system, as will be seen by reference to the map of the north-eastern counties, prepared by M. C. Read, and given below. We may, however, refer all these deviations to the influence of local topography, and the general bearing of the ice-marks is such as to show a connected ice-sheet, of which the motion was from N. 20° to 30° W., to S. 20° to 30° E. That this movement of the ice was from the north southward, is demonstrated by the transportation of northern rocks into and through our State, and of blocks and fragments of indigenous rocks southward of their points of outcrop.

The second system of grooves is confined to the lake-basin and the north-western counties of the State. The direction of these grooves—which are remarkably deep and continuous—will be seen from the subjoined table:

DIRECTION OF GROOVES.

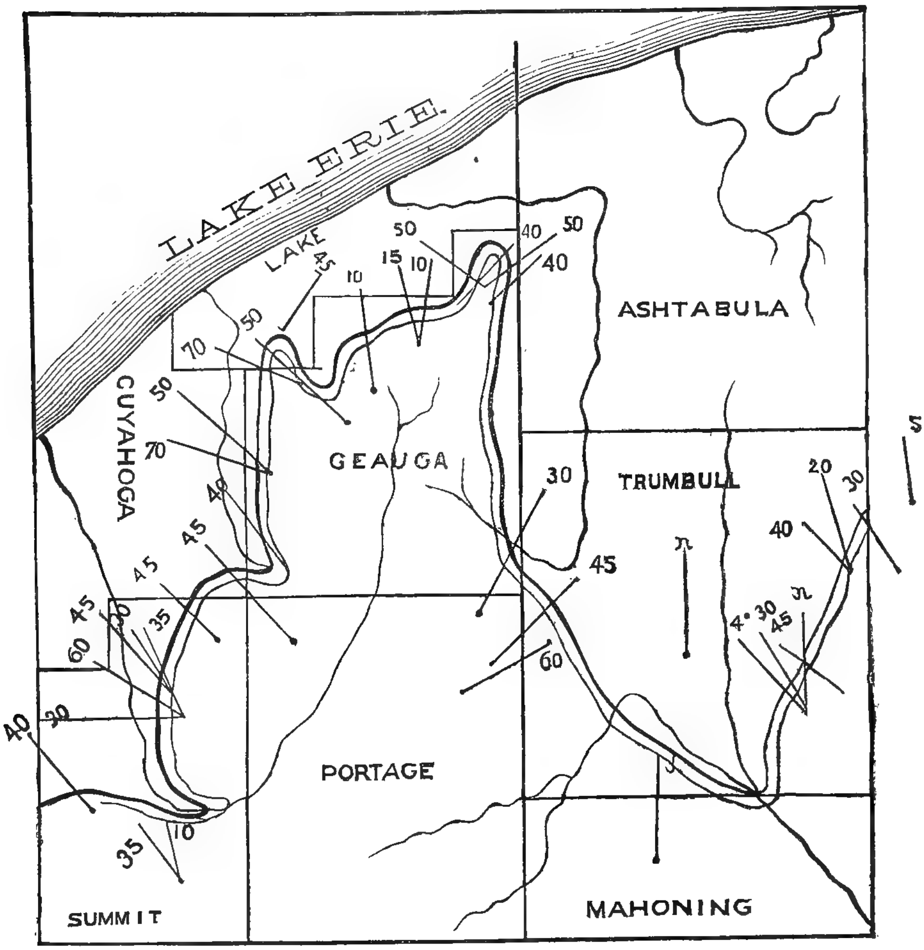
Locality.	Rock.	Number Observations.	Bearing.
Put-in-Bay Island .....(Newberry) ...	Waterlime	20	S. 80° W.
" " intersecting series	"	1	S. 15° W.
Kelley's Island ....(Newberry)...	Corniferous limestone...	12	S. 80° W.
" " " ...	" " ...	1	S. 60° W.
Sandusky City " ...	" " ...	4	S. 78° W.
" " " ...	" " ...	2	S. 80° W.
" " " ...	" " ...	1	S. 81° W.
" " " ...	" " ...	1	S. 75° W.
Bellville, Sandusky county " ...	Waterlime	1	S. 65° W.
Genoa, Ottawa county (Gilbert) ...	" and Niagara..	2	S. 65° W.

DIRECTION OF GROOVES—Continued.

LOCALITY.	ROCK.	NUMBER OBSERVATIONS.	BEARING.
West Sister Island ...... (Gilbert)...	Waterlime	Many.	S. 80° W.
" " intersecting series	"	1	S.
Sylvania, Lucas county (Gilbert)...	Corniferous limestone...	5	S. 50° W.
Monclova, Lucas county " ...	Waterline	4	S. 62° W.
Whitehouse " ...	Corniferous limestone...	1	S. 50° W.
Defiance, Defiance county " ...	Huron shale	1	S. W.
Junction, Paulding county " ...	Corniferous limestone...	3	S. W.
Lima, Allen county " ...	Waterlime	3	S. 35° W.
Middlepoint, Van Wert co. " ...	"	2	S. 15° W.
Findlay, Hancock county (Winchell)	Niagara	1	S. 45° W.
" " " " ...	"	2	S. 40° W.
Blanchard, Putnam county " ...	Waterlime	1	S. 28° W.
Sugar Creek, Putnam county " ...	"	1	S. 50° W.
Auglaize, Putnam county " ...	Corniferous limestone...	1	S. 48° W.
Seneca, Seneca county " ...	Waterlime	1	S. 5° E.
" " intersecting and later series...........(Winchell)	"	1	S. 23° W.
Amanda, Hancock county " ...	Niagara limestone........	1	S. 32° W.
Crawford, Wyandot county " ...	Waterlime	1	S. 20° W.
Crane, Wyandot county " ...	"	1	S. 5° W.
Amanda, Allen county " ...	"	1	S. 35° W.
Marseilles, Wyandot county " ...	Niagara limestone........	1	S. 10° W.
" " " ...	" "	1	S. 10° E.
" " " ...	" "	1	N. S.
Grand Prairie, Marion co. " ...	Corniferous limestone...	1	N. S.
Portage, Wood county " ...	Waterlime	3	S. 50° W.
Otsego, Wood county " ...	Corniferous limestone...	2	S. 68° W.
" " " ...	" " ...	...	S. 60° W.

From these records it will be seen that in the trough of the present Lake the prevailing direction of the glacial striæ is 10° south of west, and the movement, as demonstrated by the observations made on Kelley's Island and Put-in-Bay Island by myself, on West Sister Island and at Monclova by Mr. G. K. Gilbert, was from the east westward; and farther, that in the basin of the lake, but south-west of the Lake itself, the movement of the glacier was deflected southward until it became south-west. An interesting fact in this connection has been noticed by Mr. Gilbert, Mr. Winchell, and myself, that in this portion of the State a series of glacial marks, which have nearly a north and south bearing, are obliterated by the stronger, fresher, and more numerous grooves of which the bearing is nearly east and west. As I have shown elsewhere, the striæ which cover the highlands and southern portions of the State were probably made by the continental gracier which existed during the period of greatest cold, and which had in Ohio a movement from the north toward the south or south-east; while the glacier which moved from the east westward in the lake basin was a local glacier of later date, and the one by which the excavation of the lake basin was principally effected.

Map showing directions of glacial striæ along the margin of the highlands in Northeastern Ohio.



The broad ice-sheets which have existed outside of Ohio have left their records in the nearly uniform and continuous glaciated surface which covers so much of Canada, New England, New York, and the States of the north-west. In nearly all parts of New England are traces of an ancient ice-sheet which moved in a direction about south south-east, and was of such thickness and magnitude as to override all the features of the local topography, except Mt. Washington. Hence the action of this agent was directly antagonistic to that of local glaciers. That the New England ice-sheet was of great thickness is proved by the continuity of the furrows made by it, up hill and down dale; showing that these irregularities of surface, though considerable, were slight when compared with the thickness of the ice-mass above them. Mount Washington serves as a kind of Nilometer to the glacier, and proves its upper surface to have been 6,000 feet above the level of the sea; in other words, that the ice was 3,000 feet thick. Dana has estimated that at its place of origin, on the watershed between the St. Lawrence and Hudson's Bay, the thickness of the ice-sheet was 11,500 feet; but there is little doubt that the watershed was higher then than now, and hence the thickness of the ice may have been less than estimated.

BURIED CHANNELS.

Intimately connected with the glacial markings, and in part produced by the same cause, are the great number of deeply excavated, now buried, channels, which have already been briefly noticed. Some of these channels may have been, in part, formed long anterior to the ice period, as all 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. My attention was first called to these ancient water-courses by the facts brought to light in the borings for petroleum, so actively prosecuted in the valleys of our western rivers in 1860–61. In this enterprise I had both pecuniary and scientific interests, by which I was led to visit all the centers of oil production in the country, and in all I found some traces of deeply excavated, and now partially filled, valleys and ravines, of which I could, at first, give no explanation. When the observations made in different localities were combined, however, they revealed the existence of a connected system of drainage lying at a lower level than that now in action, and one that could only have been excavated in a long interval of time, and when the continent stood at a much higher level than now. Some of the facts to which I have referred, and the conclusions to which they led, were given by the writer in a paper on the *Surface Geology of the Basin of the Great Lakes*, published in the Proceedings of the Boston Natural History Society, May, 1862. In this paper these interesting phenomena were first brought to the notice of American geologists. Since that time a fuller exposition of the subject has been presented in the Annals of the Lyceum of Natural History, New York, June, 1869, and in the Report of Progress of the Geological Survey of Ohio for the same year. A summary of the facts cited in these papers, with others observed since, is given below.

Lake Michigan, Lake Huron, Lake Erie, and Lake Ontario occupy basins excavated by mechanical agencies in undisturbed and nearly horizontal sedimentary rocks. Of these, Lake Michigan is 900 feet deep, with a surface level of 578 feet above tide; Lake Huron is 800 feet deep, with a surface level of 574 feet; Lake Erie is 234 feet deep, with a surface level of 565 feet; Lake Ontario is 450 feet deep, with a surface level of 274 feet above the sea. An old, excavated, and now filled channel connects the basins of Lake Huron and Lake Erie. At Detroit the rock surface is 130 feet below the city. In the oil regions of Enniskillen and Bothwell, on the opposite side of Detroit river, from 50 to 200 feet of clay overlie the rock, where the land surface is but little above the level of Lake Huron. What the greatest depth of this channel is, is unknown.

A low, area over which no rock is found, apparently deeply underlaid by gravel and sand, stretches across from Lake Superior, east of the Grand Sable, to Lake Michigan. This probably marks the line of deep channel once connecting the basins of these two lakes. (Winchell.)

An excavated trough runs northward from Lake Michigan to the north line of Iroquois county, Illinois; thence south-west through Champaign county, beyond which point it has not been traced. Its western margin is sharply marked at Chatsworth, Livingston county, where it has a depth of 200 feet, and reaches to the Cincinnati group. Further north its bounding walls are composed of Niagara limestone, and terminate in buried cliffs on the Calumet and Kankakee rivers. At Bloomington this trough has a depth of 230 feet, and it there contains one or more strata of carbonaceous earth, supposed to represent ancient soils. Where penetrated in other localities, the depth of this channel is from 75 to 200 feet.—(F. H. Bradley.) In the excavations for the piers of the new bridge at St. Louis, rock was reached at a depth of 100 feet below the surface of the stream, on the margin of the old channel. Its central depth has not been detemined. The Ohio throughout its entire course runs in a valley which has been cut nowhere less than 150 feet below the present level of the river. At the junction of the Anderson with the Ohio, in Indiana, a well was sunk 94 feet below the level of the Ohio before rock was found.—(Hamilton Smith.) In the valley of Millcreek, in the suburbs of Cincinnati, gravel and sand were penetrated to the depth of 120 feet below the stream before reaching rock. On the margin of the Ohio, at Cincinnati, gravel and sand have been found to extend to a depth of over 100 feet below low-water mark, and the bottom of the trough has not been reached. The falls of the Ohio, formed by a rocky barrier across the stream, though at first sight seeming to disprove the theory of a deep continuous channel, really affords no argument against it; for here, as in many other instances, the present river does not follow accurately the line of the old channel, but runs along one side of it. At the Louisville falls, the Ohio flows over a rocky point which projects from the north side into the old valley, while the deep channel passes on the south side, under the lowlands on which the city of Louisville is built.

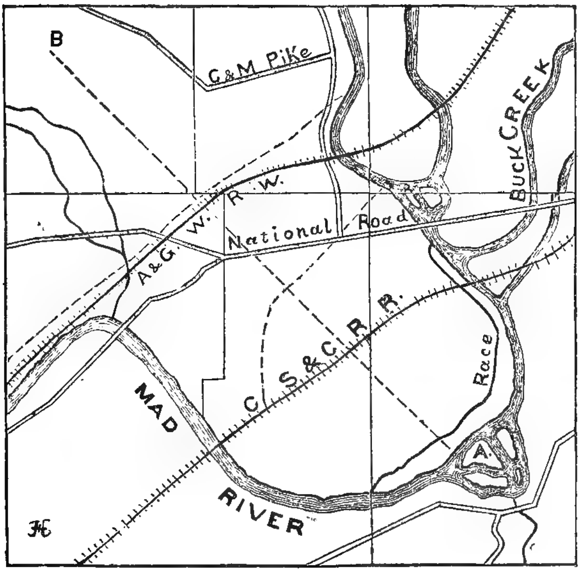
The tributaries of the Ohio exhibit the same phenomena. At New Philadelphia, Tuscarawas county, the borings for salt wells show that the Tuscarawas is running 175 feet above its ancient bed. The Beaver, at the junction of the Mahoning and Chenango, is flowing 150 feet above the bottom of its old trough, as is demonstrated by a large number of oil wells bored in the vicinity. Oil creek is shown by the same proofs to run from 75 to 100 feet above its old channel, and that channel had sometimes vertical and even overhanging walls.

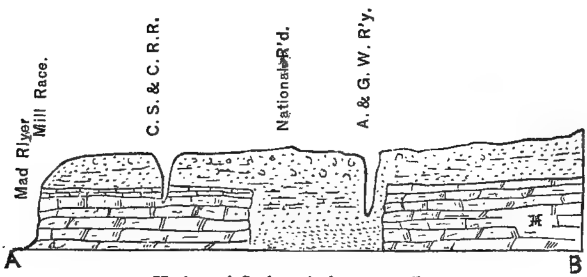
An old channel of Mad river, now completely filled up, has been brought to light by the railroad cutting at Springfield. It is described by Prof. Orton in his report on Clarke county, and I here reproduce his notes upon it, and the figure which illustrates them:

"An old valley of Mad river is disclosed in the heavy cut of the Atlantic and Great Western Railway, from the river bridge westward to Col. Peter Sinz's crossing. A sketch of the course of the river, and also of the railroads that cross it, is appended, by which the facts can be more readily understood. The tongue of land that occupies this bend of the river has an elevation of 100 feet to 125 feet above the level of the stream, and gives no hint in its contour of any break in the rocky floor underlying it. The Sandusky railroad (C. S. & C.), which was first in order of construction, cuts across this tongue, as will be observed in the figure. A considerable portion of this cut is wrought in solid cliff rock, the maximum depth of the stone cutting being 18 feet. With these facts before them, and guided also by the contour of the land, the Atlantic and Great Western Company, whose line crosses the river half a mile higher and on a grade of ten feet below the first road, expected also to find rock, and made arrangements for tunneling the hill. The route that they selected, however, chanced to be a buried channel of the river, which allowed an open cut of 65 feet through clay and sand, instead of a rock tunnel. Soundings that have since been made from the track to the level of the river show Drift materials through this whole extent. The dotted lines in the figure indicate the buried channel, whose general limits can be assigned with a good degree of accuracy from the cliffs that remain and the soundings that have been made.

"It will be observed that the old channel was much shorter and more direct than that which the river has since wrought out for itself, accomplishing in three-fourths of a mile the same advance that is now gained by two and one-half miles."

Buried Channel of Mad River, at Springfield.

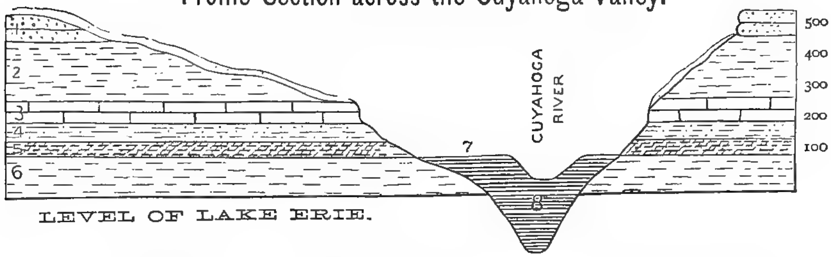




Horizontal Scale, 2 inches to 1 mile.
Vertical Scale, 1 inch to 200 feet.

The valleys of the rivers which run into Lake Erie have frequently been bored for oil, and these explorations have revealed the fact that some of these streams once flowed more than 200 feet below the level at which they now enter the lake. For example: borings at Toledo show that the old bed of the Maumee is at least 140 feet below its present surface level. In the valley of the Cuyahoga many borings have been made, nearly all of which show a great depth of clay, sand, and gravel above the rocky bottom of the valley. Of these, one, situated in the city of Cleveland, passed through clay and sand to the depth of 238 feet before reaching the rock. In this case the well head is about ten feet above the lake-level. We, therefore, have evidence that at this point the rocky bottom of the Cuyahoga lies 228 feet below the surface of the Lake. In another well, bored twenty miles above the mouth of the river, pipe was driven through clay and sand to the depth of 220 feet; the well beginning less than ten feet above the surface of the stream. In the valley of Grand river, at Painesville, Gen. J. S. Casement drove a pipe 70 feet below the level of the stream without reaching the rock. Rocky river, seven miles west of Cleveland, runs in a trough which has rock bottom and sides; it therefore shows an exception to the general rule which has

Profile Section across the Cuyahoga Valley.



1. Conglomerate.
2. Cuyahoga shale.
3. Berea grit.
4. Bedford shale.
5. Cleveland shale.
6. Erie shale.
7. Old Flood plain.
8. Erie clay in old valley.

been indicated; but a little west of the present mouth of Rocky river we find its ancient channel, now filled with clay, which extends to an unknown depth below the lake-level. Two miles above its mouth, Rocky river breaks into this old channel, and one of its banks is composed of clay, the other of rock. From this and similar instances we learn that the old channels of rivers were sometimes filled to the brim by subsequent submergence, and when, ages after, these lines of drainage were re-established, new channels were formed, which have since been cut, in some cases, to the depth of 100 feet in solid rock.

In parts of our country outside of Ohio, and in Europe, buried river channels, similar to those I have described, have frequently been met with. The filled-up channel of the Genessee at Portage, described by Prof. Hall in the Geology of the Fourth District of New York, presents a case resembling that of Rocky river, just cited. Onondaga lake lies in an old excavated channel mainly filled with gravel, sand, etc. This channel is cut through the Onondaga salt-group, and the Salina salt wells are bored in it. The deepest of these extends 414 feet below the surface level of the lake, *i. e.* 50 feet below the sea level, and it is not certain that rock was reached in this.—(Geddes Trans. N. Y. State Agricultural Society, 1859.) The long level of the Erie canal between Utica and Rome lies in the old, partially filled valley of the Mohawk, in which the rocky bottom is far below the surface—how far is not known, as it has never been reached. The trough of the Hudson is deeply silted up, as we know by the explorations made at Jersey City and in the East river. The channel of this stream, as has been shown by Dana, can be traced on the sea bottom eighty miles south and east of New York, where it once discharged itself at the true margin of the continent, 600 feet below the present level of its mouth. The peculiar character exhibited by the present outlets of the Delaware, the Potomac, and James rivers indicates that they also, like the Hudson, once entered the Atlantic much farther east than now, and that their old mouths are completely buried and obliterated.

The lower Mississippi bears unmistakable evidence of being—if one may be permitted the paradox—a half-drowned river; that is, its old channel is deeply submerged and silted up, so that the "father of waters," lifted above the walls that formerly restrained him, now wanders lawless and ungovernable whither he will in the broad valley.

The thickness of the delta deposits at New Orleans is variously reported from 1,500 feet upwards, the discrepancies being due to the difficulty of distinguishing the alluvial clays from those of the underlying cretaceous and tertiary formations. It is certain, however, that the bottom of the ancient channel of the Mississippi has never been reached between New Orleans and Cairo; the instances cited by Humphreys and Abbot in their splendid study of this river being but repetitions of the phenomena exhibited at the falls of the Ohio—the river running over *one side* of its ancient bed.

The trough of the Mississippi is not due to synclinal structure in the underlying rocks, but is a valley of erosion simply. Ever since the elevation of the Alleghanies—*i. e.*, the close of the Carboniferous period—it has been traversed by a river which drained the area from which flow the upper Mississippi, the Ohio, the Tennessee, etc. Since the Miocene period, the Missouri, Arkansas, and Red rivers have made their contributions to the flood that poured through it. The depth to which this channel is cut in the rock proves that at times the river must must have flowed at a lower level and with a more rapid current than now; while the Tertiary beds formed as high as Iowa and Indiana in this trough, and the more modern Drift clays and bowlders which partially fill the old rock cuttings, show that the mouth and delta of the river have, in the alternations of continental elevation, traveled up and down the trough at least a thousand miles; and that not only is it true, as asserted by Ellet, that every mile between Cairo and New Orleans once held the river's mouth, but that in the several advances and recessions of the waters of the Gulf the mouth has been more than twice at each point.

The change of place of the delta was caused, however, for the most part, by oscillation of the sea level, and not, as Ellet supposed, by the simple filling of the channel with the materials transported by the river itself without change of bed.

Prof. E. W. Hilgard, in his interesting report to Gen. A. A. Humphreys on the Mississippi delta, states that he found true northern Drift 354 feet below the surface in Calcasieu district, Louisiana; and he cites evidence that, during the early part of the Drift period, the country about the mouth of the Mississippi was at least 600 feet higher than now. During the subsequent period of submergence it was, as he states, much lower than at present. It will be noticed that these facts accord precisely with those observed in the upper Mississippi valley and lake-basin, where, in the period of excavation of the buried channels, the country must have been high, and the drainage free. Afterward a great submergence occurred, which has left its indubitable records in the stratified Drift overlying the Forest Bed and in the Loess. The locality where Prof. Hilgard found northern Drift in Louisiana was undoubtedly in, though not in the bottom of the old trough of the Mississippi, as I have noted elsewhere. I regard this as valley Drift, swept down the Mississippi from its northern watershed, when the continent was higher, and its current more rapid than now.

On the west coast of North America evidence of a subsidence of the continent is afforded by the deeply excavated and partially silted-up channels of the Golden Gate, the straits of Carquinez, the trough of the lower Columbia, the Canal de Haro, Hood's Canal, Puget Sound, and all the net-work of channels in that vicinity. As Dana first pointed out, years ago, the systems of inlets or fiords on both sides of our continent—channels which must have been excavated by subærial erosion—afford additional proof of modern continental subsidence.

The importance of a knowledge of these old channels in the improvement of the navigation of our larger rivers is obvious, and it is possible that it would have led to the adoption of other means than a rock canal for passing the Louisville falls, had it been possessed by those concerned in the enterprise.

I ventured to predict to General Warren that an old, filled-up channel would be found passing around the Mississippi rapids, and his examinations have confirmed the prophecy. I will venture still further, and predict the discovery of buried channels of communication between Lake Superior and Lake Michigan, probably somewhere near and east of the Grand Sable, at least between the Pictured Rocks and the St.

Mary's river—between Lake Erie and Lake Ontario*, through Canada—between Lake Ontario and the Hudson by the valley of the Mohawk—between Lake Michigan and the Mississippi, somewhere along the line I have indicated before.

The channel of the lower Tennessee must have been excavated when the southern portion of the Mississippi valley was higher above the Gulf level than now, and Prof. Hilgard has shown that at a subsequent period, probably during the Champlain epoch, the Gulf coast was depressed 500 feet below its present relative level. This depression must have made the lower Mississippi an arm of the sea, by which the flow of the Ohio and Tennessee was arrested, their channels filled up, terraces formed, etc. If the upper Tennessee has, as appears, a channel lower than the Muscle Shoals, it must be somewhere connected with the deep channel of the lower river.

It should be said, however, that it by no means follows that when an old earth-filled channel passes around the rocky barrier by which the navigation of our rivers is impeded, it will be most convenient and economical to follow it in making a canal to pass the obstacle; as the course of the old channel may be so long and circuitous that a short rock cutting is cheaper and better. The question is, however, of sufficient importance to deserve investigation before millions of dollars are expended in rock excavation.

If it is true that our great lakes can be connected with each other and with the ocean by ship-canals—in making which no elevated summits nor rock barriers need be cut through—the future commerce created by the great population and immense resources of the basin of the Great Lakes may require their construction.

THE DRIFT DEPOSITS OF OHIO.

The area over which the Drift is spread in Ohio corresponds in a general way with the area of glaciation, but through the influence of ice-

* When the water in the lake-basin had subsided to near its present level—the old avenues of escape being all silted up by the Drift clays and sands—the surplus made its exit by the line of lowest levels, wherever that chanced to run. That happened to lie over the rocky point that projected from the northern extremity of the Alleghanies into the lake-basin, and the line of drainage was established there, in what is now known as the Niagara river.

Though among the most recent of the events recorded in our surface geology, this choice of the Niagara outlet by the lake waters was made so long ago that all the erosion of the gorge below the falls has been accomplished since. The excavation of the basin into which the Niagara flows—the basin of Lake Ontario, of which Queenstown Heights form part of the margin—belongs to an epoch long anterior.

bergs, which in the last great submergence seem to have carried their freight, in some instances, beyond the points reached by the glaciers, and especially by the action of local currents of water which flowed down through certain great lines of drainage, the Drift materials have been borne far beyond the line I have indicated as bounding the erosive action of the ice-sheet. In the valleys of the Beaver, the Muskingum, the Hocking, Scioto, and Miami, we find vast accumulations of Drift, which are, however, confined, in the lower part of these valleys, to the immediate vicinity of the stream. Here they form terraces which rise sometimes a hundred feet above the present stream beds, and they undoubtedly filled the old deeply excavated channels through which these streams once flowed at a much lower level than now. In the valley of the Ohio itself, also, we find similar accumulations of Drift, composing the terraces so noticeable to one who passes up or down the river, and also filling the old rock channel to the depth of from 100 to 200 feet. The terrace on which the city of Cincinnati stands, and which has an altitude of 100 to 120 feet above low-water mark, will serve as a good example of the gravel terraces to which I have referred. In all the valleys enumerated above, the Drift material has evidently been washed down from the highlands of the interior of the State, where the Drift deposits are continuous and of considerable thickness. Hence it is more properly termed Modified Drift, or Valley Drift. By the action of the streams which transported it, the valley Drift was assorted and rearranged, and exhibits no record of the series of important changes of which the history is written in the sequence of Drift deposits where these remain undisturbed. Very naturally, the swift-flowing streams which have carried the Drift so far from their original place of deposition have washed out all the finest material, and have deposited this far beyond the limits of our State. We therefore find but little clay in the valley Drift. It is composed mainly of gravel and bowlders, with more or less sand, and the materials are all rounded, as they would necessarily be, from the attrition to which they have been subjected. They also exhibit an interesting gradation of fineness as we follow these streams down toward their mouths. In the valley of the Ohio, at Louisville, the Drift material found in and along the river bed is all fine, and bowlders of sufficient size to form cobblestone pavement are comparatively rare. Many of these are composed of granite, greenstone, quartzite, etc., which have been brought from beyond the lakes, and only the hardest and toughest of these metamorphic rocks have resisted the wear to which they have been subjected in their long journey. At Cincinnati the valley Drift is sensibly coarser than at Louisville, though still fine, as compared with that which is found further up the Ohio valley or in the beds of the tributary streams referred to above. On the hills of the Coal Measures lying east of the Muskingum (and Tuscarawas) and south of the glaciated and Drift area, no bowlders or Drift deposits of any kind are found, and no Drift is discoverable in any of the tributaries of the Ohio between the Pennsylvania line and Marietta. The highlands in the angle between the Muskingum and the Hocking are also free from Drift, and the same may be said of the hills of the area inclosed by the valleys of the Hocking, Muskingum, Scioto, and Ohio. West of the Scioto valley no Drift is found on the hills bordering the Ohio, nor on the knobs which have been denominated the Sun-Fish hills. The highest hills in Tuscarawas, Coshocton, Holmes, Richland, and Knox come into the same category.

All the highlands enumerated in the above list seem to have been beyond the reach both of the glaciers and the floods of the Drift period, and here we find the soil formed by the decomposition of the underlying rocks. Over all other portions of the surface of Ohio the Drift deposits were once spread in an unbroken sheet.

The succession of these deposits and their most prominent characteristics have been briefly noted in the earlier part of this chapter. They will now be described somewhat more in detail, in order that the features they present may be better understood, and that the history read from them may be intelligently judged.

ERIE CLAY.

Over most of the glacial area in Ohio we find resting directly on the planed and polished rock surfaces a sheet of variable thickness of blue or gray clay. As it generally appears, this clay is unstratified, and is thickly set with small pebbles or fragments of stone, and it also contains a few, usually small, bowlders. Hence it may, with propriety, be denominated a bowlder clay, and it closely corresponds in position and character with the clay bed called by that name which covers so much of the glaciated surface in other states and countries. Though generally exhibiting the features that I have assigned to it, the clay bed under consideration does not always present these characters, as it is sometimes rudely stratified throughout, and in many localities the upper portion is very finely and distinctly laminated and without pebbles. These phases of the deposit shade into each other, however, in such a way that it cannot well be separated into distinct formations or strata. I have, therefore, considered it as one formation, and have distinguished its divisions simply as the *bowlder* or lower and the *laminated* or upper member, and have called the whole the "Erie clay," accepting the name conferred by Sir William

Logan upon the same formation where conspicuously exposed on the north shore of Lake Erie.

The Erie clay immediately underlies the surface over a large part of the northern half of the State. This is especially true of the counties included in the Western Reserve, and has given them the clay soil which makes them the great dairy district of the West. In the north-western portion of the State the Erie clay is very thick, frequently 100 feet, and continuous, but it is more generally covered with lacustrine deposits than on the Reserve. In several of the north-western counties it has been pierced by numerous wells, sunk to obtain water, and its thickness and structure have been by this means very clearly revealed. It is here found to have a thickness of 100 to 150 feet, to contain irregular sheets of sand, gravel, and bowlders, which are water-bearing, and the source from which the artesian wells of this region are supplied with their flow of water. It should also be said, that in this part of the State the Erie clay contains more and larger bowlders than farther south. These are, for the most part, fragments of crystalline rock, which have come from the far north, with many others derived from the Silurian and Devonian limestone, which outcrop in the lake region, north of Ohio, but south and west of the Laurentian belt. Among the bowlders contained in the Erie clay in this section, rolled masses of coal are not unfrequently met with, and some of these, struck in boring, have given rise to much hope of finding coal in the vicinity. It is hardly necessary to say that such hopes will be fallacious, for this coal has undoubtedly come from the coal-field of Michigan. In the Maumee valley the upper portion of the Erie clay is often laminated, and its color is yellow where exposed to atmospheric action.

In the more easterly of the northern counties the Erie clay is generally thickly set with small fragments of shale, evidently derived from the Huron and Erie shales excavated to form the basin of Lake Erie. On weathered surfaces these fragments are exposed in great numbers, and the clay is rendered yellow or brown by the oxidation of its iron. In recent sections this change of colors is found to follow down all cracks in the clay as far as atmospheric water penetrates, and where such joints are numerous it is divided into irregular blocks, of which the central portion will be blue or gray, the exterior brown. The best development of the Erie clay in the northern part of the State is found in the old valley of the Cuyahoga, which it fills from the bottom to a point some 60 feet above the lake-level, giving a total thickness of 280 feet. It covers the highlands adjoining, however, rising to the height of 400 to 500 feet above the lake. It there has a thickness of from 10 to 30 feet.

At Cleveland that portion of the Erie clay which lies above the river is finely laminated and without pebbles or bowlders, but beneath the lake surface, as shown by the excavation for the new tunnel, the clay is thickly set with fragments of shale, and contains a few small bowlders. These are composed of granite, greenstone, or crystalline limestone, brought from the Canadian highlands, and are usually ground off and striated. At the mouth of the old valley of Rocky river the bowlder clay rises to the height of 50 feet above the lake, and the laminated clay of the Cuyahoga valley is wanting. Twenty miles above the mouth of the Cuyahoga the base of the Erie clay is distinctly shown. It is there a remarkably tough, compact, gray hard-pan, wholly unstratified, and containing many rounded and scratched bowlders. It rests upon a mass of fine-grained sandstone, in layers of a foot or more in thickness. These have been much broken up by the ice, and the under part of the clay is thickly set with angular or partially rounded fragments. Where undisturbed, the ledge of sandstone bears the characteristic glacial marks. Following the valley of the Cuyahoga from its mouth to the summit of the watershed at Akron, we find the following section of Drift deposits, which will show the relations of the Erie clay to the overlying members of the Drift series:

No. 1. Gravel, sand, and bowlders, more or less stratified, and forming hills resting on the Conglomerate, but from which the materials have been washed down, covering No. 2.

No. 2. Stratified sand and sandy clay; the latter in many remarkably even and well-defined alternations, yellow, blue, and red in color. Thickness, 30 to 100 feet.

No. 3. Finely laminated clay, without pebbles or bowlders; as a general rule, yellow where weathered, blue where its iron is protoxide. In two instances striated bowlders of Cuyahoga shale, which forms the rocky walls of the valley, were found imbedded in this laminated clay, evidently dropped into the position they occupy. The greatest observed thickness of this deposit is 90 feet.

No. 4. Pebbly Erie clay, penetrated by oil wells 228 feet to rock bottom of valley.

In the foregoing section, No. 1 represents a portion of the kames, or sand and gravel series of the highlands; No. 2, the lacustrine deposits of the upper Drift; No. 3, the laminated portion of the Erie clay; and No. 4, its pebbly aspect. The composition of the mass of Erie clay which fills the Cuyahoga valley will be seen from the section given below, taken at the well of the Standard Oil Company, in the city of Cleveland:

SECTION OF ERIE CLAY.

1.	Delta sand, clay, and gravel	25 ft.
2.	Laminated clay above lake level	75 ft.
3.	Blue clay below lake level	75 ft.
4.	Coarse sand	1 ft. 6 in.
5.	Blue clay	27 ft.
6.	Quicksand	10 in.
7.	Blue clay	29 ft. 2 in.
8.	Quicksand	1 ft. 6 in.
9.	Blue clay	2 ft. 6 in.
10.	Quicksand	1 ft. 6 in.
11.	Blue clay	30 ft.
12.	Fine gravel	5 ft.
13.	Blue clay	29 ft.
14.	Coarse gravel, with much gas	3 ft.
15.	Fine quicksand	1 ft.
16.	Blue clay	5 ft.
17.	Coarse gravel	2 ft. 6 in.
18.	Clay to shale rock	8 ft. 6 in.

On the lake-shore, a mile distant from this locality, a carbonaceous stratum, with many logs of coniferous trees, lies on the surface of the Erie clay, and separates this from the Delta sand deposit above.

An analysis made by Prof. Wormley of an air-dried specimen of the laminated portion of the Erie clay from this locality gave the following results:

Water	4.00
Silicic acid	59.70
Alumina	14.80
Iron, sesquioxide	4.60
Lime, carbonate	8.90
Magnesia	5.14
Fixed alkalies	3.40
	100.54

Along the summit of the watershed the Erie clay is less distinctly shown than in most other parts of the State. Many patches of it remain, however, and it would seem to have been once much more widely spread than now. From this region it has unquestionably been generally washed away by the drainage from the glacier when it filled the lake-basin and terminated at its southern rim; and subsequently, when this rim was a chain of islands, washed—and in some instances swept over—by the waves of our great inland sea, the clay was still further removed, and kames and sand banks left in its place. In the southern portion of the glaciated area, the Erie clay is pretty constantly present, but it is less conspicuous than farther north, because it is thinner, is more generally covered with later deposits, and has been cut away along the great channels of drainage, through which the waters of the lake-basin were drained into the Ohio. It is a somewhat singular circumstance that the bowlder clay is more continuous in the counties which lie along the margin of the Drift area, than nearer the divide where the Drift deposits are thicker; probably for the reason that shore waves and draining streams have been more general and powerful in their action, and have removed the clay in the region where it is less abundant. Throughout most of the southern counties of the State the bowlder clay may be found in many exposures, forming the basal portion and perhaps half the thickness of the upland drift. In the valleys it is less constantly present. In the reports of Prof. Orton, on Hamilton, Clermont, Highland, Montgomery, and other counties, more detailed descriptions of the Drift deposits of southern Ohio will be found than can be given here. A type section, however, from Clermont county, quoted from Prof. Orton's report, will serve to give a good general idea of the relations of the bowlder clay to the other members of the Drift series.

SECTION OF DRIFT, SOUTHERN OHIO.

No. 1.	Soil.	
No. 2.	Surface clays, generally white; sometimes blackened by swampy conditions, entirely free from gravel	1 to 8 feet.
No. 3.	Yellow clays, abounding with gravel, with occasional bowlders, often constituting the surface instead of No. 2; seldom over	10 feet.
No. 4.	Forest soil; a stratum of carbonaceous clay, containing vegetable matter, with occasional beds of peat; in some districts replaced by bog iron ore	1 to 8 feet.
No. 5.	Blue bowlder clay, or hard-pan, with occasional layers of sand intercalated, resting on the rocky floor	5 to 20 feet.

Prof. Orton thus describes the bowlder clay of this region: "The bowlder clay, or hard-pan, is found very generally, but not universally, in the northern and central regions of Clermont county. It is shown in many of the natural sections that are furnished by the streams, and in such artificial sections as are carried to sufficient depth. It is covered by varying thicknesses of the remaining members of the series. Where the total depth of the Drift beds reaches twenty feet, a full half of the section generally belongs to the bowlder clay. It cannot be confounded with any other formation in the district in which it occurs. It is composed of dark-blue, fine-grained, and tenacious clay, holding polished and striated pebbles and bowlders. Most of the pebbles are derived from the blue limestone formation, though frequent representatives of more distant rocks are found. Many fragments of blue limestone are scratched and polished on their sides, but their edges are still unworn. The bowlders belong almost without exception to the crystalline and igneous rocks that are found *in situ* only to the north of the great lakes. Specimens of northern ores—iron, copper, and lead—are sometimes, though rarely, met with. The occurrence of *gold* in the bowlder clay, and in the gravels derived from it, is a matter of considerable theoretical interest, and seems never to have attracted the attention which it well enough deserves."

Rolled fossils derived from the older rocks are not uncommon in the Erie clay—*Spirifer mucronatus* from the Hamilton being the most abundant. Except these, I have never discovered any organic remains in the formation, though shells and timber are reported to have been found in it. From the fact that it is a mass of glacial detritus, it seems almost impossible that any shells could be contained in it, and I suspect that all the cases of this kind reported are errors occasioned by confounding the Erie clay with the overlying beds of later date. The buried timber found at Cleveland lies distinctly above, and not in the Erie clay. The piece of wood obtained by Mr. M. C. Read, referred to in the report on Lake county, was a rolled fragment, and coniferous. It was thought by Mr. Read to be buried in the Erie clay, but it was found near the lake-shore, and may possibly have been deposited there by other agencies than those which spread this formation.

From the fact that the Erie clay, with its bowlder and laminated divisions, holds the same relation to the glaciated surface with the "bowlder" and "Leda" clays of eastern Canada, and the "Champlain" and "glacial" clays of the Atlantic coast, it has been regarded as their equivalent, in time as well as place. The proof of identity is, however, yet wanting. The bowlder and Leda clays of the St. Lawrence valley accumulated in a subsidence of the eastern coast, in which the waters of the Atlantic followed the retreating glaciers, covered and in part stratified the materials ground up by them; and they contain marine shells of an arctic character. These clays do not, however, reach far enough inland to connect with the Erie clays of the lake-basins, and it is quite possible that they were not exactly synchronous.

By Prof. Dawson the greater part of the markings which are usually attributed to glaciers are supposed to have been produced by icebergs, and it is his theory that, by a general subsidence of the continent, an arctic current, carrying icebergs, flowed up the St. Lawrence valley through the basins of the great lakes, accomplishing in great part the erosion which has been effected there, and passing downward to the

Gulf by the valley of the Mississippi. The difficulties in the way of this theory are such, however, that I am sure Prof. Dawson, clear-sighted and conscientious as he is, would abandon it if he could examine with his own eyes the surface geology of the lake-basin and the Mississippi valley. Without going into a lengthy argument to disprove this view, I will mention one or two facts which seem to me incompatible with it.

First. The basins of Lake Erie and Lake Ontario have unquestionably been excavated by glaciers, and not by icebergs. The evidence of this is conclusive. From my own observations on the erosive action of glaciers in the Alps and in the Rocky Mountains and the Sierra Nevada, I do not hesitate to assert that the inscription left on the bottom and sides of Lake Erie was made by a glacier, and nothing else. The uniform, continuous, and exact furrowing of horizontal and vertical surfaces which is visible among the islands of Lake Erie, is the precise counterpart of that which is executed by glaciers, and it certainly could not have been done by floating ice.*

Second. A deep, broad ocean current flowing through the lake-basin from the Gulf of St. Lawrence would certainly have brought marine shells further than they have been traced by Prof. Dawson, and we should now find them more or less abundantly throughout our Erie clay.

Third. We should find in our Drift deposits abundant representatives of the rocks which form the shore of eastern Canada, Labrador, etc., but, so far as I know, not a trace of any of these rocks has been discovered in our Drift; while, on the contrary, nearly all the constituents of the Drift can be traced to places of origin in localities north and north-west of Ohio. Some of these materials are so peculiar, such as the native copper, and epidotic rock containing metallic copper, and this copper including specks of silver, that there can be no possible mistake about its derivation. The discovery of northern Drift in Louisiana has been suggested as an argument in favor of this hypothesis, but it should be remembered that this drift lies at the bottom of the entire Quaternary

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* Probably no finer exhibition of glacial markings exists in the world than those which cover the summits and slopes of the Cascade Mountains in Oregon. Here we find, over hundreds of square miles, rocks of all kinds, planed, polished, and grooved in the most surprising way. These markings lead from various centers, and I have traced them down continuously 2,500 feet below the present snow line. Whoever goes there doubting the erosive power of glaciers, will come away doubting no longer. And whoever comes from this scene of stupendous Alpine glaciation to the glaciated rocks of Ohio, and especially of the islands in Lake Erie, will not hesitate for a moment to attribute the inscriptions he finds here to the same agent that has planed and scored the slopes of the Oregon mountains.

series, that it is in fact valley Drift, such as was transported by the Mississippi while the continent was several hundred feet higher than now, and the river current swift enough to carry material from its headwaters to the Gulf. The Champlain epoch came long afterward, when the Gulf coast was sunk one thousand feet lower than when the valley Drift of Louisiana was deposited. In that submergence the valley of the Mississippi was an arm of the sea. Still water then filled the valley of the Ohio, and the upper Drift deposits of the Ohio valley were laid down over not only the bowlder clay, but the Forest Bed that covered it. If this submergence was synchronous with that of the Atlantic coast, in which the Champlain clays were deposited—a point not yet established—then our representatives of the Champlain are the upper Drift deposits of the Ohio valley, the Lacustrine clays of the lake-basin, and the Loess of the Western States. Even if synchronous with the marine Champlain clays, our Erie clays, where stratified, are fresh-water deposits made in a different water-basin and at a higher level, as some portions of our laminated Erie clay are found nearly one thousand feet above the level of the sea.

MODE OF FORMATION OF THE ERIE CLAY.

As some misapprehension, as it has seemed to me, has prevailed in regard to the manner in which the materials forming the Erie clay were deposited, I venture to suggest a view of the mode of formation of this member of the Drift series to which a careful study of the phenomena it presents has led me. As we learn from all observations on the erosive action of glaciers, the materials excavated and comminuted by a glacier are carried forward by it, and are thrust out at its extremity. If coarse, they are left there, with whatever blocks it transports on its surface, as a terminal moraine. If fine, they are more or less completely washed away by the water draining from it. This finer material is what renders all the streams flowing from a glacier "turbid, or milky." The character of the material ground up and transported by a glacier, and the proportion of fine to coarse material deposited by it, will vary with the nature of the rock over which it passes, the freedom of the drainage from it, and the presence or absence of overhanging cliffs and pinnacles, from which blocks may descend upon its surface. The great glacier which once covered so much of Ohio, like all others of ancient and modern times, undoubtedly pushed out and left behind it the coarse and fine flour which it ground. As the rocks over which it passed were, for some hundreds of miles northward, soft sedimentary strata, mostly shale and limestone, the product of its grinding action was a calcareous clay, thickly studded with fragments of the excavated material. From the fact that the slope over which this glacier moved was very gentle, and a great barrier crossed its path, the drainage was never free, except locally, and as a consequence, the greater part of the ground material was never washed away, nor even suspended in water, and it remains as a sheet of irregular thickness, and mostly unstratified bowlder clay. It is mainly composed of the debris of the shales and limestones which occupied an area of many hundreds of square miles, from which they have been removed, in and north of the basin of Lake Erie. The few well-worn pebbles and bowlders of crystalline rock contained in the bowlder clay are fragments brought by the glacier from the far-distant Canadian highlands. In their long journey, few have resisted the attrition to which they were subjected, and these have been worn, scratched, and planed off as we find them. As we go northward and approach their place of origin, they become more and more abundant, and increase in size.

Since the glacier that formed our bowlder clay was a broad ice-sheet, and passed over a nearly level plain, where there were no summits or pinnacles from which stones or earth could fall upon it, all the material it carried was pushed along beneath it, or was frozen in to its under surface. Hence few large, and no angular blocks were brought by it from the northern highlands. Some blocks of large size were, as we know, torn by it from ledges of limestone and sandstone within or near the limits of our State; as we find in the northern counties masses of Corniferous limestone, evidently taken from the islands in Lake Erie, or from the outcrops of this formation north of the Lake. These were carried one hundred miles or more south-west, to points several hundred feet above their places of origin.

That the bowlder clay was not deposited *beneath* the glacier, as sometimes stated, is apparent from the fact that it covers the glaciated surface on which the ice rested, in a sheet sometimes a hundred feet in thickness. *It must, therefore, have accumulated at the margin of the glacier.* As the glacier retreated northward, the clay which it pushed out accumulated year by year, following it till it rose on to the Canadian highlands, where, with hard material, and free drainage to wash away the finer portions, it is largely replaced by beds of gravel, sand, and bowlders. In the retreat of the great ice-sheet across the lake-basin, at first small pools, then larger basins, and, finally, a great inland sea, bordered it on the south. In these bodies of water a portion of the material ground up was suspended, and then deposited as the laminated portion of the Erie clay. This, as I conceive, is the true and simple history of its formation.

The theory advanced by Prof. N. H. Winchell, in his paper on the Drift of the North-west, published in the Popular Science Monthly for June and July, 1873, viz., that the Erie clay is a mass of dust or dirt, which gathered on the surface of the glacier and was dropped, as it melted, seems to me to be quite untenable, as there were no highlands surrounding the great ice-sheet from which the earth could be washed or blown on to its surface; and all material grasped by the glacier in its motion tends to work out below rather than at the surface, inasmuch as the glacier grows from above downward, melting below, and being renewed by constantly recurring snow-falls above. It may also be said that no existing glaciers terminate in the manner suggested by Prof. Winchell—*i. e.*, in a thin, earth-covered edge—but they always end in an abrupt ice-wall.

The glaciers of the Alps and Himalayas, those of Terra del Fuego, described by Agassiz, and those of Alaska by Blake, all tell the same story. The true counterparts, however, of the great glaciers now under consideration, are the continental glaciers of Greenland and the Antarctic.

THE FOREST BED.

Allusions have frequently been made on the preceding pages to a sheet of vegetable matter which overlies the Erie clay in various parts of Ohio, Indiana, Illinois, etc. Buried timber has frequently been found in sinking wells and in other excavations in different parts of the valley of the Mississippi, but the connection and significance of the phenomena were first pointed out in the reports of the present Geological Survey. A great number of instances of the occurrence of buried timber, peat, and carbonaceous layers in the Drift are given by different writers on geology. A few only of these can be cited here:

1. *Ross County, Ohio.* Wood, apparently cedar, from a well in clay 30 feet from surface, 150 to 200 feet above Scioto river. (Col. Whittlesey.)

2. *Coventry, Summit County, Ohio.* Muck and branches of trees, 42 feet beneath surface, in a well 544 feet above Lake Erie. (Col. Whittlesey.)

3. *Cleveland, Ohio.* A carbonaceous stratum, with many trunks of coniferous wood on surface of Erie clay beneath 20 feet of sand, and gravel, and clay (Delta deposit), 50 feet above Lake Erie.

4. *Hamilton County, Ohio.* Thirty-five wells containing muck beds, leaves, or timber, from 300 to 500 feet above the Ohio. (Col. Whittlesey.)

5 *Oxford, Butler County, Ohio.* An upright trunk and roots of a tree in blue clay, at the depth of 30 feet. (David Christy.)

6. *Highland County, Ohio.* In the village of Marshall, eleven wells out

of twenty have reached a stratum of vegetable matter with leaves, branches, roots, and tree trunks. Many similar cases in the same county. (Orton.)

7. *Clermont and several adjoining counties.* Ancient soil above the bowlder clay, and below the upper Drift deposits. (Orton.)

8. *Germantown, Montgomery County, Ohio.* Bed of peat from 12 to 20 feet in thickness, the surface covered with sphagnous mosses, grasses, and sedges, and containing quantities of coniferous wood, with twigs, branches, and berries of red cedar; also, containing bones of elephant and mastodon, and teeth of giant beaver, the whole covered with 90 feet of gravel and sand. (Orton.)

9. *All through South-western Indiana.* Ancient soil, with peat, muck, rooted stumps, trunks, branches, and leaves of trees, 2 to 20 feet in thickness, 60 to 120 feet below surface, called "Noah's cattle-yards," water of wells spoiled by them. (John Collett.)

10. *Peoria County, Illinois.* Drift over Coal Measures; average thickness, 70 feet, consisting of blue clay below 50 feet thick, overlaid by old soil, with cedar timber; above this, yellow clay and sand 16 to 20 feet thick; section shown by thirty-nine borings and many wells. (William Chapman.)

11. *Lawrenceburg, Indiana, and many places in Ohio Valley.* Old soil, with trunks and roots of trees, the latter *in situ*, layers of leaves, ripened fruits, grasses, and sedges, all clearly distinguishable. Several of the species of trees and plants can be determined, some by their wood, others by their leaves and fruit. Among them may be named the sycamore beech, shell-bark hickory, buckeye, red cedar, and wild balsam apple, 6 feet above low-water mark, and 40 feet below flood plain. (Orton. Vol. I., Part I., p. 427.)

12. *Several Counties in Iowa.* An old soil, with buried timber, from 40 to 50 feet beneath the surface, struck in sinking wells over several counties. (Morris Miller, in letter.)

13. *Walworth County, Wisconsin.* Timber resembling white cedar, from a well 18 feet deep in the prairie region, about 250 feet above Lake Michigan. (I. A. Lapham.)

14. *Appleton, Wisconsin.* Red cedar in red clay, 18 feet below surface, 150 feet above Lake Michigan; also, white cedar, 30 feet below surface, in red clay. (Dr. C. S. E. Beach, cited by Col. Whittlesey.)

15. *Green Bay, Wisconsin.* Apparently willow in red clay, 50 feet below the surface of Lake Michigan. (Col. Whittlesey.)

16. *Iowa City, Iowa.* Two logs of resinous timber in a well 60 feet deep on general level of country. (Col. Whittlesey.)

17. *Grand Sable, south shore of Lake Superior.* Layer of roots and limbs of trees, sometimes 12 or 14 feet thick, resting on bluish-drab clay, covered with sand interstratified with gravel 300 feet thick. (Sir William Logan, Geology of Canada, 1863, p. 905.)

18. *Toronto, Canada.* Trunks and branches of trees imbedded in yellow clay overlying blue clay, at a depth of from 10 to 20 feet from the surface. (Prof. Hinds.)

It is by no means certain that all the cases cited above belong to one category, as timber may have been buried, in some instances, quite deeply, by causes that now are in operation; but excluding all doubtful cases, a sufficient number of well authenticated facts remain to justify us in the conclusion announced on a preceding page, viz: 1st. That after the retreat of the glacier from the glaciated area, a growth of vegetation spread over the surface of the bowlder clay, reaching northward to and into the lake-basin, and westward to and beyond the Mississippi. 2d. That a forest occupied the surface long enough to produce a deep carbonaceous soil over all the lower and more moist portions. 3d. In the marshy portions of this land surface beds of peat were formed, in some instances even 20 feet in thickness. 4th. Most of the ancient forest was coniferous, and cedar and cranberry grew in the peat bogs; from which we may infer that the climate was colder than now in the same region. 5th. In the Forest Bed we find the remains of the mammoth, mastodon, giant beaver,* and some other animals, which mark this as the first horizon of life in the Drift series. In deposits of later age, even reaching to the advent of man, extinct or existing species of animals and plants are abundantly represented, but I have never been able to obtain any proof of the existence of organic remains in the Erie clay.

While ice covered so much of our State, whatever animal or vegetable life existed north of the Ohio was confined to the highlands east of the Scioto valley. We have every reason to believe, however, that the mammoth, mastodon, megatherium, megalonyx, etc., lived on the southern portion of our continent during the glacial period.

Though occupying an insignificant portion of the vertical thickness of

* In several of the wells which penetrate the Forest Bed, chopped timber and chips are reported to have been found. As the number of such cases is so numerous, we must suppose that the stories are founded on fact, and I have suggested that possibly the chopping was done by the great dental chisels of the giant beaver. The common beaver is capable of cutting down trees of large size, as at one of our camps on the Dolores river, in Arizona, I measured three cottonwood trees, felled by the beaver, each of which was more than two and one-half feet in diameter above the cut. The Giant Beaver could as easily have felled trees six in diameter.

our Drift deposits, the Forest Bed represents a great lapse of time. The advance of a forest growth over the barren Drift area must have been slow, and much time was certainly required to form the distinct sheet of carbonaceous matter which we now find. The climate of the State, at that period, must have been cold and damp, as the glaciers were still near, and the drainage from them which filled the water basin was icy cold.

In the Forest Bed of the valley Drift we find quite a number of plants of the species now growing in the same localities, and such as could not have grown there had the climate been *much* colder than now, but the deep valley would have been warmer than the uplands; and, as has been already stated, it is not certain that the old soils of the valleys and the highlands are of the same age, though both belong to periods when the physical condition of the country was quite different from the present. Further investigations, following up the suggestions and conjectures now made, will undoubtedly result in the perfect elucidation of this interesting chapter on the complicated history of the Drift.

I should not omit to mention that a stratum of bog iron ore accompanies the old soils in both the valley and upland Drift beds.

DRIFT OF THE TERRACE EPOCH.

The materials which overlie the Forest Bed, and which form the uppermost members of the stratified Drift deposits, are clearly the product of a wide-spread submergence of an immense area in the Western States which had before been dry land. In a great number of instances in southern Ohio, where the Forest Bed is present, the materials overlying it have been penetrated in water wells, and their character has been accurately determined. For the purpose of showing what these strata are, I quote again, in part, the general section of the upland Drift of Clermont county, as described by Prof. Orton (Vol. I, Part I, p. 440):

No. 1.	*Surface clays, generally white,* sometimes blackened by swampy conditions, entirely free from gravel	1 to 8 feet.
No. 2.	*Yellow clays, abounding with gravel,* with occasional bowlders, often constituting the surface instead of 1. Thickness seldom exceeding	10 feet.
No. 3.	*Forest soil and bog iron ore.*	
No. 4.	*Blue bowlder clay,* or hard-pan.	

The white clay of the above section is a somewhat localized deposit, but one that is spread over a wide area. In Clarke county it is called the Springfield clay, and has been worked as a brick and tile clay for many years. It contains so little iron that the ware made from it is white, or cream color. A similar clay at Miamisburg, supposed by Prof. Orton to be of the same age, has been quite extensively used for paint. A like deposit in the valley Drift at Cincinnati has been used in forming concrete for the bottom and sides of the new reservoir. Every thing indicates that this is a lacustrine deposit, that is, that it accumulated at the bottom of a body or basin of fresh water. It is probable that a precisely similar clay is now being deposited in Lake Geneva by the milky water that flows from the glaciers. We may even carry the analogy further, by supposing this to be the very finest portion of the bowlder clay, which, stretching over the northern divide, was washed away by shore waves and draining streams, and was deposited in the still waters of the gulf or bay formed by the valley of the Ohio in its last submergence. The yellow clay, abounding with gravel, and containing occasional bowlders, which overlies the Forest Bed, and is more generally the surface deposit of southern Ohio, is evidently the more immediate and coarser product of the action of the in-coming flood, and copious drainage from the north upon the ancient forest-covered land, of which the sub-soil was the bowlder clay. So far as yet observed, there is no satisfactory proof that an ice-sheet passed over the State of Ohio after the accumulation of the old Forest Bed. The yellow clay under consideration is quite different from the blue bowlder clay which lies beneath it and the Forest Bed; and it seems scarcely possible that it could have been spread by glaciers, and the Forest Bed and bowlder clay be left so intact over large areas. I would rather ascribe it to the action of water; but calling to the aid of that water the icebergs that we know floated on the surface of the inland sea, and, in the flooding of the Ohio valley, passed over the summit, or through the gaps of the divide, and scattered gravel and bowlders along their route in the country farther south.

If, as seems probable, the stratified sediments which once partially filled the immediate valley of the Ohio, and now form terraces like those at New Richmond and Lawrenceburg, belong to the same epoch with the upland Drift of southern Ohio, it would appear that when the Forest Bed accumulated the continent was somewhat higher than now, and the Ohio flowed at a lower level; and that during the subsequent submergence the later Drift sediments were deposited over all the irregularities of the surface.

In the basin of the great lakes, the upper portion of the Drift series is not quite so distinctly marked as in the valley of the Ohio, perhaps for the reason that in the descent of the water line of the inland sea nearly every portion of the slope which formed the southern boundary was exposed to the full force of its great waves, and, as a consequence, the denudation has been greater there. In the Maumee valley, however, the yellow laminated clays which form the summit of the Drift series are regarded by Mr. Gilbert, who has carefully examined them, as of lacustrine origin, and of comparatively modern date.

In the valley of the Cuyahoga—which was a deep gorge previous to the epoch under consideration—we find a series of finely stratified yellow, blue, and red sandy clays, that overlie all the other Drift deposits. These are very peculiar in character, and seem to represent a portion of the Drift series, which, if once generally deposited in the lake basin, has been for the most part since removed. The nature of these strata may be gathered from the following sections:

LACUSTRINE CLAYS, AKRON, OHIO.

		Feet.	Inches.
1.	Stratified sand	10	...
2.	Blue clay	...	4
3.	Mixed yellow sand and blue clay, stratified	1	1
4.	Blue clay	...	10
5.	Yellow sandy clay	...	10
6.	Blue clay	1	...
7.	Red clay	...	1
8.	Yellow loamy clay	1	...
9.	Blue clay	...	8
10.	Red clay	...	2
11.	Blue clay	...	6
12.	Red clay	...	10
13.	Blue clay	1	6
14.	Red clay	...	2
15.	Yellow loamy clay	1	6
16.	Blue clay	2	...
17.	Red clay	...	1
18.	Fine yellow sand	...	1
19.	Yellow loamy clay	2	...
20.	Blue clay	...	4
21.	Yellow loamy clay	3	...
22.	Blue clay	4	...

LACUSTRINE CLAYS, THREE MILES NORTH OF AKRON.

		Feet.	Inches.
1.	Hard concretionary clay, with much iron	25	...
2.	Blue clay	8	...
3.	Yellow clay	...	3
4.	Blue clay	...	3
5.	Red clay	...	1
6.	Yellow loamy clay	2	...

		Feet.	Inches.
7.	Blue clay	...	10
8.	Yellow clay	...	8
9.	Blue clay	...	1
10.	Red parting	...	¼
11.	Yellow clay	...	10
12.	Blue clay	...	2
13.	Red clay	...	½
14.	Yellow loamy clay	2	...
15.	Blue clay	...	2
16.	Yellow loamy clay	4	...
17.	Blue clay	...	4
18.	Yellow clay	...	4
19.	Blue clay	2	...
20.	Yellow clay	1	6
21.	Blue clay	...	3
22.	Yellow clay, streaked with blue and red	5	...
23.	Blue clay	...	2
24.	Yellow clay	2	...

In the preceding sections the clay is all more or less loamy, *i. e.*, mixed with very fine sand; and though plastic when wet, is crumbling when dry. All the layers contain much iron: that in the blue bands, which are finer and *wetter*, as protoxide; that in the yellow layers, which are somewhat ochery, in the condition of hydrated sesquioxide; that in the red bands, as anhydrous peroxide. The remarkably regular stratification of the series of beds now under consideration proves them to have been deposited in quiet water; and as they reach down the valley of the Cuyahoga for many miles, apparently connecting with the laminated portion of the Erie clay, we are compelled to conclude they were deposited in the Cuyahoga valley when it was completely filled with the water of Lake Erie; and the absence of all coarse material proves conclusively that this was not then a drainage channel. From their peculiarly permeable and loamy character, these clays would be removed with more facility than any other of our Drift deposits; and it is probable that the only reason why they are present here, while wanting over most of the slope of the watershed, is, that, in this deep gorge, they have been protected from the action of the shore waves, which washed away from the surrounding country all of the superficial deposits, except the tough and impervious bowlder clay.

THE LOESS.

The "Bluff formation" of the West is sometimes called the "*Loess*," from its resemblance to the Loess of the Rhine. I have designated it, in a paper on the Drift of the Mississippi valley, published some years since, as a "Lacustrine, non-Glacial Drift deposit," and considered "it the sediment precipitated from the waters of our great inland sea in its shallow and more quiet portions, to which icebergs, with their gravel and bowlders, had no access." It is evidently the most recent of our stratified Drift deposits, and I regard it as the equivalent of the lacustrine, ochery clays, enumerated in the preceding sections, and of the surface clay and loam, which overlie the Forest Bed in the Ohio valley. Some years since, Mr. Morris Miller, writing me from Iowa, where he was carefully observing the surface geology, made a suggestion in regard to the origin of the Loess, which has been fully confirmed by the descriptions and conclusions of the geologists of Iowa and Missouri; *i. e.*, that the Loess is the silt brought down by the Missouri river, and spread over the great water basin that occupied the Mississippi valley at the time of its deposition. As the water was gradually withdrawn, the Loess was deposited farther and farther southward, until now it is carried into the Gulf of Mexico. The Loess is simply a river silt, just such as now renders the waters of the Missouri so remarkably turbid. All rivers transport more or less sediment, the quantity and the character of which depend upon the configuration and geology of the country through which they flow. It is said that the sediments of the Amazon render the waters of the Atlantic turbid for 200 or 300 miles from its mouth; and in the season of floods the Mississippi discolors the waters of the Gulf to an almost equal extent. As the flow of a river current is checked and finally arrested in a body of still water, the sediment it transports is precipitated in the order of its fineness, and the ratio as to quantity of the motion of the water. Hence around the mouth of the river the silt will be coarsest and thickest; finer and thinner as we recede from that point. In examining the Loess of the Mississippi valley we find that it conforms precisely to this law, being thickest and most sandy about the old mouth of the Missouri in eastern Iowa, Missouri, and western Illinois. North and east of this region the Loess becomes thinner and finer, until it merges into and is lost in the sediments transported by streams which drained into the Mississippi Gulf, or Lake, from the east.

The Loess is called the Bluff formation, because it once formed the upper part of the filling of the old rocky troughs of the Missouri and Mississippi, and having been but partially washed out by the present streams, often stands as bluffs along the water side. In such cases, however, the Loess is simply a facing to the rocky bluffs which form the true walls of the valleys.

It is an interesting fact that the Loess is generally separated from the underlying older Drift deposits by a carbonaceous layer, or old soil, which shows that it was laid down on a submerged land surface. Whether this soil corresponds to our Ohio Forest Bed remains to be proven, but it seems highly probable that they are continuous and identical. Dr. E. Andrews states that the Loess covers the upper ridge at the head of Lake Michigan, and he infers that the water from which it was deposited was rapidly withdrawn, as otherwise it would have been washed from exposed points from shore waves, and its continuity be broken by beach lines.

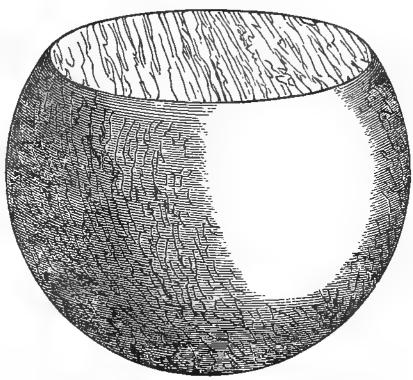
BOWLDERS.

The bowlders, or *erratic blocks*, as they are sometimes called, which are scattered over so much of the surface of the State, have attracted the attention and excited the wonder of most of its inhabitants. They are usually composed of some kind of crystalline or metamorphic rocks, such as are foreign to the geology of Ohio, and were on that account recognized, even by the unlearned, as foreigners which had been brought from a distance and strewed over the surface or perched upon declivities in some incomprehensible way. Though greatly varying in quantity in different localities, the bowlders may be said to be common to all parts of the State, except the highlands which have been specified as lying outside of the Drift area or which rose beyond the reach of the agent or agents by which the distribution of the Drift material was effected. In the valley Drift of the channels of the Miami, Scioto, Muskingum, and even the Ohio,, bowlders are exceedingly common, but they are never of large size, and are only such as have been washed down by river currents from their original places of deposition; and these grow smaller and smaller as we descend the valleys in which they are found.

Some of the bowlders distributed over Ohio are of immense size, and some may be found in almost every county which have attracted special attention. We have space to enumerate but few of these. In Montgomery county, on the hill near the Soldiers' Home, is a partially buried, rounded mass of gray granite, twelve feet in diameter horizontally, and, as shown by execavations, not much less vertically. This would give a bulk of 904 cubic feet and a weight of 75 tons. In Harrisville, Medina county, are three blocks of granite, which were, apparently, once parts of the same mass. The exposed portion of one of these measures is 10x12x15 feet. This would give a weight of about 150 tons for what is seen only of this block. Another shows a corner projecting seven feet above the ground, of which the three triangular faces measure respectively 12, 15, and 12 feet along their bases. In the valley of Black river, in Huron county, above Monroeville, is a block of Corniferous limestone, said to be nearly equal in bulk to a cube twenty feet on a side. A great number of bowlders, scarcely smaller than these, are mentioned in the notes of the Geological Corps, but these are sufficient to show the power of the transporting agent. Smaller bowlders are sometimes found in immense numbers over a limited space. Near Euclid, in Cuyahoga county, they are so thickly strewn over a field of several acres as to resemble a large herd of sheep and cattle. Even in southern Ohio they are locally very numerous. Prof. Orton mentions a belt of these bowlders, two or three miles wide, between Dayton and Eaton, where they are so thickly set as to make the cultivation of the soil almost impossible. Here the bowlders are almost exclusively Canadian metamorphic rocks, among which a granite, with rose-colored felspar, a gray gneiss, diorite, and silicious slate, are the predominating varieties. Along the highlands of the divide we occasionally see blocks of considerable size, which have been torn from some neighboring ledge, and among the smaller rounded bowlders found on and south of the divide, a large number are derived from indigenous rocks, but the greater part of the larger bowlders strewed over the surface are of foreign origin.

Very few of the surface bowlders show any striation or planing, such as is seen in those of the bowlder clay. This is a distinction that has an important meaning; for so large a number of the bowlders in the glacial clay (where they have been transported by glaciers) are planed and scratched, that the absence of such markings from the surface bowlders is pretty good evidence that they have had a different experience. We may, therefore, conclude that the striated bowlders have been transported beneath glaciers, and that the rounded and unscratched bowlders have not. With the great limestone bowlder of Huron county are many of smaller size, which are very much scratched and worn. These rest on the surface of the Huron shale, and we can hardly doubt that they have been transported and left where found by a glacier moving from the north. In the vicinity of these limestone bowlders a spherical concretion from the Huron shale was found, of which one side is planed off as smoothly as it could be done by art. Whether it was held in the glacier, or in the shale, when the grinding was done, is somewhat uncertain;

CONCRETION FROM DRIFT GROUND OFF BY GLACIER.

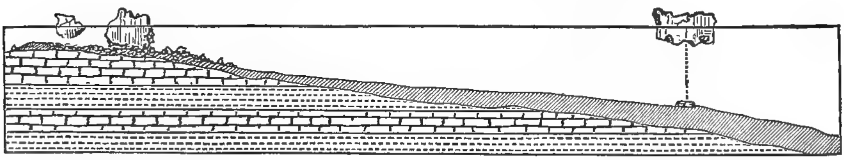


but that it was ground off by glacial action there can be no doubt. A wood-cut of this interesting specimen is given on the preceding page.

Scratched bowlders are not uncommon in the Drift of the highlands, and they may be always accepted as evidence that the material in which they are imbedded is glacial Drift. One of these bowlders, peculiar from its size and position, deserves to be mentioned. This is composed of diorite, is some three feet in diameter, and is planed on three sides. It lies in a cutting on the Sandusky, Mansfield, and Newark Railroad, three miles south of Mansfield, and 700 feet above the Lake.

The large unscratched bowlders described above are generally found on the surface. This we might suspect to be merely the result of the washing away of surrounding softer material; but in the great series of excavations which have been made in the construction of our railroads, canals, etc., large bowlders have been rarely met with below the surface, and they are scarcely found in such circumstances any where except in the bowlder clay of the north-west counties. We often see, also, the large surface bowlders resting on the fine, stratified clays which constitute the upper portion of the Erie clay, and on the stratified sands and clays which form the upper part of the Drift. It seems impossible that they should have been brought to such positions by glaciers or currents of water, as either of these agents would have torn up the underlying clays. We also learn, from their relative position, that these bowlders were deposited at a later date than the most recent stratified beds of the Drift series, and that they were floated to their present resting places. In short, no argument is required to convince any one who will glance at the facts, that these bowlders, and probably the gravel and sand with which they are sometimes accompanied, were floated on icebergs from the north shore of the great fresh-water lake which once filled the lake basin, and that as these icebergs melted, or when they stranded, their loads were discharged on the top of all the Drift deposits which had been laid down in the preceding epochs of the Quaternary age.

SOUTH SHORE OF INLAND SEA, WITH ICEBERGS.

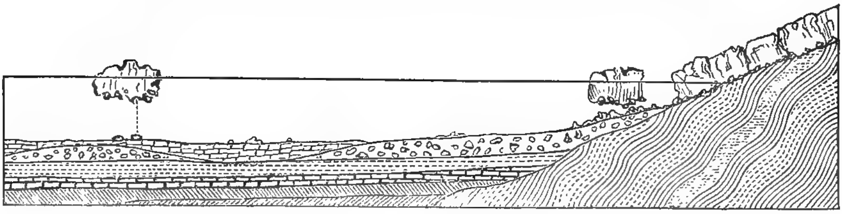


Outlet, with floating and stranded icebergs.

Iceberg dropping bowlders on drift.

At the period of the greatest submergence of the land, icebergs undoubtedly passed through the gaps of the divide, and thus scattered their bowlders over the southern part of the State. It should be remembered, however, that it is not claimed that all the large bowlders were transported by icebergs; simply that many of them must have been so transported, and probably most of them were. The accompanying wood-cuts will better explain my idea of the method of transport of these bowlders than I can do it in words.

NORTH SHORE OF INLAND SEA, WITH GLACIER AND ICEBERGS.



Palæozoic rocks and drift. Laurentian hills and glacier.

That icebergs can and do transport great quantities of bowlders, gravel, and sand, is attested by thousands of observers who have seen them doing it. For example: in 1822 Captain Scoresby saw a large iceberg drifting along, loaded with earth and rocks, conjectured to be from 50,000 to 100,000 tons; and Captain James Kent, quoted in Kane's Arctic Expedition, speaks of millions of tons of stone and other solid matter carried by icebergs. These materials are sown broadcast over the bed of the North Atlantic and the banks of Newfoundland, just as formerly over the shallows bordering the southern shore of our fresh-water inland sea.

KAMES.

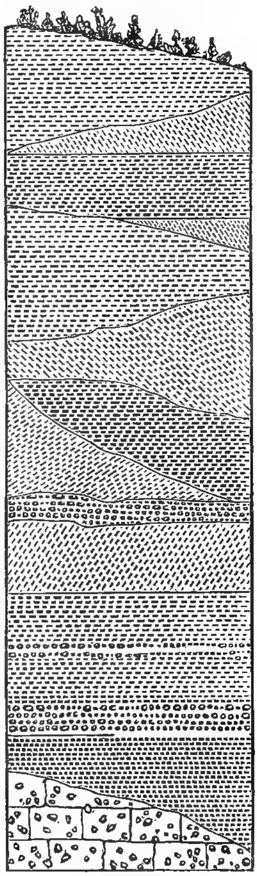
Along the summit of the watershed, between the Lake and the Ohio, from the eastern to the western margin of the State, accumulations of Drift material occur, which are peculiar in their character and position, and of which the history is less easily made out than that of any other portion of the Drift series. These are beds, banks, and hills of sand, gravel, and bowlders, with little admixture of clay. In many localities, these materials are heaped up into rounded, or, more often, elongated hills, from 50 to 100 feet in height, to which the name "hog's-back" is very frequently applied. Sometimes several of these hills are grouped together, forming an undulating surface, with inclosed basins, which are often occupied by lakes, or peat bogs; though frequently without water, from the porous nature of the material which surrounds and underlies them. A large number of the peat bogs, lakes, and marshes, which constitute such a marked feature in the topography of the summit of the watershed, are surrounded by gravel hills, and owe their existence to the irregular and undulating surface formed by the Drift materials under consideration. Nearly every county which lies on the divide contains more or less of the gravel hills to which I have alluded, and they are the source from which is derived a large part of the gravel used for road-making and railroad ballast, and the sand employed for mortar. Few, only, of these gravel knolls can be enumerated here, but they will be recognized from description by a large number of the residents of the State. A typical group of these hills occurs in Randolph, Portage county, the general appearance of which is shown in the subjoined wood-cut. Others may be seen east of Ravenna, and near Earlville, where they

GRAVEL HILLS, RANDOLPH, PORTAGE COUNTY.

From 50 to 100 feet high; 500 feet above Lake Erie.

supply a vast amount of gravel used in the construction of the Atlantic and Great Western and the Cleveland and Pittsburgh railroads. At this locality we have a good illustration of the part these gravel ridges have played in the formation of lakes, as the two lakes, Brady's Lake and Lake Pepin, are here held in basins surrounded by ridges and hills of gravel. In Summit county a good example of a "hog's-back" is seen at the "Old Forge," and its composition is fully revealed by the excavations made in the construction of the railroad and canal. At Akron, on both sides of the Little Cuyahoga, are heavy beds of gravel, which belong to this category, and which I shall have occasion to refer to again, as their composition and relation to the other Drift deposits are here quite plainly shown. In the northern part of Stark county gravel hills are very numerous, and an excellent example of this peculiar formation is furnished by "Buck Hill," of which I shall give a section on another page. Following the divide from Akron westward, collections of coarse Drift materials, in ridges, hills, or swells of the surface, will be in view almost constantly to the State line. In the western counties these are so well marked and continuous that Mr. N. H. Winchell, in describing the Drift phenomena of this portion of the State, brings these into the category of lake ridges, making two chains of them, one of which he calls the St. John's ridge, the other the Wabash ridge. Both of these lie along the crest of the divide where it is unusually low; the St. John's ridge having an elevation at different points of from 390 to 490 feet above the Lake, the St. Mary's ridge, 350 to 408 feet. Careful observation will show, however, that this belt of sand and gravel hills has little in common with the lake ridges; being composed of different materials, holding a higher level, and being far less continuous and uniform in altitude. It may easily be shown, also, that they were produced by different causes, and belong to a different series of Drift phenomena. They are, indeed, almost the exact equivalents of what are called *Kames* in Scotland, *Eskers* in Ireland, and *Asar* in Scandinavia. They are also to be compared with the accumulations of coarse Drift material which crown the highlands in Michigan, Wisconsin, and in the country north of the lakes; also, with the "hog's-backs," the abrupt conical or elongated hills of gravel and bowlders so common in eastern Canada and New England.

SECTION OF SAND AND GRAVEL HILL AT AKRON.

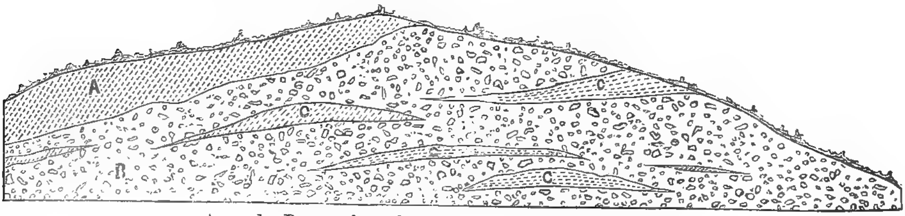


Base conglomerate; 428 feet above Lake Erie.

The form and composition of the "Kames"—as we shall call them—which are set along the highlands of Ohio, varies considerably in different circumstances. Where the accumulation of material is large, it forms hills of some height, and they are seen to be composed mainly of gravel and sand. They sometimes contain bowlders, however, and not unfrequently, those of considerable size; and often rest upon the glaciated surface of the underlying rock, with no intervening sheet of bowlder clay or other Drift material. In other localities the gravel is more widely spread, as though dispersed from its original position, and it then frequently covers not only the bowlder clay, but also the most recent of the Drift deposits. Such cases, however, I attribute to the washing down of gravels from higher lands, at a comparatively recent date. Examples of this may be seen in the railroad cut north of Ravenna, where the gravel rests upon bowlder clay, and in the cuts for the Valley railroad near Akron, where it overlies the laminated sandy clays which form the summit of the Drift series. The gravel and bowlders that form the kames are both indigenous and exotic. In some instances, the underlying or neighboring rocks have contributed largely to make up the deposits; as, near Akron, where masses of conglomerate, sandstone, and pieces of coal, often of considerable size, are found in the gravel beds; evidently derived from the strata which were once continuous over all this region. Near Ravenna, the sandstone overlying coal No. 1 has contributed largely to the formation of the masses of loose material; and in Stark county the compact and tough Coal-Measure limestones have supplied many of the rounded bowlders and gravel stones. In the western portion of the State, the limestones that form the Cincinnati arch have sometimes furnished nine-tenths of the materials composing the kames. Mingled with these native rocks, however, we often find a large, frequently a preponderating, number of representatives of the crystalline or palæozoic rocks of the country north of the lakes, viz., granite, greenstone, quartzite, silicious slate, crystalline limestone, and also pebbles and fossils of the Silurian and Devonian rocks of the varieties found in Canada and not in Ohio. These transported masses are generally small, well rounded, and never, so far as I have observed, scratched or ground like the pebbles and bowlders of the Erie clay; much of which is true glacial Drift. In one or two instances, native copper, evidently from Lake Superior, has been found in these gravel beds. The arrangement of the materials in the kames is irregular, but it generally shows plain indications of the action of water. Sometimes its stratification is quite distinct, and bands of gravel and sand succeed each other in nearly perfect horizontality and parallelism. In such cases the deposits are spread over a large area, and where cut into hills and tables, are plainly the portions of once continuous and somewhat extensive sheets. Here we may conclude that the materials are rearranged, having been washed down from higher levels and spread by the action of shore-waves and currents.

The "hog's-backs" and more well-defined hills of the kames usually show oblique and irregular stratification; beds of sand, gravel, and occasionally of bowlders, alternate, but the sheets are rarely horizontal, and they interlock by wedging. The sand beds are also frequently cross-stratified. I give below a section of Buck Hill, Stark county, as a good illustration of the structure of our kames. It is 40 feet high, and its base is 560 feet above Lake Erie.

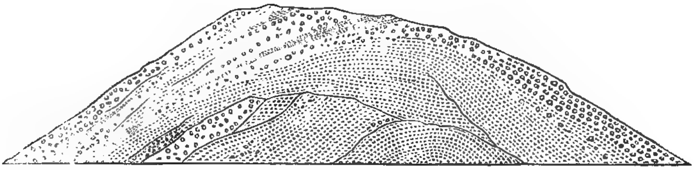
PROFILE SECTION OF BUCK HILL, STARK COUNTY, OHIO.



A, sand. B, gravel, sand, and bowlders. C, sheets of sand.

For comparison with the above cut, I give herewith a profile section of a kame near Lanark, Scotland, copied from Geikie.

SECTION OF A KAME. LANARK, SCOTLAND.

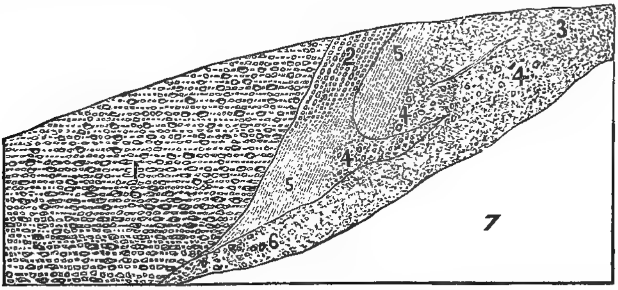


Gravel and sand. (Geikie's "Ice Age," p. 213.)

The character of the kames on the divide in Auglaize and Mercer counties will be seen from the following description, taken from the full and carefully prepared notes furnished me by Prof. N. H. Winchell. Speaking of the St. John's ridge, he says:

"At the village of St. John's, in Auglaize county, it has its most marked development. It consists there of a series of gravel knolls and short subordinate ridges, whose height above the intervening valleys is, in some cases, over 95 feet. The surface to the east or west (the trend of the gravel belt being north-east and south-west) becomes an almost unbroken flat within a half mile either way, while in the direction of the ridge this broken character of the surface prevails. This ridge is sometimes nearly a mile across. The contents of these knolls and subordinate ridges, wherever seen, are always gravel and sand, in glacial stratification (*i. e.*, in inclined and interlocked wedges). Some beds also consist almost entirely of rounded stones, of three to six inches in diameter. In excavating for gravel, bowlders of several hundred pounds weight have also been occasionally taken out of these banks, and such bowlders are sometimes seen perched on the tops of them. About a mile and a half south-west of Westminster, in Allen county, is one of the most remarkable of these subordinate ridges. It has the local name of the 'Devil's Back-bone,' and its

SECTION FROM GRAVEL KNOLL AT ST. JOHN'S, AUGLAIZE COUNTY. (Winchell.)

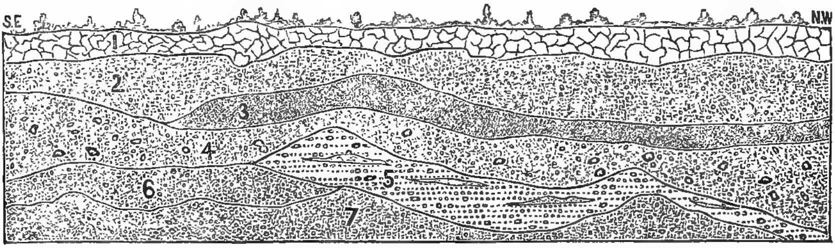


1. Coarse and fine gravel, with a distinct, yet imperfect, assortment in horizontal beds, 15 feet. 2. Gravel in layers, inclined at an angle of 70°. 3. Unassorted gravel and sand. 4. Coarse gravel, with some stones. 5. Sand in layers, inclined at angle of 70°. 6. Stones, the interstices filled with gravel. 7. Concealed.

length north and south is about half a mile. At its northern extremity it consists entirely of sand and gravel in glacial stratification, but toward the north and east it becomes gradually more mixed with clay, and is less evidently stratified. It is also forked and channeled toward the south, and extends east and west for a number of miles. Further south the slope is gentle, and the ridge is soon lost in a flat surface. This subordinate ridge is not higher than the adjoining knolls or the general level. In approaching it from the north, there is a sudden descent before reaching it; there is also a swampy tract along each side. On the top of this ridge of gravel, and also on the slopes, are many large bowlders; one, which lies exactly on the summit, measures 4 by 2½ feet. This is of diorite. Many others also seen on the ridge are of limestone, the Waterlime predominating."

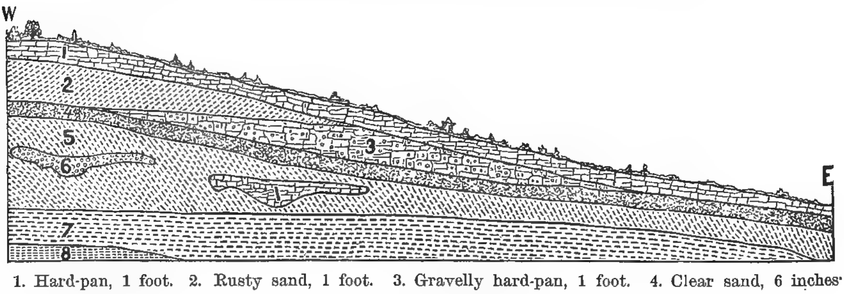
The following section, taken by Mr. Winchell, will serve to illustrate the arrangement of materials in the kames he has described:

SECTION OF WABASH RIDGE AT WAPAKONETA, AUGLAIZE COUNTY. (Winchell.)



1. Rusty hard-pan, 1 foot. 2. Unassorted gravel and sand, 1 to 4 feet. 3. Damp sand, with some gravel 1 foot. 4. Unassorted gravel and sand, with some stones a foot in diameter, 1 to 4 feet. 5. Stratified sand the beds broken by lenticular beds of unassorted sand and gravel, 1 to 4 feet. 6. Unassorted gravel and sand, 4 feet. 7. Unassorted sand and gravel, 2 feet.

SECTION FROM GRAVEL KNOLLS AT ST. JOHN'S, AUGLAIZE COUNTY.



1. Hard-pan, 1 foot. 2. Rusty sand, 1 foot. 3. Gravelly hard-pan, 1 foot. 4. Clear sand, 6 inches. 5. Stratified sand, 2 feet. 6. Gravel. 7. Coarse and fine sand in distinct beds, exposed, 8 inches. 8. Sand, exposed, 4 inches.

DRAINING OF THE INLAND SEA.

On a former page I have referred to certain waste-weirs through which our great inland fresh-water sea was drained off toward the Ohio and Mississippi long before the present outlet was established. Some of those which occur in the State of Ohio were incidentally described in Vol. I., Part I., p. 43, of this report, where they are cited as interesting features in the topography.

It seems that in the period of the 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 a sufficient depth of water existed in the passes of the watershed to float icebergs of considerable size, and as currents flowed through these passes, some of the bowlders scattered over southern Ohio were probably transported by them. 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, cutting the gaps deeper, and transporting great quantities of gravel and bowlders, and depositing them in lines which lead down toward the valley of the Ohio.

The first of these passes through the watershed is that traversed by the Miami Canal at the St. Mary's summit. This has a level above the Lake of 367 feet, and connects the valleys of the Maumee and Miami.

The second is that called the Tymochtee summit, in Wyandot county, which connects the valley of the Sandusky with that of the Scioto. This has an altitude at present of 337 feet.

The third pass is in Harrisville, Medina county, between the valleys of Black river and the Styx, a tributary of the Tuscarawas, at a height of 336 feet.

The fourth is the Akron summit, through which the Ohio Canal passes, connecting the valley of the Cuyahoga with that of the Tuscarawas. The summit level of the Ohio Canal is 395 feet above the Lake.

The fifth pass is that between the valleys of Grand river and the Mahoning, of which the summit is in Orwell, Ashtabula county, and has an altitude of 363 feet above the Lake.

Each of these gorges is now more or less filled with Drift; but the remarkable similarity of level which they present will strike the most casual observer, and will not fail to suggest their reference to a common producing cause. All the lines of drainage leading southward from these passes are marked by deeply excavated channels, now more or less perfectly filled by great accumulations of rolled and transported material, such as would be the natural product of a copious flow of water, continued through ages of time, and gradually diminishing and losing its transporting power. Whoever has passed up the valley of the Miami must have had his attention drawn to the great masses of local Drift with which it is obstructed. This Drift is largely composed of rounded pebbles of the limestones which form the highlands bordering the upper part of the valley, and they doubtless represent the materials which once occupied the gorge now opened northward through the watershed. The more easterly gaps present the same phenomena. The valley of the Scioto was once a broad and deep trough, cut in the solid rock, now nearly filled with beds of gravel, sand, and bowlders, of which the thickness has never been determined. In boring the State House well at Columbus, 123 feet of coarse, valley Drift was penetrated before the rock was reached. The State House stands on a terrace of gravel, sand, and bowlders, which is on the eastern side of the old valley, and it is apparent that the old rock trough, here at least a mile in width, was once filled to this level. Its depth in the central portion is, doubtless, much greater than it is under the city of Columbus.

From the great bend of the Cuyahoga a belt of gravel reaches southward through Summit and Stark counties, forming a geological and topographical feature which will be found described in the reports on these counties. There are here, apparently, two deep channels, one of which is quite filled, and the other is partially excavated by the Tuscarawas river. The first of these lies west of Canton, and has been penetrated to the depth of 100 feet without finding the rock bottom. Buck Hill, of which a section is given on page 44, is one of the gravel knolls which mark the line of this channel. The other gravel belt borders the present course of the Tuscarawas in Stark county. The numerous borings that have been made for coal in and near the valley of this stream show that the gravel is sometimes more than 100 feet in depth, reaching far below the present stream bed. The gravel hills and terraces west of the river, at and below Massillon, form parts of this belt. At the Charity School, a well was sunk 100 feet in gravel and sand, and coniferous wood was taken out at the bottom. In the town of Dover, at the junction of Sugar creek and the Tuscarawas, a boring for salt showed an accumulation of gravel and sand reaching to the depth of 175 feet below the present surface level of the Tuscarawas.

The accumulation of Drift in the valley of the Beaver, and in that of the Ohio, near the mouth of the former stream, is so unusual that Mr. Morris Miller, who has given much attention to the surface geology of this region, was much struck by it. In a paper which he has published, he accounts for the existence of this mass of transported material by supposing it to be the product of a great flood which burst through the gap I have described. It seems to me, however, that the rolled and rounded condition of the gravel and bowlders which compose this great bed of valley Drift plainly records the action of a steady flowing, though powerful stream.

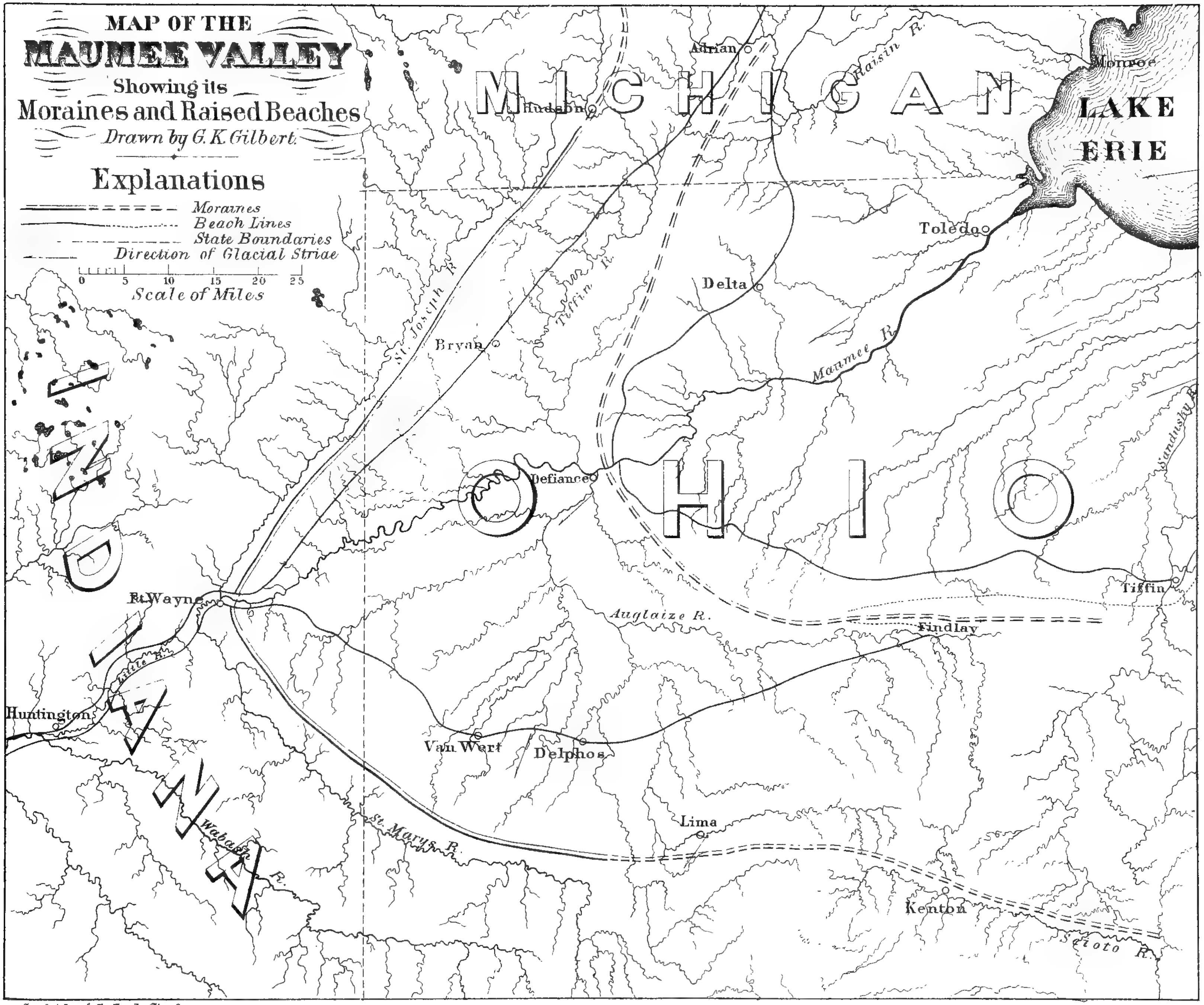
A more recent water-gap, yet very ancient, apparently similar in character to those described above, is that which connects the valley of the Maumee with that of the Wabash. Of this a detailed description is given by Mr. G. K. Gilbert in his report on the "Surface Geology of the Maumee Valley." As this is so minute and graphic, I quote largely from it, for the purpose of bringing the facts he cites into connection with those observed by myself. Speaking of the old lake beaches, he says:

"The upper beach (having an altitude of 220 feet above the Lake) consists in this region of a single, bold ridge of sand, pursuing a remarkably straight course, in a north-east and south-west direction, through portions of Defiance, Williams, and Fulton counties. When Lake Erie stood at this level it was merged in the north with Lake Huron. Its south-west shore crossed Putnam, Allen, and Van Wert counties, and stretched north-west in Indiana nearly to Fort Wayne. The north-western shore line, leaving Ohio on the south line of Defiance county, is likewise continued into Indiana, and the two converge at New Haven, six miles east of Fort Wayne. They do not, however, unite, but, instead, become parallel, and are continued as the sides of a broad water-course, through which the great lake basin then discharged its surplus waters south-westward into the valley of the Wabash river, and thence to the Mississippi. At New Haven this channel is not less than a mile and a half broad, and has an average depth of twenty feet, with sides and bottom of Drift. For twenty-five miles this character continues, and there is no notable fall. Three miles above Huntington, Indiana, however, the Drift bottom is replaced by a floor of Niagara limestone, and the descent westward becomes comparatively quite rapid. At Huntington the valley is walled, on one side at least, by rock *in situ*. In the eastern portion of this ancient river bed the Maumee and its branches have cut channels fifteen to twenty-five feet deep, without meeting the underlying limestone. Most of the interval from Fort Wayne to Huntington is occupied by a marsh, over which meanders the Little river, an insignificant stream, whose only claim to the title of river seems to lie in the magnitude of the deserted channel of which it is sole occupant. At Huntington the Wabash emerges from a narrow cleft of its own carving, and takes possession of the broad trough to which it was once but a humble tributary. The limestone above Huntington is the rocky rim, or dam, which determined the altitude of the overflow at this point, and is 170 feet above the present level of Lake Erie. Above it the stream must have resembled the Detroit, bearing a smooth surface, but with enough current to excavate its soft bottom somewhat deeply where the marsh and prairie of the Little river are now spread; below, it was more comparable to the Niagara at Buffalo, where it rushes over the outcrop of the Corniferous limestone. At Fort Wayne the St. Joseph's and St. Mary's contributed their waters. Their mouths were fifty feet higher than now, and the flood-plains of gravel and sand which they then formed now flank their valleys as terraces, and can be traced for forty miles toward their sources. When they were united by the retiring of the Lake, but slight cause was needed to turn them eastward along the level bottom of the deserted channel; and they have now cut their beds so deeply in the Drift that the highest freshets do not connect them with the Little river."

TERRACES AND BEACHES.

The withdrawal of the water of the last submergence of the Drift took place slowly, and its progress was marked by periods of rest, and, perhaps, of recession. In these intervals, the terraces which line the banks of so many of our rivers were formed, and hence this has been designated the *Terrace Epoch.* Local and minor terraces are produced by streams as they deepen their channels and swing from side to side in their valleys, but all the great and general valley terraces were formed by the arrest in still water of the materials transported by water in motion; the still water having been that of lakes subsequently drained, or that of the ocean withdrawn from inlets or arms which it once occupied. Terraces are also formed on the shores of the ocean and large lakes by shore waves, which deeply notch the slopes upon which they beat. Should the water level be depressed, or the land elevated, with intervals of stability, such terraces would constitute a series of steps, or benches, cut in the superficial or rocky material of the shore.

The terraces of the valleys of the Ohio and its tributaries have never been carefully studied, but it is well known that all the important streams of the Ohio system show them with more or less distinctness. In the Ohio valley are some strongly marked terraces, which rise high above the flood-plain, and are favorite sites for residences and towns. Cincinnati is built on one of these. This has an average elevation of 108 feet above low-water mark in the Ohio. According to Prof. Orton, this may be taken as a fair sample of them all: "It is composed of distinctly stratified gravel and sand of various degrees of fineness and purity. The gravel stones are all water-worn. In weight they seldom reach ten pounds. The upper tributaries of the Ohio supplied the materials, in part; but a much larger proportion, in the vicinity of Cincinnati, is derived from the limestones of western Ohio and the crystalline rocks of Canada. Occasional seams of clay loam occur in the terraces, but seldom of tenacity enough to constitute reliable water-bearers. Less frequently met, but still constituting a noteworthy feature of the gravel terraces, are seams of bituminous coal in small, water-worn fragments." It is scarcely necessary to say that the gravel terraces of the Ohio were once the bottom of this stream, then flowing 250 feet above its more ancient



Strobridge & Co Lith. Cin. O.

rocky bed. As the current of this river was checked by the still water which then set far up from the Gulf, the coarser materials transported by it were deposited, forming a flood-plain which once stretched across the whole breadth of the valley. A subsequent elevation of the continent made the drainage freer, and caused the river to cut away all the vacancy between the terraces in which it now flows. It will be understood, from the allusions before made to them, that the gravel terraces are the last formed of all the series of Quaternary deposits, and they were produced during the retirement or reflux of the water which filled the whole valley and caused the deposition of the sheets of Drift which overlie the Forest Bed.

The probable equivalents of these are found beneath the gravel terraces in the Ohio valley, and have been described by Prof. Orton in his report on the geology of Hamilton county. They have also been alluded to on a preceding page in this chapter, and it will be remembered that they include an old soil, with rooted stumps, prostrate trunks, leaves, and fruits of trees and plants now growing in the valley of the Ohio. But this old soil lies nearly down at low-water mark, the flood-plain of the present river being forty feet above it. We have evidence, therefore, that at a time previous to the last submergence of the Ohio valley, and previous to its being filled with the gravel beds which now form its terraces, the Ohio river flowed full forty feet lower than now, and its bottom lands were overgrown with a dense forest similar to that which now grows at a higher level. The record of this sequence of events, surprising as it may be to many, seems to be clearly legible.

The valley of the Ohio was, for the most part, cleared of water while yet the lake basin was filled, and formed a great fresh-water sea. This was gradually drained, first by the waste-weirs, already described, and subsequently by the opening of other outlets, until finally the water level has been reduced several hundred feet, and the old inland sea is represented by our chain of great lakes. This depression of the water level either took place in a number of paroxysms, or slowly, with long intervals of arrest. These paroxysms, or stops, are distinctly recorded in the remarkable series of ancient beaches (lake ridges), terraces, and cliffs which mark the old shore lines on all the declivities that surround the lakes. Just how this vast body of water was drained away we shall probably never fully ascertain, but we know that it flowed off by several outlets, and in several directions. As remarked elsewhere, it is probable that the glaciers which filled the lake basins for ages, constituted ice-dams, that obstructed the natural lines of drainage, and maintained a high surface level in the water that succeeded them. As the glaciers melted away, one and another outlet was opened for the water, and these outlets were certainly deepened in the lapse of time. It is also possible that warping of the earth's crust may have changed the relative altitudes of different portions of the margin of the lake basin. We know that deeply buried channels connect the basin of Lake Michigan with the Ohio and Mississippi, but they were probably excavated previous to or during the ice period, and were subsequently filled and obliterated by the later deposits of the Drift. The present divide between the waters of Lake Michigan and the Mississippi is so low that water would pass over it if the channel of the Niagara below the falls were filled, and the river were forced to flow, as it once did, into Lake Ontario from the summit of Queenstown heights. It is, therefore, evident that the margin of Lake Michigan has been depressed, or that the Straits of Mackinaw were closed by ice, earth, or rock, when Lake Erie stood, as we know it did stand, several hundred feet higher than now. Great changes must have taken place, also, at the Niagara outlet since the old shore lines that encircle Lake Erie were marked out, as the restoration of the barrier at Queenstown heights would not bring the surface of the Lake up to the lowest of the old beaches. There is no doubt that an old channel, more than 200 feet deep, connects the rock basin of Lake Erie with that of Lake Ontario, and the latter with the Hudson; but these old channels were filled with Drift deposits long before the lake ridges were made, and by the heaping up of Drift material the drainage was turned into new channels, along the line of lowest levels. It happened that this line ran over a spur which projects into the basin of the great lakes, and this spur, partially cut away, now forms the rocky barrier over which Niagara pours. The establishment of this line of drainage is a very modern affair, for all the sequence of Drift phenomena, even to the formation of the successive lake ridges, preceded it. But its antiquity, as compared with the reach of human history, is shown by the profound gorge which has been slowly excavated since the waters of Lake Erie began to flow over this barrier.

Whatever was the condition of other portions of the country bordering the great lakes, we have incontestible proof that in Ohio the water of Lake Erie once covered all the northern counties, and reached up to the passes in the divide, and that subsequently the water level descended step by step, resting at certain intervals, while the shore waves heaped up beaches along the gentle slopes, cut the more abrupt declivities into terraces, and washed prominent rocky headlands into water-worn and often vertical cliffs, until finally the present water level was attained, and shore cliffs and beaches were formed as we now find them.

The formation of the lake ridges and terraces was the last in the sequence of events which make the history of our surface geology. These bring us down to the present time, which, to our limited view, seems a period of rest, but every day sees something taken from the barrier of Niagara, and at no distant day, geologically speaking, Lake Erie will have shared the fate of all lakes, and have been drained to its bottom. The present shore line, with its terraces and ridges, will then simply add another to the list of those that have preceded it, and which we can so distinctly trace upon the surface. The lake ridges, as they are commonly called, have been more or less minutely described by many writers on the geology and topography of the lake basin. They are found encircling all the great lakes, but more careful observation is required before the relations between the different series which have been observed can be considered established. The ridges which surround Lake Ontario were first described by Lieutenant Roy and Sir Charles Lyell. They found on the Canada side eleven of these ridges, rising one above another, the highest being 762 feet above the surface of the Lake. On the south shore a similar series has been described by the New York geologists. Prof. Hall mentions five of these, while other observers have reported as many as fourteen, of which the highest has an elevation about the same as that of the highest on the Canada shore. On Lake Superior old lake beaches have been noticed in several localities, and some of them have been described in the reports of Messrs. Foster and Whitney. No extended survey has been made of them, however, from which the history of the decline of the water level can be fully made out. Some of them approach closely to the present water line, and give evidence of comparatively recent changes in that region. This is also shown by the interesting facts reported by Prof. Pumpelly, and brought to light in the excavation of the Portage Canal. Here copper implements and the copper shoe of a setting-pole were found in the bed of a channel, which, though now dry land, was evidently once filled with water, and was navigated by the ancient inhabitants of this region.

On the Canadian side of Lake Superior, at Petit Ecris, seven terraces of sand and gravel rise, one above another, to the height of 931 feet above the sea level. Their elevations above the Lake are respectively 30, 40, 90, 224, 259, 267, and 331 feet. Terraces in the solid rock, marking old water lines, have been also noticed in the north shore of Lake Superior by the Canadian geologists. The ridges of Lake Huron have never been carefully examined, but they are mentioned as occurring in various places, and at different levels, by Dr. Bigsby and Sir William Logan. On Owen's Sound three are mentioned, which lie at 120, 150, and 200 feet above the present level of Lake Huron. At Piette's Harbor two ancient beaches are found, one at 149, and another at 175 feet above the Lake; besides others at lower levels. In many of the lower beaches of Lake Huron fresh-water shells of species now inhabiting the Lake are found in great numbers, also human and other bones, twigs, trunks, and the bark of trees; in fact, all the things that wash up on the beach and are buried there in the sand. On the west side of Lake Huron lake ridges are mentioned by Prof. Winchell as occurring in many places, and old water lines are plainly traceable, both by ridges and rock terraces, at Mackinaw. Near Detroit parallel ridges are described as occurring on opposite sides of the Detroit river, 130 feet above the stream.

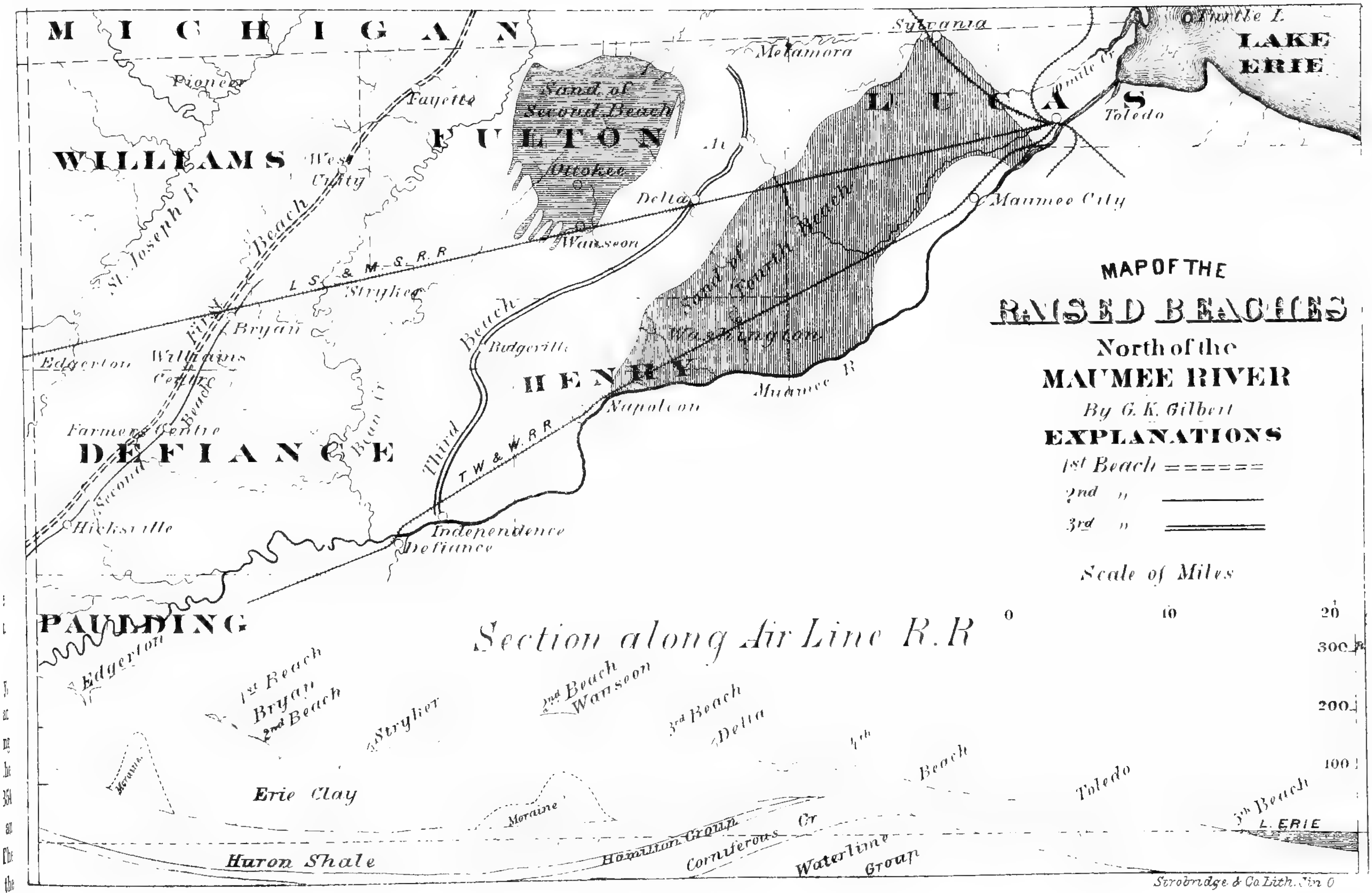
The old beaches of Lake Michigan have been studied and described with much care by Dr. E. Andrews, of Chicago. On the west side of the Lake the land is usually low, and the highest ridge below Milwaukee is 54 feet above the surface of the Lake. This sweeps around the south end of Lake Michigan, and is supposed to be continuous with a ridge which has an elevation of 140 feet on the east side of the Lake. At the head of Lake Michigan there are three parallel ridges, with several broken ones, and many sand dunes formed by the wind. Of these ridges, the highest is that before mentioned, 54 feet above the Lake. The second is 15 to 18 feet lower, and the third is just above the water line. The interesting fact is mentioned by Dr. Andrews, that of the three ridges on the south shore of Lake Michigan, the highest was formed first, the lowest next, and the middle one last; showing that a depression of the water level took place somewhat suddenly from the upper to the lower ridge, and that subsequently the water rose again to form the middle ridge. This is indicated by a bed of peat, which, in places, reaches from the upper to the lower ridge beneath the middle one. Dr. Andrews's theory is that this peat bed was formed in a marsh behind the lower ridge, and was subsequently covered with sand washed from the lower ridge to form the middle one. The upper ridge, about the south end of Lake Michigan, is said by Dr. Andrews not to be continuous back of Chicago, but to form two converging lines, which pass westward on either side of an old river bed through which the water of Lake Michigan once flowed into the Mississippi, precisely as the water of Lake Erie once drained into the Wabash. Fresh-water shells are also said to be found in the surface deposits on the Kankakee summit, and these are regarded as evidence that Lake Michigan once extended southward over that summit. If it should prove, as supposed by Dr. Andrews, that the highest lake ridge at Chicago is continuous with a much higher one on the east side of the Lake, this will indicate a great subsidence of the western shore of Lake Michigan at a comparatively recent date. But the continuity of these ridges has not yet been demonstrated, and, therefore, this subsidence cannot be said to be proven. Until this theory shall be sustained by further evidence, it will probably be safer to suppose that the highest ridges on the two sides of the Lake are not identical, and that when the highest ridge in Michigan was formed the Lake overtopped the barriers that now surround it, and extended far to the south and west of its present limits, covering all northern Illinois and southern Wisconsin. We may even suppose that it covered the country about the confluence of the Mississippi and Missouri around St. Louis, and formed the body of water in which the Loess was deposited. In this view, the absence of higher ridges around the south end of Lake Michigan would be due simply to the fact that no shore lines were there upon which they could be formed.

In Ohio the lake ridges can be traced almost continuously from the line of Michigan to that of Pennsylvania. In this series three distinctly marked ridges are to be seen in a great number of localities, and several intermediate ones may often be discerned. The local phenomena presented by these ridges have been described somewhat in detail in the reports of Messrs. G. K. Gilbert, J. H. Klippart, and N. H. Winchell, and also in the reports on the different counties through which they pass—Fulton, Henry, Putnam, Hancock, Seneca, Huron, Lorain, Cuyahoga, Lake, and Ashtabula.

In the western counties, where the slope of the watershed is gentle, the lake ridges are widely separated, strongly marked, and continuous; while toward the east, where the land rises rapidly back from the Lake, they are crowded closely together, are often broken, and on abrupt declivities composed of hard material, are replaced by terraces. In the Maumee valley the ridges are frequently raised above the adjoining country, like railroad embankments; and being well drained and dry, they are generally chosen as routes for the country roads and as sites for residences. By Mr. Gilbert there are thought to be four lake ridges in the Maumee valley, of which the altitude, where they are crossed by the air-line branch of the Lake Shore and Michigan Southern Railway are 220, 195, 165, and 90 to 65 feet above Lake Erie. Of these, the highest passes from Adrian, Michigan, through Fayette, Bryan, Unity, Hicksville, and New Haven, to Fort Wayne, where it forms parallel lines on the opposite sides of the old river which once flowed out of Lake Erie; thence it passes eastward through Van Wert, Delphos, Findlay, etc. A higher and equally continuous ridge lies back of this, passing from Hudson, Michigan, on the left bank of the St. Joseph's river, to Fort Wayne, and on the south side of the Maumee, running south-easterly to Lima and Kenton. This ridge he does not consider to be an old lake beach, but rather a swell of the Erie clay determined by a buried moraine. The conjecture seems very plausible, except that it is hardly necessary to suppose that a moraine of gravel and bowlders here underlies the Erie clay, since this clay—if I am correct in my ideas of its genesis—when unstratified and a bowlder clay, is itself true moraine material. It would not be strange if we should find this accumulated in unusual quantities along certain lines within the lake basin, where the reach of the glacier was for a long time constant, and where circumstances were not favorable for its being washed away. The controlling influence which this *St. Mary's ridge*—as it is called by Mr. Winchell—has exerted over the flow of the St. Joseph's and St. Mary's rivers, would seem to indicate that it was a feature in the original topography of the country when left bare by the retirement of the lake waters.

The second beach of Mr. Gilbert's series runs closely parallel with the first, and is often confounded with it. The third beach, with an altitude of 165 feet, passes through Delta, Ridgeville, (Henry county) to Defiance; thence eastward to Tiffin. This, also, Mr. Gilbert supposes to be a beach line traced along the slope of a swell of Erie clay, over a buried moraine; a suggestion which I would emend as before. It will be noticed that this swell—but not the ridge—had the same influence on the courses of the Tiffin and Auglaize as the former one on those of the St. Mary's and St. Joseph's.

Mr. Winchell recognizes six parallel ridges in the Maumee valley, which he names the St. John's, the Wabash, the St. Mary's, the Van Wert, the Leipsic, and the Belmore ridges; his Van Wert ridge being identical with Mr. Gilbert's beach No. 1; his St. Mary's ridge being the same with Mr. Gilbert's upper moraine, having an altitude of from 354 feet at Hudson, Michigan, to 322 feet at Lima. This is certainly not an old lake beach, and should not be included in the same category. The same is true of his higher ridges, the Wabash, 350 to 408 feet, and the St. John's ridge, 386 to 490 feet above the Lake. These upper ridges of Mr. Winchell's series are altogether distinct, in their external characters and in their composition, from the lower ones, and have evidently been pro-



MAP OF THE
RAISED BEACHES
North of the
MAUMEE RIVER
By G. K. Gilbert
EXPLANATIONS
1st Beach
2nd "
3rd "
Scale of Miles
0
10
20
MICHIGAN
WILLIAMS
FULTON
LUCAS
HENRY
DEFIANCE
PAULDING
LAKE ERIE
Turtle I.
Sylvania
Metamora
Pioneer
Fayette
Sand of Second Beach
Ottokee
Wauseon
Delta
West Unity
St. Joseph R.
L. S. & M. S. R.R.
Stryker
Bryan
Edgerton
Williams Centre
Farmers Centre
Hicksville
Bean Cr.
First Beach
Second Beach
Third Beach
Ridgeville
Sand of Fourth Beach
Washington
Maumee R
Maumee City
Toledo
Napoleon
T. W. & W. R.R.
Independence
Defiance
Section along Air Line R.R.
300 ft
200
100
Edgerton
1st Beach
Bryan
2nd Beach
Stryker
2nd Beach
Wauseon
3rd Beach
Delta
4th
Beach
Toledo
5th Beach
L. ERIE
Moraine
Erie Clay
Moraine
Huron Shale
Hamilton Group
Corniferous
Cr
Waterlime Group
Strobridge & Co. Lith. Cin. O.

duced by quite different causes. The Wabash and St. John's ridges can hardly, with propriety, be considered ridges, as they are rather belts of knolls and hog's-backs, having no distinct continuity, nor uniformity of altitude; and they plainly belong to the same category with the gravel hills of Portage, Summit, Medina, and other counties occupying the more easterly portion of the watershed. The materials which compose them are doubtless in part morainic, but they have been rearranged, water-worn, and rounded, as they would not be by glacial action alone. I have compared this class of deposits with the kames and eskers of the Old World, and have considered them the product of breakers dashing over bars and shoals. The "St. Mary's ridge," which forms the divide between the St. Joseph's and Tiffin, and the St. Mary's and Auglaize, is as continuous as the lake beaches proper, but it is a gentle swell in the surface, several miles in width, and is composed mainly of undisturbed Drift clay.

In contrast with the so-called ridges I have enumerated, the lower three or four embankment-like elevations which traverse the surface parallel with the lake shore are much lower, narrower, and of a more uniform level. These are composed of water-washed beach sand and gravel, and contain, in some places, sticks, leaves, and fresh-water shells; and they only are, in my judgment, old lake beaches, washed up along shore lines, and marking different stages in the elevation of the water surface of the Lake.

Sometimes, instead of forming narrow embankments, the old beaches expand into broad sand-flats, or areas, set with knolls and broken ridges, some of which are shown in Mr. Gilbert's map of the raised beaches north of the Maumee river, here reproduced.

The following description of the lake ridges of the north-western counties is copied from Mr. Klippart's "Report on the Agriculture of the Maumee Valley," published in the Report of Progress for 1870, p. 321:

"A very remarkable feature of the surface of the valley is the distinct outline of ancient beaches, locally known as 'Sand ridge,' 'Oak ridge,' 'Sugar ridge,' found in nearly every county. The principal one of these enters Gorham township, in Fulton county, and passes diagonally in a south-westerly direction, taking in its course the village of Fayette. In this township the ridge has an elevation ranging from 225 feet in the north to 220 feet in the south. From here it passes into the north-eastern corner of Williams county, near the center of Mill Creek township; thence south-westerly through the village of Hamar, in West Unity. It here has an altitude of 230 feet above the Lake. Near Pulaski village it has an elevation of about 200 feet. The towns of Bryan and Williams Center are situated on it. From the latter place it passes into Defiance county, and is divided into two nearly parallel lines, west of

Farmer's Center, and continues its course south-westerly through Hicksville into the south-east corner of DeKalb county, Indiana; thence southward to a short distance south ot Fort Wayne, where it has an elevation of 230 feet, and forms the left bank of the Maumee. On the right bank is a similar ridge, which, entering Ohio at the south-western corner of Benton township, Paulding county, is traceable south-easterly to the town of Van Wert, where it has an altitude of 224 feet; thence to Delphos, where its elevation is 218 feet; thence to Gomer, and so on through Columbus Grove, Pendleton, Webster, and Benton, to Fort Findlay, in Hancock county. This portion of the ridge was the first wagon-road from Fort Findlay to Fort Wayne, and even at present is the best road in that region. Being composed chiefly of sand and fine gravel, with sufficient clay to pack well, and yet sufficiently porous to drain readily, it must always remain a good road. At Findlay its elevation is 225 feet. It undoubtedly passes through Marion and Big Lick, in Hancock county, but its outline is here obscure. There are sand dunes and small hillocks of sand, well mixed with clay, with an outline bearing a strong resemblance to a former ridge, through the four townships just named; but a similar obscure ridge may also be traced from Findlay to Fostoria, where it assumes a definite form again, with an elevation of 200 feet, and is traceable in the south-eastern direction through London and Hopewell townships, in Seneca county. Near Tiffin it has an elevation of 200 feet. From Tiffin it is traced in a north-easterly direction through Clinton, Pleasant, and Adams townships, where it leaves Seneca county, and passes into Green Creek township, Sandusky county. The village of Galetown is situated on it, and is here called the South Ridge road, leading to Bloomingville, in Erie county, where, for a short distance, its altitude is less than elsewhere.

"The second ridge passes south-westerly through Richfield township, in Lucas county; thence through Fulton, York, and Clinton townships, in Fulton county, and through Freedom and Ridgeville townships, in Henry county; thence south through Adams, Richland, and Highland townships, in Defiance county. At Independence, two miles east of the town of Defiance, this ridge crosses the Maumee at right angles. At Ayersville, in Highland township, Defiance county, there is an apparent junction of two ridges, the outer or oldest passing through Munroe, Farmer, Greensburgh, Ottumwa, and Blanchard townships, in Putnam county; Blanchard and Portage, in Hancock county; the southern portions of Henry, Bloom, and Perry, in Wood county; Jackson and Liberty, in Seneca county; Jackson, Baldville, Sandusky, Riley, and Townsend, in Sandusky county; and Margaretta township, in Erie county.

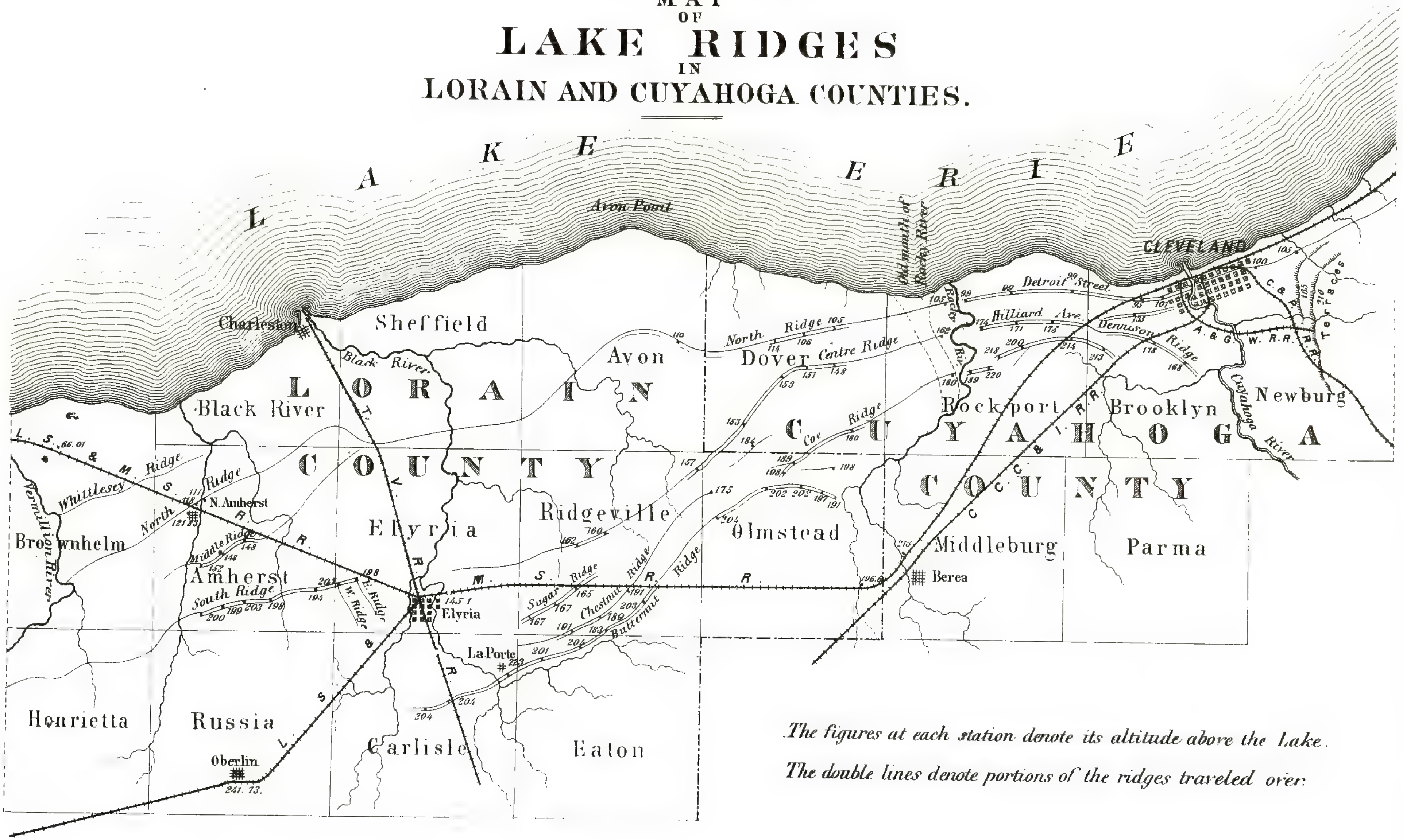
"From Ayresville, in Defiance county, the inner or more recent ridge passes through Pleasant and Marion townships, in Henry county, and the northern portion of Van Buren, in Putnam county, to Jackson, Liberty, Center, and Freedom townships, in Wood county. In the latter two townships it is locally known as the 'Scotch ridge.' Thence it passes into Woodville and Harris townships, Sandusky county, where it becomes obscure, or vanishes.

"These sand ridges are usually very narrow, but in places they are spread out over a considerable area, sometimes one-half to three-fourths of a mile wide. Again, they form vast dunes, as in Washington township, Henry county.

"The course, or direction, of these ridges is, as a rule, parallel to the shore of the Lake; or, in other words, at right angles to the general direction of the most rapid drainage. As a consequence, this drainage has been much obstructed, and we not

GEOLOGICAL SURVEY OF OHIO.

MAP OF LAKE RIDGES IN LORAIN AND CUYAHOGA COUNTIES.



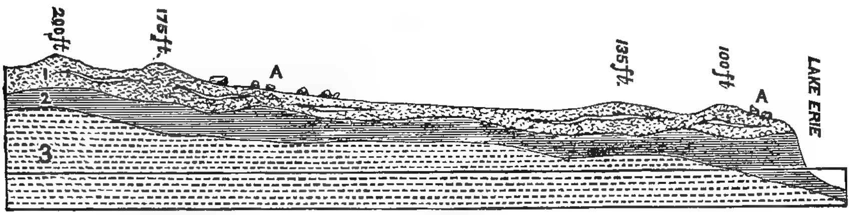
The figures at each station denote its altitude above the Lake.

The double lines denote portions of the ridges traveled over.

unfrequently find a marsh created by a ridge which presents a barrier to the passage of water to a lower level."

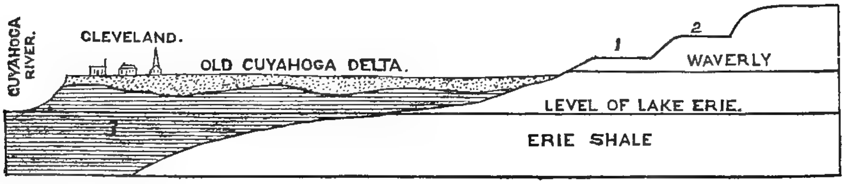
The lake ridges have not been carefully traced throughout their entire extent, as this was a task which required more time and money than we have felt justified in devoting to it; but they have been carefully examined and mapped in many different localities, and the succession at these points shows a remarkable correspondence. In some places, where the topography of the lake shore has been irregular, the ridges are much broken up and run into each other, in such a way that it is very difficult to trace them. This has led to some confusion of identity, and has caused an unwarranted variation of level to be assigned to some of them. On abrupt declivities, as has been mentioned, these old shore lines are represented by terraces. A very good example of this is seen at Berlin Heights, Erie county, where the highlands approach nearest to the lake shore and the connection of the ridges is broken. Here the base of the bluff is 60 feet above the Lake, and it shows on its slope three terraces, at the heights respectively of 100, 150, and 195 feet. Similar terraces may be seen on the slope of the headland which bounds the valley of the Cuyahoga on the east at its mouth. Here the old delta of the Cuyahoga forms a plain, which surrounds the base of the declivity, and is traversed by a ridge, of which the elevation is about 100 feet. Two terraces are seen over it, one of which is 165 and the other 210 feet above the Lake. We, therefore, have here three shore lines, which correspond to those on Berlin Heights; the slight differences of level reported in the two cases being due, perhaps, to irregularities in the surface of the terraces, or differences in the reading of the barometers employed. The lake ridges between the Vermilion river and the Cuyahoga have been examined by Prof. A. A. Wright and myself, and they will be found described in detail in the reports on the geology of Lorain and Cuyahoga counties; their relations will also be seen at a glance by reference to the accompanying map. It will be noticed that in some instances the ridges curve up into the valleys of the rivers, as on the Cuyahoga at Cleveland, and the Black river at Elyria, while, in other instances, they terminate abruptly at the sides of the valleys, and their bearings are unchanged by these topographical features. This is noticeable in all the ridges which cross Rocky river, and in the crossing of all the streams by the lower ridge. The cause of this is to be found in the general topography of the lake shore, upon which these old beaches are contour lines, marked by the shore waves at the water level. The valley of the Cuyahoga was, as we know, deep and broad near its mouth, and was only partially filled by the Drift sediments. Hence, when the upper ridges were formed, it was an arm of the Lake, into which the ridges were deflected on the west side, where the slope was gentle and the material soft. On the east side the waves raised by westerly winds cut terraces at corresponding elevations. The valley of Rocky river, near its mouth, is a narrow gorge of quite recent date, and the manner in which the ridges terminate on its margins show that it had no existence when they were traced on the surface; hence we are justified in concluding that all the rock-cutting of the Rocky river gorge has been done since the ridges were formed. The fact that the lower ridge runs directly across the delta plain at the mouth of the Cuyahoga proves not only that the valley was filled to this point when the ridge was formed, but since this ridge is here underlaid by about 300 feet of Drift deposits, the upper part consisting of fine laminated clays and stratified sand and gravel, that glaciers could have had no agency in its formation. The succession of beaches on the west side, and the terraces east of the valley at Cleveland, are shown in subjoined wood-cuts.

PROFILE SECTION OF LAKE RIDGES, CLEVELAND, WEST SIDE.



1. Sand, gravel, and clay. 2. Erie clay, laminated. 3. Erie shale. A A. Bowlders.

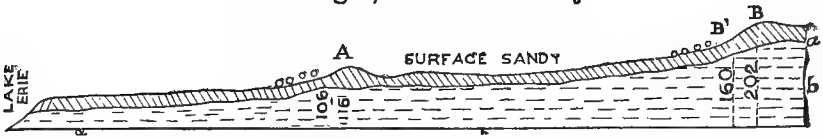
Terraces East of Cleveland.



1. First Terrace, 165 feet above the Lake.
2. Second Terrace, 210 feet above the Lake.
3. Drift deposits forming the old Delta of the Cuyahoga and filling the old valley.

East of Cleveland the lake ridges continue into Pennsylvania and western New York, and probably connect with the series observed on the south shore of Lake Ontario; for when the water stood at the level of the lowest of the ridges of Lake Erie, they overtopped the divide which separates Lake Erie from Lake Ontario. In the counties of Lake and Ashtabula two distinct ridges are usually traceable, and sometimes one or two intermediate ones. Here, as west of the Cuyahoga, the north or lowest ridge, about 100 feet above the Lake, and another which corresponds to the south or highest ridge of the country west of Cleveland, and which has an elevation of about 200 feet, are the most constant. I give below two profile sections of the lake ridges in Lake and Ashtabula counties, taken from the reports of Mr. M. C. Read.

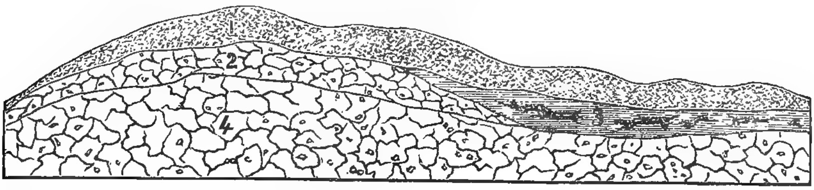
Lake Ridges, Ashtabula County.



a. Drift clay. *b.* Erie shale.

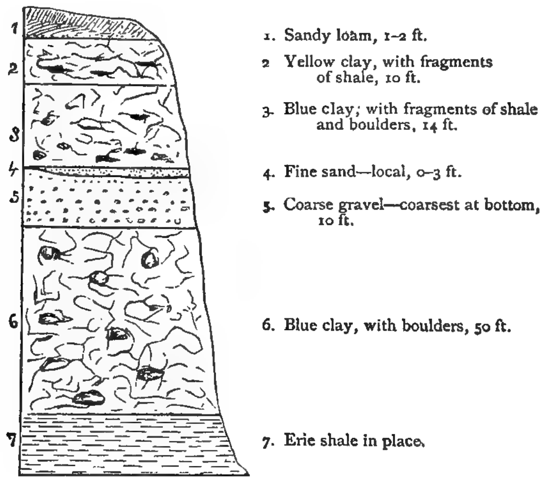
In explanation of the above profile Mr. Read says: "A and B represent the two continuous lake ridges, averaging in Ashtabula county about one mile apart. The spaces between them and between the north ridge and the Lake present to the eye the appearance of level terraces, but they slope gradually toward the Lake. The records of icebergs in the old lake, at comparatively recent epochs, are left in the granite bowlders scattered along the north slope—most abundant on the slope of the northern ridge." The following sections of the south ridge, taken by Mr. Read, give an interesting view of its structure:

PROFILE SECTION OF SOUTH RIDGE, ASHTABULA COUNTY.



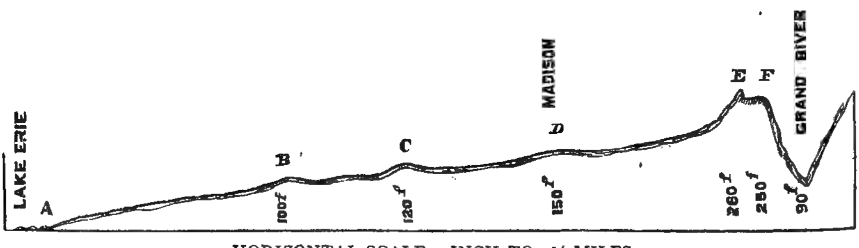
The summit of the ridge at this place is 202 feet above the Lake. No. 1 of the section is composed of water-washed sand and loam, from 4 to 6 feet thick, the maximum thickness being south of the crest of the ridge, where the sand is stratified in billowy lines, evidently carried by the wind from the old beach on the opposite side. No. 2 is yellow clay, and No. 4 blue clay, the first varying in thickness from 0 to 12 feet, the latter 20 feet thick to the railroad track. Both these deposits of clay are unstratified, and are filled with fragments of the local rocks, with many striated pebbles of metamorphic rock, and no water-worn pebbles or bowlders. No. 3 is an old swamp, containing fragments of coniferous wood, the earth deeply stained with iron, and in places containing bog iron ore at the bottom, the whole now covered with drifted sand. In the opinion of Mr. Read, the base of this ridge is an old moraine of bowlder clay, and such may be its character; but, as will be seen from the section given below, taken at the point where the Ashtabula and Jamestown Railroad cuts through this ridge, its upper portion is stratified, and it is capped with beach sand. It seems to me more probable that it is a clay terrace, capped with a ridge thrown up by the shore waves. The old swamp,

Section of Drift Clays, Ashtabula, O.



with its muck bed and buried timber, is the counterpart of others that are found behind the ridges in a great number of localities. Similar swamps may be seen behind the beach ridges now forming along the present shores of Lake Erie and Lake Michigan.

Profile Section from Lake Erie to Grand River.



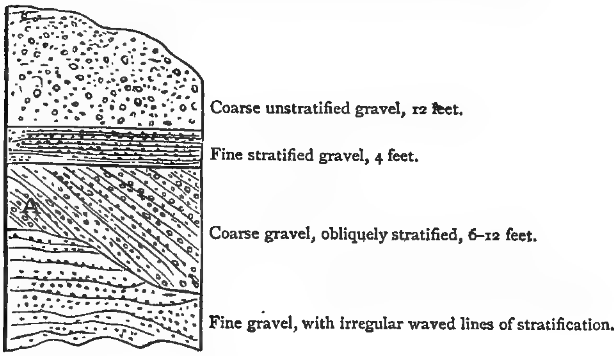
HORIZONTAL SCALE, 1 INCH TO 1½ MILES.

In his report on Lake county, Mr. Read gives a profile section of the lake ridges, with the following explanatory notes:

"In Madison township the slope from the Lake rises more gradually than further west, and the lake ridges are more regular and are better defined. The section given below reaches from the Lake through Madison Center to the bed of Grand river.

The bluff of the river is 250 feet above the Lake. An irregular clay ridge is a half mile north of the bluff. This is 260 feet above the Lake, and is composed of bowlder clay, with a surface somewhat irregular from the effects of erosion, but gently sloping to the sandy ridge, D, on which Madison village stands. From this point there is a rapid descent to the level of the railroad, the incline beyond being so gradual that the surface appears quite level, until the gravelly ridge, C, is reached. Between D and C the soil is a gravelly loam, with some clay. Near the ridge, C, it is somewhat swampy. The general slope from B to C is very regular, but the surface is much diversified by sand dunes and stretches of marshy land. The ridge at B is made of fine, water-washed and drifted sand. The north ridge, B, continues from Madison to Painesville, and consists of irregular sand dunes, constantly changing in form under the influence of the wind. Where undisturbed, it is from 10 to 12 rods wide, with a gentle descent on each side."

SECTION OF SOUTH RIDGE, PAINESVILLE, OHIO.



ORIGIN OF THE LAKE RIDGES.

In the preceding notes on the lake ridges so much evidence has been furnished that they are raised beaches, that little more need be said on this subject. It is, however, necessary that I should make brief reference to some theories that have been published in regard to the mode of formation of these ridges, and which are inconsistent with the views I hold. Of these theories, one is that advanced by Col. Chas. Whittlesey, who has gathered and published a vast number of interesting facts connected with the Drift of the Western States, that the lake ridges are sub-aqueous bars which were formed in the Lake, parallel with the shore, when the water stood at higher levels than now. The considerations which prevent my acceptance of this view are: First, that they show too much continuity, regularity of form, and uniformity of level, to have been produced in the manner suggested. Sand-bars, as we know, form off the mouths of rivers, and these, sometimes, have considerable linear extent; but so far as my knowledge extends, no sand-bars exhibit anything like the extent, continuity, and definiteness of form which we see in the lake ridges. Second, the materials that compose the ridges are frequently quite coarse, the stones which they contain sometimes being several inches in diameter, so coarse, indeed, as to be quite beyond the transporting power of currents in open water. Where the ridges widen out into knolls and plateaus, not composed of wind-drifted sand, we may very well suppose such sand-banks to have been formed by shore waves sweeping over flats or shallows. But the ridges proper are now under consideration, and these are seen to run, with almost mathematical accuracy, as contour lines around all the irregularities of the topography of the slope on which they were formed. Their summits are less uniform in altitude than their bases, because in some places they were built up higher than elsewhere by the wind, just as we see the sand of the beach now forming at Michigan City piled up by the wind in hills 175 feet in height. The ridges have been unequally eroded, too, in the thousands of years during which they have been exposed to the action of rain, frost, and wind, since their first formation.

By Mr. N. H. Winchell all the lake ridges are considered as moraines, more or less affected by the waves of the Lake. But, as we have seen, he has placed the kames, the broad ridges of bowlder clay—which may very well be considered as moraines—and the old lake beaches in the same category; whereas the narrow, continuous ridges, so constant in level and so nearly uniform in height—such as the lower three of his series—have very little in common with his upper so-called lake ridges, and are the products of a different cause. That these are not moraines, is plainly shown by the positions they frequently occupy; resting, as they do, on stratified sands and gravel, which would have certainly been broken up if the glacier had reached to the line of the ridges. It should be remembered that the polished floor of the old ice-excavated lake basin is covered with thick sheets of unstratified and stratified Drift, and that the lake ridges—when not terraces—are on the surface of these, and were formed by agencies acting long subsequent to the departure of both continental and local glaciers. The force which raised the ridges acted simply along the water lines formerly existing. It is possible that sheet-ice floating on the water surface may have contributed to their formation; and if in former ages the winters, colder than now, had covered our lakes with sheets of ice five or ten feet in thickness, their expansion in freezing would have been certain to leave some marks upon the shore, and we should have had our great lakes walled, as the little ones are now in Iowa. But in that case rocks and stones would have most sensibly felt the thrust of the ice, and would have been pushed up into the ridges.

As a matter of fact, bowlders are almost never found upon the true lake ridges, but are abundant on the slope between them, where they have been washed out and left specially conspicuous by the waves which carried away the softer material and piled it up in ridges. We seem, therefore, compelled to reject the supposition that ice in any form took part in the creation of the lake ridges. But we have ample demonstration that causes now in operation are abundantly capable of producing just such effects. Any one who will visit the head of Lake Michigan will see lake ridges now forming, and he will also see there older beaches at higher levels, made in ancient times, precisely as the modern ones are built up. The present shore of Lake Erie also furnishes similar examples, one of which I have before cited, viz., that which stretches from Cedar Point to the main land west of the mouth of the Huron, in Erie county. This has closed the former outlet of Sandusky Bay, and will, eventually, cause the shallow water basin behind it to fill up with sediment and become a marsh, or peat bog, like so many we find behind the older ridges. The Atlantic coast affords us innumerable examples of the formation of lake ridges at the present day. At Old Orchard beach, south of Portland, Maine, a continuous ridge of sand, from ten to twenty feet in height, completely encircles the bay, just back from the water's edge; and on the sandy shores from New Jersey southward such shore ridges would be almost constantly in sight to any one who would follow the coast. Some part of the confusion of ideas which has prevailed in reference to the lake ridges has arisen from the fact that they have been confounded with terraces, into which they sometimes merge. Thus, the north ridge, which stretches continuously from the Cuyahoga to Rocky river, is generally composed of loose material, water-worn gravel and sand, but in part of its course it is a terrace cut out of the Erie shale, slightly covered with a coating of gravel. In other cases, the lake ridges become terraces in the Erie clay, but they are shore lines all the same, and I find it hard to believe that any intelligent and unprejudiced observer, who will carefully examine the facts, will fail to subscribe to the view which I advanced many years since, that they are the product of shore waves along lines which mark periods of rest in the descent of the water level in the lake basins from the altitude it once reached, several hundred feet higher than now.

THE CAUSES OF THE ARCTIC CLIMATE OF THE ICE PERIOD.

The evidences of great alternations of climate during the latest geological periods are such that few intelligent persons hesitate to accept them as proven. From the Tertiary deposits of the far north, Alaska,

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Greenland, Spitzbergen, etc., the remains of more than 200 species of plants have been procured, which show that all the arctic land then enjoyed a mild climate, and were covered with luxuriant forests, such as would not now grow on this continent north of the 40th degree of latitude. We have also abundant proof that in the next succeeding age, the Quaternary, an extreme arctic climate prevailed over most of North America, and great ice-sheets, if not continental glaciers, reached as far south as Cincinnati; subsequently the climate ameliorated, and the glaciers retired to Greenland. Very naturally, when incontestible proof of these changes had been gathered, much discussion was excited in regard to their probable causes. This discussion is still going on, and there is great diversity of opinion on this subject, even among our most learned and wisest geologists. For the solution of the problem, the most detailed and laborious investigations have been made, such as required the profoundest knowledge of mathematics, physics, astronomy, and geology. It is evident, therefore, that anything like a thorough review of the subject would be out of place in this report of the facts gathered by the Geological Corps, and the briefest possible sketch of the present attitude of the question is all I shall attempt here. So much as that seems, however, to be required for the gratification of the interest which the facts I have given may have excited.

Various suggestions have been made to account for the ice period, which are mere efforts of the imagination; such as the passage of the solar system through cold spaces in the universe, changes in the position of the axis of the earth, etc. These, however, have been generally rejected, as they are destitute not only of all proof, but of probability. Sir Charles Lyell, perhaps the most sagacious and conservative of modern geologists, has attempted to explain the alternations of climate to which I have alluded, by referring them to changes in the distribution of land and water; arguing that by the concentration of land about the pole, where snow and ice could gather in unlimited quantities, and propagate the cold of which they themselves were the product, arctic conditions might be brought down as low as during the glacial period. He also claims that when the opposite condition prevailed in the distribution of land and water, and the continents were spread out under the tropical sun to absorb and disseminate its heat, while an open sea occupied the arctic regions, glaciers could have no existence in either hemisphere. This view has been quite generally accepted by geologists, and is that advocated by our highest American authority in physical geology, Prof. Dana. The conviction, however, has, of late years, been gaining ground, that this theory was inadequate to account for the stupendous changes of which we have record, and geologists and physicists have been reaching out for some broader and more powerful influence than any terrestrial changes could produce. The objections to Lyell's theory are simply its insufficiency; and while no one questions the fact that very considerable changes of climate could be produced by altering the arrangement of continents and seas, it seems hardly possible that so great variations of climate as those under consideration could be effected by the most radical re-distribution of territory. The advocates of Sir Chas. Lyell's view hardly realize, as it seems to me, that if the land surface of the globe was concentrated in a belt in the tropics, the distribution of heat from the tropics to the poles would be almost exclusively through the medium of the atmosphere, for the great system of oceanic circulation which now prevails would then be totally abrogated. But it is more than doubtful whether much heat could be carried from the tropics into the arctic regions through the agency of the winds, since the upper strata of the atmosphere are very cold, and heated air rising from the tropical land would soon be cooled, and thus the influence of such land could not reach far, either north or south. It seems to be well established, also, that the present diffusion of tropical heat is chiefly through the agency of ocean currents, such as the Gulf stream, and these ocean currents all spring from a great equatorial current which passes from east to west across the Atlantic and Pacific oceans. From this, branches, which are great ocean rivers of warm water, flow off north and south, forming circles in each half of each great ocean. The motive power of this system of oceanic circulation is apparently derived from the equatorial belt of trade-winds, which derive their motion, from east toward the west, from the slight lagging of the atmosphere in the rapid rotation of the earth's surface. Hence it is evident that if we were to fill the interval between the tropics of Capricorn and Cancer with land, the transfer of heat through this medium would be arrested.

Another argument against the Lyellian hypothesis may be drawn from observed geological facts. As I have before stated, the proof is abundant that in the Miocene Tertiary epoch a warm-temperate climate prevailed as far north as the shores of the Arctic sea. But we know that at that time the land area in the arctic regions was scarcely less extensive than now; and that the outlines of the central and southern portions of the continent have changed but little since then. Hence we are justified in saying that no changes in the land area of North America have taken place since the Tertiary age which could be regarded as the cause of the great changes of climate which are distinctly recorded in the Quaternary. It may also be said that no stronger confirmation of Lyell's theory can be drawn from the geological facts observed in the Old World. We are, therefore, apparently driven to seek a solution of the problem in some extra-terrestrial or cosmical cause. One has been suggested, in the variation in the eccentricity of the earth's orbit, which places the subject in an altogether new light, and promises, at least, to lend important aid in removing the obscurity which has hitherto hung over it. This suggestion was first made by Sir John Herschell, but it has been recently advocated with so much originality and force by Prof. James Croll, of Glasgow, that we may almost consider him as its author. At the instance of Prof. Croll, Mr. Stone, of the Greenwich Observatory, made careful determinations of the eccentricity through several millions of years, running forward and backward from the present time. It was thus ascertained that it passed, at remote intervals, through maxima and minima of considerable magnitudes. During the period of the greatest eccentricity, the earth, in aphelion, would be about 100,000,000 miles from the sun, or over 8,000,000 further than now, while in its perihelion it would be proportionally nearer. As the amount of heat received by the earth from the sun would be the same in its maxima and minima of eccentricity, it might be supposed that the climate would not be affected by this cause; but when the precession of the equinoxes is taken into account, it can be shown that the winter in the northern hemisphere was sometimes thirty-six days longer than the summer; the heat received being, during the winter, one-fifth less than now. Hence, though the summer was one-fifth hotter, it was not sufficiently long to melt the snow and ice of winter; and thus the effects of the cold winter might be cumulative* in each hemisphere through what may be called the winter half of the great year (of 21,000 years) produced by the precession of the equinoxes. Prof. Croll estimates that the influence of extreme eccentricity, acting in the manner described, might be sufficient to depress the average annual temperature of London 40° Fahrenheit, and thus produce an arctic climate. We have space only for the results and not for the processes of Prof. Croll's theory, but the subject will be found discussed in great detail in his papers published in the *London and Edinburgh Philosophical Magazine*, 1867 to 1871. It is but fair to state that Prof. Croll's conclusions have

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* This effect would be the result of the difficulty with which ice is melted when once formed. It requires eight tons of rain, at 58° Fahrenheit, to melt one ton of ice; and large bodies of ice, in melting, surround themselves with vapors which intercept the sun's rays and retard the melting process. Such vapors rising to the height of a few hundred or, at most, a few thousand feet, are congealed to snow, to be remelted, or to pass into *neve*, and thence into ice again. Thus they become both active and passive agents in preventing the melting of ice fields.

been questioned by high authority; but it is also true that they have been received with much favor by both geologists and physicists, and have been generally accepted as affording a rational and plausible explanation of phenomena which have hitherto been regarded as inexplicable and mysterious.

THE CAUSE AND MANNER OF MOTION IN GLACIERS.

The theory that a great ice-sheet once covered much of North America, and moved from the north southward, has been opposed by the argument that there was no declivity down which it could flow; that is, that the surface over which it has been traced was too nearly level and too irregular to permit a glacier to pass over it moved by gravity; and that no other *vis a tergo* could have caused its motion. To which it may be replied, that the record of the existence and reach of one or several great ice-sheets stands graven in solid rock, and is indisputable. Also, that the altitude of the northern highlands has, as we know, been greatly reduced, largely by the action of the glaciers themselves; and further, that the relative levels of different portions of the glacial track may have been changed by local subsidence or elevation. It should also be said that ice is not an inflexible solid, like wood or stone, but that it is endowed with a plasticity that makes it comparable rather with resin or pitch. This is shown by the manner in which it flows through valleys, expanding and contracting according to the nature of the channel, flowing faster at the surface than at the bottom and sides; in short, behaving as water does in similar circumstances. If piled high enough, even on a plain, ice would unquestionably spread and sink by its own weight. If with a depression of temperature snow were now to accumulate to the depth of several thousand feet on the Canadian highlands, it would be compacted below into ice, which would be pressed out on all sides, unless some impediment restricted its flow. If impediments resisted its motion in certain directions, it would flow toward the point of least resistance. During the ice period the movement of the ice toward the north was prevented by a continuous ice-sheet, held in adamantine solidity by perpetual cold; while toward the south it was softened by a mild temperature, and in certain directions no impediment lay in its way, except irregularities of the surface, which were relatively small. Hence it flowed out in these directions to points where it was melted.

The manner in which ice flows has been discussed with more prolixity and bitterness than perhaps any other problem in physics. By Principal Forbes the practical plasticity of ice was called a viscosity; in other words, a freedom of motion of the particles on themselves, as in pitch;

while Prof. Tyndall claims that the change of form in ice is effected by fracture and regelation; ice having the peculiar property of reuniting in a solid mass when fractured and the separated surfaces brought together again in water. It has been generally supposed that the position taken by Prof. Tyndall had been demonstrated to be correct, but ice sometimes exhibits a change of form where regelation seems impossible. For example, Dr. Kane describes, in his Arctic explorations, a sheet of ice eight feet thick, resting on supports twenty feet apart, which curved downward five feet, although the mercury was constantly far below the freezing point. This seems to be an *experimentum crucis*, and shows that ice is capable of undergoing a change of form through a rearrangement of its molecules without fracture and regelation. This will not seem surprising when we reflect that most solids exhibit the same property in a greater or less degree; even iron and steel, which may be permanently bent without fracture, show a change of form through a molecular rearrangement. The motion of glaciers is undoubtedly effected partly by sliding, partly by fracture, and in part also by a true plasticity or molecular change of form in the ice which composes them.

DRIFT GOLD.

Gold has unquestionably been found in the Drift in a large number of localities in Ohio and Indiana. My attention was first called to it many years since by Prof. L. H. Smith, then of Kenyon College, who showed me scales of gold taken from the Drift near Bellville, in Knox county. Since the organization of the Geological Survey I have received a number of additional specimens obtained from the surface deposits in the same region. It occurs in very fine particles, and is associated with beds of clay, sand, and gravel, of which the latter is largely composed of quartz pebbles. These may have been derived from the Waverly conglomerate, which has here been very extensively eroded. In the adjoining county of Licking, Prof. Andrews reports finding gold in the Drift at several points. He mentions that—

"In the summer of 1868 gold dust of the value of seventeen dollars was washed out of fine drift material, in a little gully, well up the hill-side, on the farm of Daniel Drum, Bowling Green township, a mile north of Brownsville. The largest grains were reported to be of the size of a wheat grain. * * Near Newark, and north of the high grounds which divide the waters of the Licking river from those of the Moxahala and its tributaries, are other and larger deposits of gold-bearing sands. The place examined by me was one and a half miles south-east of Newark. Here is a range of Drift terraces, about fifty feet above the bed of the Licking river. These terraces are cut through by small streams from the hills to the south, and in the narrow ravines the gold is obtained from the sand and clays. The terraces contain also bowlders of granitoid rocks, quartzite, and small pebbles of white quartz. Bowlders of limestone, containing fossils of the Niagara and Clinton group, were also found in the terraces. The quantity of gold is small, but in my own experiments nearly every panful of dirt showed the 'color.' Mr. Jacob Shock, jeweler, of Newark, reports finding gold in small fragments of quartz."—*Report of Progress*, 1869.

Prof. Orton also reports the finding of gold in the bowlder clay of south-western Ohio. He says:

"It can be gathered in flakes from the surface of the clay and panned from the gravel derived from the clay. * * The total amount cannot be insignificant, but the percentage certainly runs very low. The working of beds of clay and gravel which have had such a history as our Drift formations as gold-bearing deposits, is, of course, preposterous, but just this has lately been attempted in Clermont county. A few years since the 'Clermont County Gold Mines' attained a short-lived, neighborhood, and newspaper notoriety. One or two thousand dollars in cash, and more than this in labor, were expended in ill-judged schemes, without other results than bringing into circulation a few score dollars' worth of Clermont county gold. * * From what has already been said, it will be seen that Clermont county has no monopoly of the gold-bearing formation of Ohio. This formation should be named the 'Drift gold field,' rather than the 'Clermont county gold field.' All of the counties of south-western Ohio certainly share in its treasures, and without doubt one locality is as good as another, where gravels are found that have been washed from the bowlder clay. The best results thus far known to have been obtained in gold-mining in Ohio are reported for Warren county, where in one day gold to the value of six dollars was obtained by an outlay of ten dollars; a half-dozen days' work being also thrown in."

Prof. John Collett, in his report on the geology of Warren county, Indiana (Fifth Annual Report Geological Survey of Indiana, 1873, p. 224), speaks of the occurrence of gold in the Drift as follows:

"At Gold Branch of Pine creek, north-west quarter section 23, township 22, range 8, on a gravel bar formed of the debris washed from the bowlder clay, a quantity of gold, reported at seventy dollars, was collected. An energetic Californian can pan out from one dollar to one dollar and a quarter per day at this and several other gravel bars in the county. An equal amount of labor expended at any ordinary avocation will bring better returns."

The occurrence of gold in the Drift of Ohio should not be a matter of surprise, but it would rather be strange if it were not found here. It is well known that a large part of the materials composing the Drift is derived from the Canadian highlands. These are mainly formed of Laurentian rocks, which are every where traversed by auriferous quartz veins.

Some hundreds, perhaps thousands, of feet have been taken off the Laurentian hills, and ground up and distributed over all the Drift area. The gold contained in this mass has shared the fate of the associated minerals, has been finely triturated, and has been carried as far as the glaciers reached. As the various conglomerates contained in the Carboniferous series have obtained their quartz pebbles from the same region which supplied those of the Drift, it is almost certain that gold is contained in all of them. As these rocks have been eroded, they may also have contributed something to the large aggregate quantity of gold disseminated through our superficial deposits.

ORIGIN OF THE GREAT LAKES.

The question of the origin of the great lakes is one that requires more observation and study than have yet been given to it, before we can be said to have solved all the problems it involves. There are, however, certain facts connected with the structure of the lake basins, and some deductions from these facts, which may be regarded as steps already taken toward the full understanding of the subject. These facts and deductions are, briefly, as follows:

1st. Lake Superior lies in a synclinal trough, and its mode of formation, therefore, hardly admits of question, though its sides are deeply scored with ice-marks, and its form and area may have been somewhat modified by this agent.

2d. Lake Huron, Lake Michigan, Lake Erie, and Lake Ontario are excavated basins, wrought out of once continuous sheets of sedimentary strata by a mechanical agent, and that ice or water, or both.

That they have been filled with ice, and that this ice formed great moving glaciers, we may consider proved. The west end of Lake Erie may be said to be carved out of the Corniferous limestone by ice action; as its bottom, and sides, and islands—horizontal, vertical, and even overhanging surfaces—are all furrowed by glacial grooves, which are parallel with the major axis of the Lake.

All our great lakes are probably very ancient, as, since the close of the Devonian period, the area they occupy has never been submerged beneath the ocean, and their formation may have begun during the Coal Measure epoch.

The Laurentian belt, which stretches from Labrador to the Lake of the Woods, and thence northward to the Arctic sea, forms the oldest known portion of the earth's surface. The shores of this ancient continent, then high and mountainous, were washed by the Silurian sea, where the debris of the land was deposited in strata that subsequently rose to the surface, and formed a broad, low margin to the central mountain belt; just as the Cretaceous and Tertiary strata flank the Alleghanies in the Southern States.

In the lapse of countless ages, all the mountain peaks and chains of the Laurentian continent have been removed and carried into the sea, and this has been done by rivers of water and rivers of ice. That these mountains once existed there can be no reasonable doubt, for their truncated bases remain as witnesses, and it is scarcely less certain that glaciers have flowed down their slopes, of sufficient magnitude and reach to deeply score the plain which encircled them.

It will be noticed that all the great lakes of the continent hold certain relations to the curving belt of Laurentian highlands.

Some of them are embraced in the foldings of the Eozoic rocks, and fill synclinal troughs; but most of the series, from Great Bear Lake to Lake Ontario, exhibit the same geological and physical structure, and are basins of excavation in the Palæozoic plain that flanks, in a parallel belt, the Laurentian area. Few of us have any conception of the enormous general and local erosion which that plain has suffered. Those who will take the trouble to examine the section across Lake Ontario, from the Alleghanies to the Laurentian hills of Canada, and compare it with the other sections in the Lake Winnepeg district, radial to the Laurentian arch, given by Mr. Hind in his report on the Assinniboin country, will be sure to find the comparison interesting and suggestive; suggestive especially of a community of structure and history, and of an inseparable connection between the lake phenomena and the topographical features of the Laurentian highlands, flanked by the the Palæozoic plain.

In estimating the influences that might have affected the number and magnitude of glaciers on the sides of the Laurentian mountains, it should not be forgotten that the Cretaceous sea swept the western shore of the Palæozoic and Laurentian continent, from the Gulf of Mexico to the Arctic ocean; and whether we consider this sea as a broad expanse of water simply dotted with islands, or a strait traversed by a tropical current, we have in either case conditions peculiarly favorable to the formation of great glacial masses of ice, *i. e.*, a broad evaporating surface of warm water swept by westerly winds, that carried all suspended moisture immediately on to a mountain belt, which served as a sufficient condenser.

This, at least, may be positively asserted in regard to the agency of ice in the excavation of the lake basins, that their bottoms and sides, wherever exposed to observation, if composed of resistant materials, bear indisputable evidence of ice action; proving that these basins were filled by moving glaciers in the last ice period, if never before, and that part, at least, of the erosion by which they were formed is due to these glaciers.

No other agent than glacial ice, as it seems to me, is capable of excavating broad, deep, boat-shaped basins, like those which hold our lakes.

If the elevation of temperature and retreat northward of the glaciers of the lake basins were not uniform and continuous, but alternated with periods of repose, we should find these periods marked by excavated basins, each of which would serve to measure the reach of the glacier at the time of its formation; the lowest basin being the oldest, the others formed in succession afterwards. Such a cause would be sufficient to account for any local expansions of the troughs of the old ice rivers.

Where glaciers flow down from highlands on to a warmer plain, the excavating action of each ice mass must terminate somewhat abruptly in the formation of a basin-like cavity, beyond which would be a rim of rock, with whatever of debris the glacier has brought down to form a terminal moraine.

When glaciers reach the sea, the great weight of the ice masses plows up the sea bottom out to the point where the greater gravity of water lifts the ice from its bed and bears it away as an iceberg.

If it is true, as the facts I have cited indicate, that our lakes are but portions of great excavated channels locally filled with Drift material, the fiords of the northern Atlantic and Pacific coast present remarkable parallels to them; and I would suggest Puget's Sound, Hood's Canal, and other portions of that wonderful system of navigable channels about Vancouver's Island, as affording interesting and instructive subjects for comparison. Like our lakes, these channels are for the most part excavated from sedimentary strata which form a low and comparatively level margin to the bases of mountain chains and peaks. They, too, have their depths and shallows, their basins and bars, and probably all who have seen them will assent to Prof. Dana's view, that they are the "result of subærial excavation," in which glaciers performed an important part.

There can be no doubt that the basin of each of the great lakes has been produced by a local glacier, and that the great ice-sheet which existed during the period of intensest cold, moving as a solid, continuous mass of great thickness, from north to south, would have the effect to obliterate rather than form such local troughs. Our lake basins must, therefore, have been formed before or after the continental glacier, or both before and after. Probably the latter is the true statement of the case. We find on the south shores of Lake Erie and Lake Ontario proof that the great glacier moving from the north encountered here a high ridge, which, though altogether the result of erosion, seems to have had an anterior existence; since the ice rose up its northern side, planed all the slope, and curved round and embraced its irregularities as though it followed rather than fashioned the topography. In the excavation of the Lake Erie basin the glacier by which it was formed moved in the line of its major axis from Buffalo to the islands. In the immediate basin of the Lake the rocks are all planed, scratched, and sometimes deeply furrowed in this direction; while on the plateau between Lake Ontario and Lake Erie the bearing of the marks is nearly north and south. That the depths of the basin were not excavated by the glacier which produced these last named grooves is certain, from the fact that the east and west grooves prevail almost exclusively on the islands and on the immediate shore of the Lake; the north-south furrows being very rarely visible, and where the two systems are seen together, the east and west grooves seem to be the most recent.

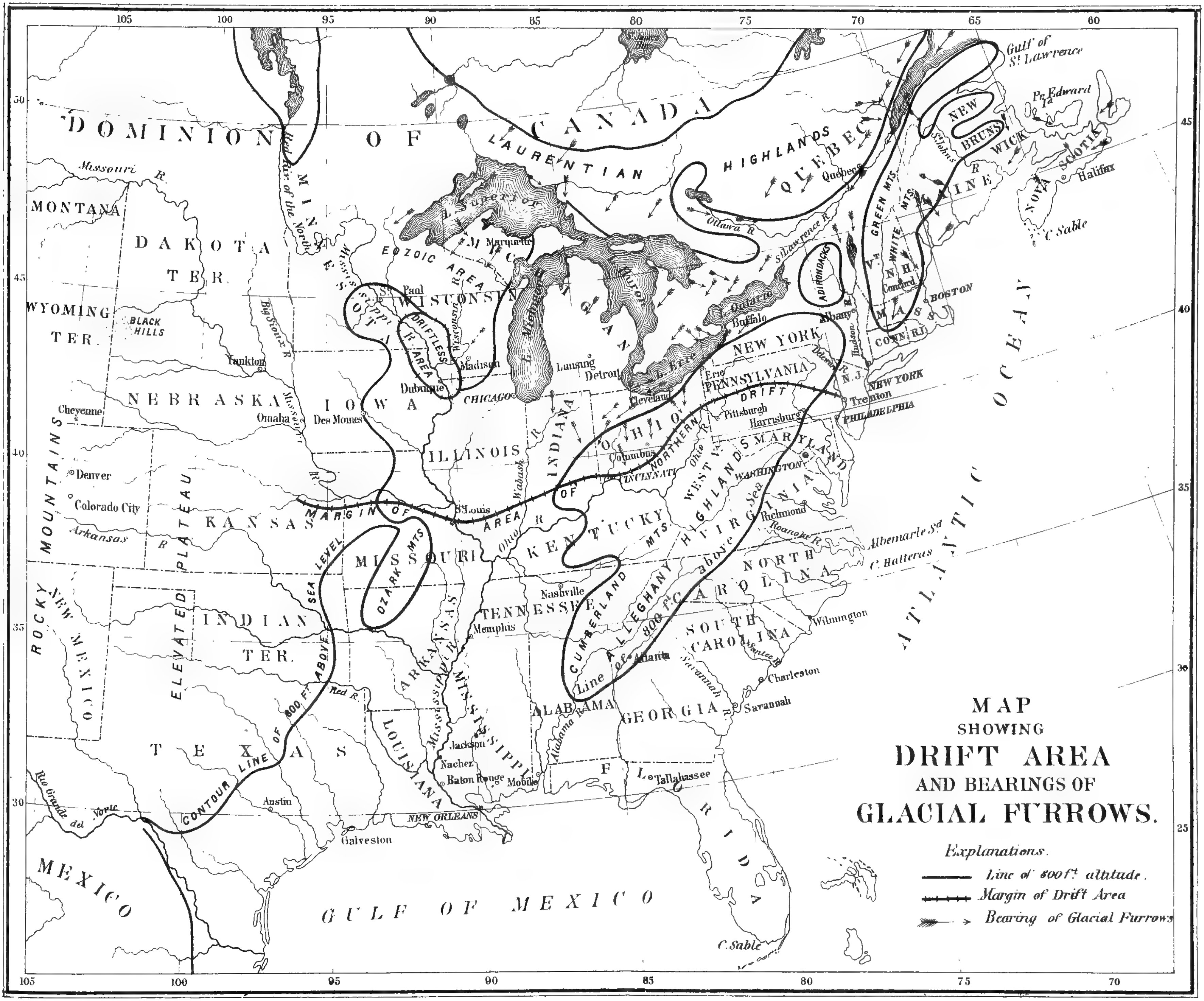
The central and eastern portions of the bed of Lake Erie were once occupied by quite soft rocks—Hamilton, Genesee, Portage and Chemung, and Waverly. Of these, more than a thousand feet in thickness were removed; and this portion of the basin was cut, to what depth we do not know, as it is much silted up, but certainly much deeper than elsewhere. When, however, the glacier which excavated the basin reached the Cincinnati arch it encountered a massive barrier of hard rock, which offered an obstinate resistance to its erosive action, and caused it to rise more than 300 feet above its eastern level. This barrier has been deeply scored, and the islands of the Lake have been wrought out of the solid beds of the Corniferous and Helderberg limestones. As I have mentioned elsewhere, previous to this time the basin of Lake Erie was traversed by a deep river channel, into which the profound gorges of Grand river, the Cuyahoga, etc., lead. Doubtless this river valley guided the excavation of the Lake Erie basin, as it did that of Lake Ontario. It traversed the area of the latter Lake nearly east and west, and connected with the Hudson through the Mohawk gap.

After leaving the basin of the present Lake, the Erie glacier was deflected toward the south, and apparently flowed down the course of the Wabash. The following table gives the bearings of the furrows made by the Lake Erie glacier at different points:

BEARINGS OF GLACIER FURROWS.

Locality.	Rock.	Number Observations.	Bearing.
South Bass Island	Limestone, Waterlime Group.	Many.	S. 80° W.
" intersecting series	" " "	1	S. 15° W.
Kelly's Island	" Corniferous "	4	S. 78° W.
Sandusky City, Erie Co	" " "	2	S. 80° W.
Ballville	" Waterlime "	1	S. 65° W.
Genoa, Ottawa Co	" " and Niagara Groups	2	S. 65° W.
West Sister Island	Limestone, Waterlime Group.	Many.	S. 80° W.
" intersecting series	" " "	1	S.
Sylvania, Lucas Co	" and Sandstone Corniferous Groups	5	S. 50° W.
Monclova, Lucas Co	Limestone, Waterlime Group.	4	S. 62° W.
Fish's Quarry, Lucas Co	" Corniferous "	1	S. 55° W.
Whitehouse, Lucas Co	" " "	1	S. 50° W.
Near Defiance, Defiance Co	Shale, Huron Group	1	S. W.
Near Junction, Paulding Co	Limestone, Corniferous Group	1	S. W.
Lima, Allen Co	" Waterlime "	3	S. 35° W.
Middleport, Van Wert Co	" " "	2	S. 15° W.

The glacial markings on West Sister Island, as shown by Mr. Gilbert, demonstrate that the motion of the ice was from east to west. In the Waterlime of which this island is composed are numerous balls of chert which have been exposed to the action of the glacier. We now find these projecting from the general surface much more strongly on their eastern than on their western sides, and from each a ridge or trail of limestone which they have protected from erosion runs off toward the south-west. Around the eastern base of each nodule is a deeply excavated furrow, which leads off on either side of the ridge just mentioned. Occasionally these flint nodules are cracked and battered, as they could hardly have been except by the action of bowlders, which, held by the ice, had come in contact with them. The exceeding fineness of the sculpture around these nodules, as well as in many of the longitudinal furrows, prove that the erosion was generally done, not by stones held in the ice, but rather by sand, which, frozen into the plastic ice, was capable of executing any sort of carving and modeling with the greatest accuracy. The glacial furrows on Kelly's and Put-in-Bay Islands have been often referred to, and are more surprising for their magnitude, extent, and variety than any others known in the country. In the fossiliferous limestone of Kelly's Island the glacial surface is thickly mottled with sections of corals and other fossils. These are ground down, often as nicely as they could be done by hand, and show distinctly that sand, under the ice, must have been the grinding agent. In many localities on these Islands the glacial furrows curve around any prominent point or rock mass which was



MAP
SHOWING
DRIFT AREA
AND BEARINGS OF
GLACIAL FURROWS.
Explanations.
Line of 800 ft. altitude.
Margin of Drift Area
Bearing of Glacial Furrows
DOMINION OF CANADA
LAURENTIAN HIGHLANDS
QUEBEC
ATLANTIC OCEAN
GULF OF MEXICO
MEXICO
MARGIN OF DRIFT AREA
CONTOUR LINE OF 800 FT. ABOVE SEA LEVEL
DRIFTLESS AREA
ALLEGHANY MTS
CUMBERLAND MTS
OZARK MTS
ROCKY MOUNTAINS
ELEVATED PLATEAU

encountered by the glacier in its motion. These prove that the ice was plastic, and folded itself around any opposing body. Near the south point of Put-in-Bay Island is a nearly vertical wall—now partly quarried away—which is distinctly beaded by the ice; and in one place, where a softer layer had worn faster than the others, a horizontal furrow with a > shaped section was produced in this wall, and the upper surface is as distinctly glaciated as the lower. These and many other examples of ice-carving, visible on these islands, demonstrate the truth of the theory that the lake basins were excavated by *glacial* action, and not, as has been urged by some geologists who have *not seen* these markings, by icebergs.

The sequence of events in the formation of the great lakes seems to have been somewhat as follows:

1st. The Laurentian belt, north of the great lakes, has been a land surface since the beginning of the Palæozoic era, was formerly a high mountain range, the degradation of which has supplied the mechanical materials which compose the sheets of Palæozoic rock that surround it. The erosion of these highlands has continued uninterruptedly till the present day, and was specially rapid during the ice period. The result has been that this mountain range has been almost entirely worn away, the truncated bases of the various arches and uplifts which compose it alone remaining to testify to its existence.

2d. The country lying between the Atlantic and Mississippi has been above the sea since the close of the Carboniferous period, and during the succeeding ages the general plan of its topography and its system of drainage have remained the same. Since it emerged from the seas, this area, too, has been constantly suffering erosion, and its lines of drainage have been more and more deeply inscribed upon it.

3d. Previous to the glacial period, the elevation of this portion of the continent was considerably greater than now, and it was drained by a river system which flowed at a much lower level than at present. At that time our chain of lakes—Ontario, Erie, and Huron—apparently formed portions of the valley of a river which subsequently became the St. Lawrence, but which then flowed between the Adirondacks and Appalachians, in the line of the deeply buried channel of the Mohawk, passing through the trough of the Hudson and emptying into the ocean eighty miles south-east of New York. Lake Michigan was apparently then a part of a river course which drained Lake Superior and emptied into the Mississippi, the Straits of Mackinaw being not yet opened.

4th. With the approach of the cold period, local glaciers formed on the

Laurentian mountains, and, as they increased in size, gradually crept down on to and began to excavate the plateau which bordered them on the west and south. The excavation of our lake basins was begun, and, perhaps in large part, effected in this epoch.

5th. As the cold increased, and reached its maximum degree, a great ice-sheet was formed by the enormously increased and partially coalescing local glaciers of the former epoch. This many-lobed ice-sheet, or compound glacier, moved radiatingly from the south, south-west, and western slopes of the Canadian highlands; its Ohio lobe reaching as far south as Cincinnati. The effect of this glacier upon Lake Erie and Lake Ontario would be to broaden their basins by impinging against and grinding away, with inconceivable power, their southern margins. To the action of this agent we must ascribe the peculiar outline of the profile sections drawn from the Laurentian hills across the basin of Lake Ontario to the Alleghanies, and across that of Lake Erie to the highlands of Ohio, viz., a long, gradual slope from the north to the bottom of the depression, and then an abrupt ascent over the massive and immovable obstacle against which the ice was banked, until, by the *vis a tergo*, it overtopped the barrier. In New York that barrier was a shoulder of the Alleghanies, too high and too rugged to be buried under a continuous ice-sheet; but its whole front was worn away for a hundred miles or more, and it was deeply creased where now we see the peculiarly elongated lakes of New York, and cut through, in certain gaps, to the valley of the Delaware. In Ohio the erosion was easier, and carried further south. The barrier was also lower, and was finally overtopped by one great lobe of ice which flowed on to the south and west until its edge reached the Ohio river.

The extent of the erosion produced in the epoch under consideration will be best appreciated by one who will stand on the cut edges of the great series of rocks exposed on the southern slopes of Lake Erie and Lake Ontario, and in imagination fill the vast vacuity which separates him from the base of the Laurentian hills.

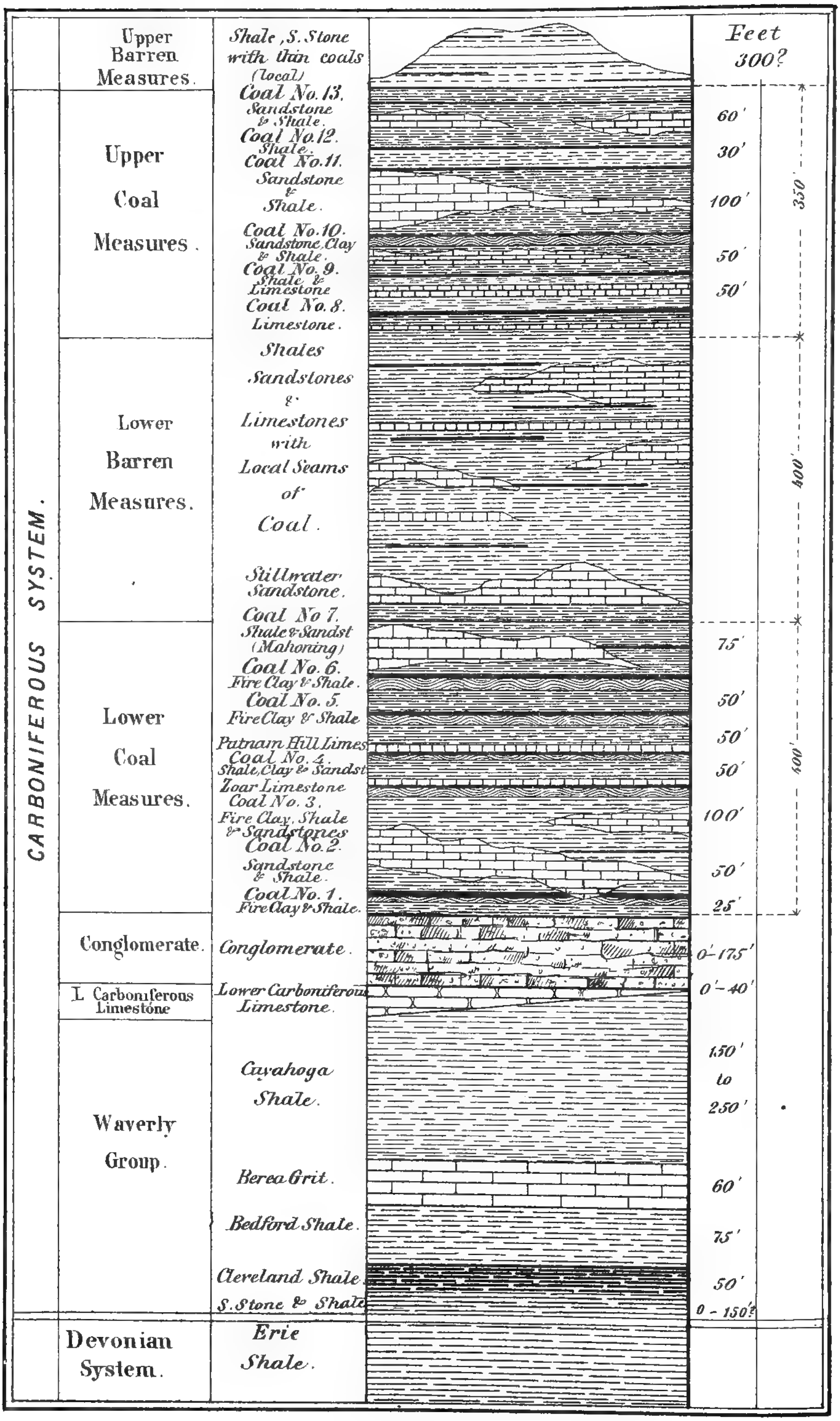
6th. With the amelioration of the climate the wide-spread ice-sheets of the period of intensest cold became again local glaciers, which completed the already begun work of cutting out the lake basins. At first the glacier which had before flowed over the watershed in Ohio was so far reduced as to be unable to overtop its summit, but deflected by it, it flowed along its base, spending its energies in cutting the shallow basin in which Lake Erie now lies.

A farther elevation of temperature curtailed the glacier still more, and Lake Erie became a water basin, while local glaciers, left from the ice-sheet, excavated the basins of Lake Michigan, Lake Huron, and Lake Ontario. The latter lake was apparently formed by the same glacier that made the Erie basin, but when much abbreviated. It flowed from the Laurentian hills and the north slope of the Adirondacks, and was deflected by the highlands south of the lake basin, so that its motion was nearly westward. This chapter in the history of our lakes was apparently a long one, for Lake Superior, Lake Michigan, Lake Huron, and Lake Ontario are all of great depth.

7th. The melting of the glaciers was accompanied, perhaps occasioned, by a sinking of the continent, which progressed until the waters of the Atlantic flowed up the valley of the St. Lawrence to Kingston, and up the Ottawa to Arnprior. (Dawson.) The valleys of the St. Lawrence and the Hudson were connected by way of Lake Champlain, and thus the highlands of New England were left as an island. It is also possible that the sea-water penetrated to the lake basin through the valley of the Mohawk and through that of the Mississippi, but of this we have no evidence in the presence of marine fossils in the surface deposits. The great area of excavation in which the lakes lie was probably at this time filled to the brim with ice-cold fresh water, and this flowing outward through all the channels open to it may have been sufficient to prevent the entrance of the arctic marine mollusks, of which the remains are so abundant in the Champlain clays of the St. Lawrence valley and the Champlain basin.

8th. When the continent was again elevated, and the water of the inland sea was drained away, the Mohawk channel was found dammed up with Drift, and a new line of drainage was established through the valley of the St. Lawrence. It is almost certain also that the elevation of the continent which took place after the Champlain epoch was not uniformly equal over all the country lying between the Atlantic and the Mississippi; for we find that the drainage of the lake system has been flowing in different directions at different times; now over barriers 1000 feet above the level of the sea from Lake Erie into the Ohio, and again, through outlets much lower, from Lake Erie to the Wabash, and from Lake Michigan, by several channels, into the Illinois and Mississippi. These great changes may have been effected by warpings of the earth's crust—*i. e.*, local elevation, or subsidence—or by the successive removal of ice-dams—glaciers—which occupied and obstructed different portions of the great interior basin. We may also find records here, as some geologists do in Europe, of great alternations of climate in the immensely long Quaternary age; and these alternations, building up and removing ice-dams, may have produced the great changes in our drainage system of which the evidence is so unmistakable. The accompanying map, which is compiled from data furnished by Dawson, Logan, Whittlesey, and my own observations, will probably aid in making the views advanced on the preceding pages a little more intelligible than they would otherwise be.

SECTION
OF THE CARBONIFEROUS ROCKS OF OHIO.



CHAPTER XXXI.

THE CARBONIFEROUS SYSTEM.

A brief sketch of the various groups of strata which compose the great Carboniferous system has been given in the first volume of this Report. These will now be described somewhat more in detail, in order that our citizens may have a more exact and comprehensive knowledge of the composition and extent of this, the most important of the formations represented in the geology of our State.

It is known to most persons that the name Carboniferous, or coal-bearing, was given to this group of rocks from the fact that they include in Europe and America extensive deposits of mineral fuel, which not only constitute a marked feature in the formation, but have great economical value, and have played a most important part in the development of our modern civilization. The name Carboniferous is, therefore, not ill-chosen, but it is liable to mislead, since the Devonian shales, in the United States, hold quite as large a quantity of carbonaceous matter as is contained in our Coal Measures; and in China, India, and Western America beds of coal occur in Mesozoic and Tertiary rocks which, in thickness and lateral extent, are not surpassed by our Carboniferous coal strata, while in these countries little or no coal occurs in rocks older than those mentioned. Hence, if geology had been first studied in China, a Carboniferous system would probably have been given a place in the geological column, but it would have been put at a higher level than it holds in our series.

The Carboniferous system, known as such among our geologists, is usually regarded as one of the most distinctly defined of all the great groups of rocks, and yet in fact the lines which are now drawn to separate it from the Devonian below and the Permian above are as shadowy as any others that divide formations in the geological series.

In England there has been much discussion as to where the lower limits of the Carboniferous system should be fixed, and there is still great difference of opinion as to how much of the Yellow sandstones of Ireland and the Upper Old Red Sandstone of Scotland should belong to the Devonian, and how much to the Carboniferous group. In our own country a similar difficulty has been encountered. The relations of the

Waverly group have been a fruitful source of discussion for many years, a discussion which, as will be shown further on, we have been able to bring to a conclusion by demonstrating that this is an integral portion of the Carboniferous system. The relations of the Waverly to the Catskill and Chemung rocks are, however, not yet accurately determined, and it is plain to see that it will not be easy to harmonize views on this subject. As I have suggested in the geological portion of Volume I., we have, at what is now regarded as the base of the Carboniferous system, a great mass of mechanical sediments—the Waverly group. This is the lowest member of a trinity of deposits—the Carboniferous limestone being the central, the Coal Measures the upper member. These form one of the great circles of deposition which compose all the systems of sedimentary rocks, each of which is the product of a distinct invasion of the continent by the ocean. But the Waverly sandstone series is underlain by the Catskill, the Chemung, and the upper half of the Portage group, which also form a mass of mechanical sediments. Much more study of this group of strata will be required before their relations to each other, or to the rocks above, can be accurately determined. As I have remarked elsewhere, the Gardeau and Cashaqua shales of the Portage group have nothing in common with the Portage sandstones above, while their lithological and zoological affinities with the Hamilton below are such that they should be properly united with that formation. I have also suggested that since a great physical change occurred at the epoch of the deposition of the Portage sandstones—and this was apparently the beginning of a new geological cycle, and one of which the Carboniferous age was the continuation—the Portage sandstone might be with propriety considered the base of the Carboniferous series. This proposition was made not for the purpose of harmonizing the facts with a preconceived theory of circles of deposition, but because both the physical and zoological evidence favor the union. The physical evidence is much in itself, since all the great material changes through which our continent has passed—of elevation, of depression, of heat and cold, alternations of land, and shore, and sea—have left lithological records which, if carefully studied, will be found to be as legible and reliable as those formed by organic remains. Indeed, the two histories are not only harmonious, but are so interdependent that each is indispensable to the proper understanding of the other.

The significance of the sequence of sediments which is observable in what I have termed *circles of deposition*, is such that no one can be blind to it and yet read correctly the history of our stratified rocks. The molluscous fauna of the Chemung is much more closely allied to that of the Carboniferous than to that of the Hamilton. This is shown by the great development of the families which include *Productus* and *Productella*, *Aviculopecten*, *Palæoneilo*, etc., in both the Chemung and Waverly. These constitute a fauna which in all its more prominent characteristics is common to both, serving at the same time to bring them together, and separate them from the underlying Devonian strata. This similarity of fauna is such that it led Prof. Hall to unite the Chemung and Waverly long before their stratigraphical relations were ascertained, and it has been the cause of much of the protracted discussion which has taken place over the age of the Waverly. I think it may be safely said, that if the question could be disembarrassed of all complications, all intelligent palæontologists would agree that the fauna of the Chemung and Waverly belong to one zoological age, and that their differences are only such as would naturally characterize epochal subdivisions of this age. The Catskill group, which nominally separates the Chemung and Waverly, is a local, and, as yet, very ill-defined formation. That it has little representation in the Catskill Mountains seems probable, both from the observations reported in our former volume and others made since. Doubtless this formation will be carefully studied and accurately defined by the newly organized survey of Pennsylvania; but with the limited information we now possess in regard to it, it seems to me to be a local, and, perhaps, a fresh-water deposit, synchronous with the marine beds of the Upper Chemung.

A sketch of the history recorded in our Carboniferous strata was given in the introductory chapters of the geological portion of our first volume. It will be remembered by those who have read that sketch, that it was shown that a round of physical changes took place in the Carboniferous age similar to those traced in the strata deposited in the other great divisions of geological time, viz.: First—A period of wide-spread land area, which in the latter portion of the Devonian age was covered with a luxuriant vegetation similar in its general aspects to that of the Coal Measures. Second—At the beginning of the Carboniferous age this land was extensively submerged and covered with shore and off-shore mechanical sediments, which are now known as the Vespertine and Umbral rocks of Pennsylvania, the Waverly sandstone series of Ohio, the Knobstones of Kentucky, the Kinderhook group of Illinois, etc. Like other of our mechanical sediments, this group thickens toward the east and north in the direction of the land, and thins at the south and west toward the sea. Third—In the progress of this submergence, where open water reached and stood for ages, calcareous sediment was deposited, which we call the Lower Carboniferous, or Sub-Carboniferous, limestone. That this submergence in Pennsylvania, Ohio, and Michigan was progressive from the south-west toward the north-east is shown by the fact that the limestone is thickest at the south-west, and thins out to a feather edge toward the north-east; reaching as far as central Ohio and the south line of Pennsylvania, where the only portion of the Lower Carboniferous limestone found is the upper or Chester division. Fourth—In the third and last epoch of the Coal Measures the Carboniferous sea retreated and left a broad area of shallow water and dry land. The transition from marine to terrestrial conditions is recorded in the Conglomerate, while the Coal Measures accumulated in synclinal troughs, which gradually sank, with many oscillations, and were filled by the wash from the surrounding land in the form of sand and clay, now sandstones and shales; by beds of peat, now coal, which grew on the marshy surfaces; and by the limestones deposited from the inflowing sea during the periods of local submergence. When sediments had accumulated in these basins to the depth of 2,000 to 3,000 feet, the continent was affected by great disturbances, recorded in the Alleghany Mountains, then raised. At this time nearly all the area between the Atlantic and the Mississippi was brought above the ocean level, where it has remained until the present time.

THE WAVERLY GROUP.

The Carboniferous system consists in Ohio, as almost every where else, of three great subdivisions: the Coal Measures above, the Conglomerate in the middle, and the Lower Carboniferous group below. The Lower Carboniferous strata are the Lower Carboniferous limestone, and those designated by the geologists of the former Survey as the *Waverly sandstone series*, from the outcrops which contain the famous building stone in the vicinity of the town of Waverly, Pike county. No effort was made by those who first described this formation to determine its precise geological age, or its relations to the rocks of New York and Pennsylvania. Few fossils were then found in it, and the knowledge then possessed of geology and palæontology would perhaps not have sufficed to settle this question even if the collections had been richer. Since the suspension of the former survey the Waverly group has been a fruitful subject of discussion among geologists; and there is perhaps no one of our formations about which there has been so much difference of opinion. From the remoteness of the localities where the rocks which were compared with the Waverly group were exposed, and the marked differences exhibited by their fossils, it was impossible to apply to the question of equivalence an *experimentum crucis* by which it could be definitely settled. The space which separated the fields of observation of the eastern and western geologists was formed by the State of Ohio, and while the geology of this State remained comparatively unknown, the different parties in the discussion could not be brought on to common ground for the adjustment of their differences. The reorganization of the Geological Survey of Ohio was, therefore, regarded with some interest by the geologists of the country as likely to throw new light upon this vexed question, and such as would lead to its final settlement. When, therefore, the directorship of the survey was intrusted to me, the work of tracing the geographical extent and investigating the structures and fossils of this group was one of the first that claimed my attention.

A careful study was made of the southern prolongation of the Waverly by Prof. Andrews and his assistants; a study which was continued north of the National Road and carried to the eastern line of the State, and thence far into Pennsylvania and New York, by myself and those immediately associated with me. We found the Waverly far more rich in fossils than had been before supposed, and obtained from it, perhaps, a larger number of species than has been furnished by any other of our formations. Of these some were new to science, while others had been described from collections made in our State by different geologists in years past, or had been obtained in other States from strata now for the first time identified with this by such a community of fossil forms as these common species proved.

The first result of our study of the Waverly was to show that all its rich fauna is of a decidedly Carboniferous type; second, that it includes a number of species characteristic of the Lower Carboniferous rocks of Kentucky, Tennessee, Illinois, Iowa, and Michigan; third, that it furnishes, at nearly all of its fossiliferous localities certain species which are also common in the Coal Measures above; fourth, that our collections made include no Chemung or Portage species; fifth, that it is continuous with the "Vespertine" and "Umbral" rocks (Lower Carboniferous) of Pennsylvania, with the "Sub-Carboniferous sandstones and shales" of Kentucky, and with the "silicious member of the Lower Carboniferous group" of Safford, in Tennessee. Hence we are compelled to regard it as a member of the Carboniferous system, and as distinct from the rocks of New York, with which it has been so generally supposed to be identical.

In the prosecution of this investigation, after we had carefully traced the different members of the Waverly group to the line of Pennsylvania, one of my assistants, Mr. A. Sherwood, went to his former home, in Tioga county, Pennsylvania, and took up a line of observation at this point. The geological structure of this region is as follows: The Chemung group forms the bottoms of the valleys. On this rests the Catskill group, 300 to 400 feet in thickness, forming the summit of the Devonian system. Above the Catskill are the Vespertine sandstones and Umbral shales; then the Conglomerate and Coal Measures. From Tioga county Mr. Sherwood worked westward, carefully tracing these various formations until his observations connected with those made by Mr. G. K. Gilbert and myself, who went eastward from the Ohio line, and met him in McKean county, Pennsylvania. At the same time my assistants, Messrs. Hooker and Potter, carried similar lines of observation at a lower level, along the outcrops of the Erie shale, from Ohio through north-western Pennsylvania into New York. Fossils were collected and sections taken at a great number of localities along each line. The results of these investigations, briefly given, are as follows:

1st. The Chemung group forms the summit of the series in Chatauqua county, New York, there attaining a thickness of nearly 2,000 feet. It includes the Conglomerate seen at the "Panama rocks," formerly regarded as the Carboniferous conglomerate—at least 160 feet below the summit of the series; as it is overlaid by that thickness of shales containing unmistakable Chemung fossils. The Chemung group, in all this region, is highly arenaceous, containing many beds of sandstone, nearly al of which are, in some localities, conglomerates. The various sandstones reached in the oil wells, on Oil Creek, are parts of this formation, and all apparently contain more or less pebbles. Coming westward into Ohio, the Chemung rocks rapidly diminish in thickness, and become more argillaceous in character. They form the greater part of the Erie shale, in its exposures between Ashtabula and Cleveland.

2d. The Catskill group constitutes a well-defined and strongly marked geological formation in Bradford, Tioga, and Potter counties, Pennsylvania, where it has a thickness of several hundred feet; has very distinct lithological characters, and contains in great abundance the remains of fishes, such as are found in no other formation on the continent. Of these the most abundant are the scales of *Holoptychius* and the plates of *Bothriolepis.* In coming westward, the Catskill formation rapidly thins, and apparently disappears before the Ohio line is reached.

3d. The Vespertine sandstones of Rogers, which have a thickness of more than a thousand feet in central Pennsylvania, are there nearly destitute of fossils. In tracing this formation towards the west, it was found to diminish in volume, and to become finer and more argillaceous in texture. It still remains, however, as a reddish sandstone, dark or light, with alternating beds of shale at Bradford, in McKean county, and in the valley of the Alleghany, near Kinzua. Lower down on the Alleghany, and in the valley of Oil Creek, it forms that portion of the section which lies within 400 feet of the Conglomerate. Here, as at Bradford and Kinzua, it contains numerous fossils, mainly of Lamellibranchiates; but in the valley of Oil Creek also some brachiopods which are characteristic of the Waverly in Ohio. Though becoming, as a general rule, more argillaceous, this formation is quite persistent, and makes up the great mass of the Waverly group as it appears within the limits of our State.

4th. The Umbral shales of central Pennsylvania rapidly diminish in coming west, and either blend with the underlying Vespertine or totally disappear before crossing the Ohio line. From the fact that these shales contain almost no fossils in Pennsylvania, it is difficult to separate them from the Vespertine group, when changed in color and assimilated in composition to that group, as they are in their westward extension.

5th. The Carboniferous Conglomerate is more persistent in thickness and character than any of the formations that have been enumerated; and although exhibiting considerable variations in thickness, it may be considered as forming a continuous sheet, stretching from central Pennsylvania to central Ohio.

The section afforded by the Waverly, or Lower Carboniferous, rocks in northern Ohio is as follows, beginning with the summit of the series:

	The Conglomerate.			
1.	Cuyahoga Shale........................	150 to 250	feet thick	Waverly Group.
2.	Berea Grit..............................	60	"	
3.	Bedford Shale........................	75	"	
4.	Cleveland Shale........................	21 to 60	"	
	Erie Shale. (Chemung.)			

1. *The Cuyahoga Shale.*—This stratum immediately underlies the Conglomerate, and forms the walls of the gorge of the Cuyahoga river from Cuyahoga Falls to the Peninsula, and the upper part of these walls from that point to the vicinity of Cleveland. It also forms the surface rock of a large part of Medina county, the southern part of Lorain and Cuyahoga, and all the region about Warren, in Trumbull county. In this section of the State the Cuyahoga shale has a thickness of from 100 to 250 feet, attaining its maximum development in Medina, Lorain, and Ashland counties.

The prevailing lithological character of the deposit is that of a gray, argillaceous shale, with thin, interpolated bands of bluish, fine-grained sandstone. In some localities, as at the Big Falls of the Cuyahoga, these layers of sandstone are very much thickened, and form massive beds, which may be used for architectural purposes.

In passing from the valley of the Cuyahoga west and south, the Cuyahoga shale is found to undergo a change of color and texture, becoming gradually lighter, until it approaches in tint the prevailing type of the

Waverly sandstone in the southern part of the State. It also becomes more arenaceous in Ashland, Richland, and Knox counties, being there represented by a fine-grained, yellow, ocherey rock, half way between a sandstone and shale. In the northern and eastern portions of the State the base of the Cuyahoga shale is formed by a fine, thinly laminated, dark gray, sometimes black, clay shale, full of *Lingulæ* and *Discinæ.* This bed is exposed at a great number of localities, of which Berea and Chagrin Falls, in Cuyahoga, and Warren, in Trumbull county, may be cited as examples. At all these places this stratum rests directly upon the next succeeding member of the series, the Berea grit, is crowded with its characteristic mollusks, and with the bones, teeth, scales, and spines of fishes.

In the gorge of the Cuyahoga, the Cuyahoga shales contain but few fossils; but at Richfield, Royalton, Weymouth, Medina, Seville, and Lodi, in Medina county, and at Ashland, it includes strata which are not only crowded with fossils, but are literally made up of shells. As is usual in cases where clay shales contain layers which are specially fossiliferous, the carbonate of lime from the shells of the mollusks has formed strata of limestone of greater or less thickness, and the most fossiliferous beds in the localities I have cited are generally quite calcareous, though never pure limestones. In the weathering of these beds—which are usually only a few inches in thickness—the limestone is dissolved out, and their exposed edges appear as brown, ferruginous layers, sometimes ocherey, and at other times compact limonite, every where filled with the impressions of mollusks.

2. *Berea Grit.*—The second member of the Lower Carboniferous series in Ohio is a distinctly marked and very persistent bed, or series of beds, of sandstone, which I have designated as the Berea grit, from the fact that it is the rock so extensively quarried at Berea, Cuyahoga county. This is also the rock quarried at Amherst, at Elyria, at Independence, at Peninsula, at Stewart's quarries near Cleveland, at Chagrin Falls, at Thompson, Geauga county, at Windsor, Ashtabula county, and at Vernon and Kinsman, Trumbull county. This stratum has acquired some notoriety from the fact that it is the rock penetrated by the oil wells in Grafton, Lorain county; Liverpool, Medina county; and Mecca, in Trumbull county; all of which have yielded considerable quantities of petroleum.

The Berea grit is usually divisible into two distinct portions: the upper, a series of thin beds, used for flagging; the lower, more massive, and quarried for building stone. At Berea the upper member has a thickness of about 20, the lower of 30 feet. In the Amherst quarries the upper division is not so distinctly marked, and the whole mass is generally more homogeneous; consisting of beds from one to five feet in thickness. At Independence the flagging stone has been mostly removed by glacial erosion, and the section opened in the quarries consists of from 25 to 30 feet of massive sandstone. At Chagrin Falls the quarries of Mr. Hamilton Goodale are opened in the upper member, while the lower forms the ledge over which the water pours.

In tracing the Berea grit eastward, it is seen to become less massive, and in the eastern counties the layers of sandstone are intercalated with beds of shale. On Oil Creek, and in other localities of western Pennsylvania, the Lower Carboniferous series is more uniform in lithological character, and the Berea grit is hardly distinguishable; the whole mass there consisting of alternations of sandstone and shale, the upper portion being more arenaceous and the lower more argillaceous than in Ohio.

In tracing the members of the Waverly group southward toward the central and southern parts of the State, a similar change was remarked, as will be seen by the sections of this formation at various localities given below. Even as far south, however, as the Ohio, the horizon of the Berea grit is marked by an unusual prevalence of sandy matter, and the famous City Ledge, quarried at Waverly and at various other localities in that section of the State, is probably its equivalent. Its greatest development seems to be in the north-western portion of the area which it underlies, as in Lorain county, at Elyria, Amherst, etc. Here the sandstone group has a thickness of sixty feet, and is more massive throughout than any where else within the limits of the State.

In Michigan this group is apparently represented by the Napoleon sandstone of Winchell, which has a thickness of 107 feet, while the overlying Cuyahoga shales have, perhaps, as their equivalent, the Michigan Salt group, 184 feet thick.

From these facts it would seem that this arenaceous material was derived from the north-west, and that in the Ohio localities, where the Berea sandstone is exposed, the group is thickest and coarsest where it approaches nearest to the Michigan outcrops. Going east and south from Lorain county—the point of greatest development of this formation within our State—its arenaceous material progressively diminishes, until in Kentucky or Tennessee scarcely any sandstone, properly speaking, is found in the series, and in eastern Ohio and western Pennsylvania argillaceous material, derived from an eastern source, enters into the composition of the beds. At Mansfield the Berea grit is seen to be converted into highly colored red and yellow sandstone, much softer than further north. In a few localities where the Berea sandstone has been examined, it contains some pebbles, but these are few in number, and generally altogether absent. In the gorge of Tinker's Creek, at Bedford, Cuyahoga county, the lower part of the Berea sandstone, which forms the cliffs at the railroad crossing, contains a few pebbles, some of which are of large size; but these are not sufficiently abundant to give to any portion of the mass the character of a conglomerate.

The economic value of the Berea grit is very great, as it supplies a building stone which is now sent to all parts of the Union, and has even been exported to England. This is the "Ohio Stone" of the New York market, where, from its homogeneous texture, the facility with which it is worked, and its warm, pleasant, buff tint, it is highly esteemed. It is equally valued in the cities upon the shores of the great lakes, and in all of these it is extensively used for architectural purposes. The principal supply of grindstones throughout the Northern States is also derived from this group, of which the center of production is Berea.

The fossils of the Berea grit, though nowhere very abundant, are of peculiar interest. The massive layers opened in the quarries at Amherst, Berea, Independence, etc., have yielded almost no fossils; but in the flagstone of the upper portion there have been found in the quarry of Mr. Goodale, at Chagrin Falls, large numbers of fishes of the genus *Palæoniscus* (*P. Brainerdi*), with bones and plates of other and larger fishes which as yet remain undescribed. At Berea the upper layers contain a large species of *Lingula* (*L. Scotica*), and spines of *Ctenacanthus*. But the most interesting fossil found in this formation is a plant that covers some of the surfaces of the layers at Bedford, and which I have been unable to distinguish from *Annularia longifolia* of the Coal Measures.

On Oil Creek, in Pennsylvania, a stratum of sandstone, which apparently represents the Berea, contains in large numbers the spines and teeth of fishes. Of these the most conspicuous are the spines of a species of *Ctenacanthus* (*Ct. triangularis*), of which more than two dozen were found by Mr. Gilbert upon a surface not larger than a square yard. With these spines are numerous teeth of Selachians, representing the genera *Orodus*, *Cladodus*, *Helodus*, *etc.*, one of which (*Helodus coniculus*) is common in the Burlington and Keokuk limestones of Illinois. In the aggregate we have now seven species of fishes represented in the fossils of the Berea grit, all of which are of decidedly Carboniferous type, and, as has been said, one or more are such as have been found elsewhere in Lower Carboniferous strata.

3. *Bedford Shale.*—Beneath the Berea grit, in northern Ohio, we find

seventy to seventy-five feet of argillaceous shale, of which the upper portion is generally of a marked red color, while the lower portion is dark bluish gray. These shales are very variable in their relative thickness, sometimes one or the other filling the entire interval between the Berea grit above and the black Cleveland shale below, sometimes that interval being equally divided between them, and sometimes again one or the other greatly preponderating, while both are present. In the section exposed at Bedford the red shale is scarcely visible, while it is met with at Newburgh, five miles distant, and in the hills east of Cleveland fills the larger part of the interval that separates the Berea grit from the black shale which underlies the East Cleveland quarries. At Berea and Elyria both shales are visible, while on the Vermilion—which takes its name from this circumstance—the red shale is much more largely developed, and attains a thickness of something like sixty feet. In most localities where the Bedford shale is exposed, the upper surface is very irregular, and it is evident that this formation has been extensively eroded by the agency which transported the beds of sand now consolidated into the Berea grit. It is probably due to this fact that the red shale is so frequently found to be wanting in the section. In the red shale no fossils have as yet been discovered, doubtless for the same reason that fossils are so generally absent from the sediments that contain a sufficient amount of peroxide of iron to derive their color from this source. The explanation of this phenomenon is very simple. The action of carbon upon the sesquioxide of iron is to reduce it to the protoxide by the absorption of one equivalent of its oxygen, so that in all deposits which contain, when accumulating, a considerable percentage of organic matter, this serves to reduce the iron to the protoxide, which imparts a bluish or greenish color to the deposit. Where organic matter is absent the iron passes to the condition of peroxide, and in this state, though in small quantity, it communicates a bright red color to the materials impregnated by it.

The lower portion of the Bedford shale, though, like the upper part, very fine and argillaceous, is generally dark gray or blue in color, contains considerable lime, and is locally highly fossiliferous. The fossils are most abundant in that portion which rests immediately upon the black shale below, and here they are sometimes so numerous as to form a large part of the mass.

The following are some of the fossils derived from this horizon: *Syringothyris typa*, Win.; *Orthis Michelini*, Lev.; *Spiriferina solidirostris*, White; *Macrodon Hamiltoniæ*, Hall; *Hemipronites crenistria*, Phil.; *Chonetes Logani*, Hall; *Lingula Cuyahoga*, Hall; *Rhynchonella Sagerana*, Win.

In this list there are several which have peculiar interest and significance, *Syringothyris typa* and *Spiriferina solidirostris*, for example, from the fact that they are characteristic of the Lower Carboniferous rocks of other States, while *Orthis Michelini* is common to the Carboniferous formation all over our country and in Europe.

South of the Western Reserve the Bedford shales are scarcely distinguishable, as in the central and southern portions of the State they assume the prevailing character of the Waverly group, and blend with the other portions of the series. At East Cleveland, Kingsbury's quarry, Newburgh, etc., the lower portion of the Bedford shale is so highly charged with silica as to become a fine-grained sandstone, which is extensively used for building, flagging, etc., in Cleveland. This is, however, only a local induration of the shale, and is not often met with elsewhere. Though nearly or quite destitute of fossils, except some fucoidal impressions, the blue sandstone of the East Cleveland quarries is highly charged with a sulphide of iron; and hence the rock is liable to stain and exfoliate on exposure by the conversion of the pyrites into limonite. It makes excellent flagging, however, and when sawed is much used for that purpose.

In all the quarries where this blue sandstone is worked the seams between the layers, as well as the pores of the stone, are often found filled with petroleum. This evidently proceeds from the underlying black shale from which it emanates by spontaneous distillation. Similar emissions of oil give rise to a line of oil springs which mark the base of the Bedford shale all along its line of outcrop. At Kingsbury's quarry, near Cleveland, a fine thread of oil may be seen floating on the surface of each little spring stream that issues from the crevices of the rock. I have seen the flow kept up for years, and have regarded it as an interesting illustration of the genesis of petroleum—from bituminous shale by spontaneous distillation.

Not unfrequently the East Cleveland stone, like that from Waverly, shows stains of oil on exposure to the sun.

4. *Cleveland Shale.*—The lowest member of the Waverly group in northern Ohio is a black bituminous shale, which I have designated by the name of the Cleveland shale, from the fact that it seems to have attained its greatest development in the region about the mouth of the Cuyahoga, and is there, perhaps, the most strongly marked element in the Lower Carboniferous series. Its greatest thickness in Cuyahoga county is 54 feet, and its best exposure is in the valley of Doane's Brook, in East Cleveland, where it immediately underlies the Bedford shale, of which the lower layers are there converted into massive, blue, fine-

grained sandstone. It is also met with at a varying distance below the Berea grit in all the exposures of the Waverly series in southern Ohio, but shows a marked diversity of thickness at different places. In the gorge at Bedford, where it is entirely cut through, it is 21 feet in thickness; at East Cleveland, as has been stated, 54 feet; in the section from Painesville to Little Mountain, 30 feet; in the valley of Black river, 50 feet; and in the valley of the Vermilion, from 60 to 80 feet. In the latter section of the State, as has been before stated, the underlying Erie shales thin out, and the Cleveland shale approaches very closely to the lower black shale (Huron shale), which has here a great development. From this point south to the Ohio river the Cleveland shale is met with in various sections of the Waverly, but diminishing in thickness in this direction. At Freestone a layer of bituminous shale, probably its equivalent, lies directly beneath the City Ledge, and has a thickness of 16½ feet.

Throughout its entire extent the Cleveland shale has nearly the same lithological characters, though differing somewhat in the relative quantities of its carbonaceous and mineral ingredients. It generally contains from 10 to 20 per cent. of combustible matter, and when freshly quarried is a tough, compact rock. Upon exposure, however, it splits into a great number of leaves, so that its outcrops form slopes covered with small, thin scales of the rock. By weathering, the carbonaceous matter is eliminated from the surface, and it becomes gray in color, except where stained, as it often is, by the oxide of iron.

The fossils of the Cleveland shale have, until recently, altogether eluded the search of geologists; but during the prosecution of the survey we have been able to gather quite a large number from different localities, some of which are of considerable interest.

In entering upon the study of the Lower Carboniferous group of rocks in Ohio, the Cleveland shale formed our point of attack, and knowing from experience in the Carboniferous and Cretaceous rocks that, "given a bituminous shale, fish scales were almost a logical sequence," these were the first objects of search. Within a few minutes after beginning such search they were found in considerable numbers in the exposures at Newburgh. Subsequently the scales of fishes were met with in all the localities where this rock was examined. These are generally minute, rhomboidal, enameled scales, and, as we now know, belong to a species of *Palæoniscus*. *Lingula* and *Discina*—like fish scales, the usual concomitants of black shales—were also found in various localities. The most interesting group of fossils, however, obtained from this stratum was discovered by Captain Jas. Patterson, near Vanceburg, Kentucky. In excavating the shale at one horizon, he found a surface covered with the remains of fishes—teeth, spines, bones, dermal tubercles, etc.

The list of the fish remains procured in the black shale at Vanceburg, Kentucky, and on the Ohio side of the river, now includes two species of *Ctenacanthus*, one of *Orodus*, one of *Cladodus*, and one of *Palæoniscus*. With these were immense numbers of minute, teeth-like organs, which have been the subjects of much speculation among zoologists. These are almost microscopic in size, and consist of a base elongated horizontally, upon which are set a great number of acute denticles, forming a miniature comb or saw. They are generically identical with the group of organs first described by Pander, under the name of *Conodonts*, obtained from the Silurian shales of St. Petersburg, and subsequently found by Mr. More in great numbers in the Carboniferous limestone of England. By Pander they were considered to be the teeth of fishes, a conclusion of which the propriety is, however, questioned by Prof. Owen. By Agassiz they are regarded as the teeth of Selachians, and as closely allied to such forms as *Ctenoptychius*. It has also been suggested that they were the teeth of mollusks, to which they have great resemblance. They will be found figured and described in the Palæontological portion of this Report, and the reasons will be given there for the view I have taken of them, viz., that they are the dermal ossicles (the shagreen) of fishes. Whatever may be their zoological affinities, these *Conodonts* have a special geological value, as they are characteristic of the Cleveland shale wherever explored. In the section at Newburgh surfaces of the shale were found completely covered with them. In the same locality a species of *Polyrhizodus* was also found, and abundant ganoid scales, which are proved by specimens obtained at Vanceburg by Captain Patterson to belong to a species of *Palæoniscus*. From the different exposures of the Cleveland shale we have now gathered the following fossil fishes: *Ctenacanthus formosus*, N., found also in the Cuyahoga shale; *Ct. furcicarinatus*, N.; *Cladodus Pattersoni*, N.; *Orodus variabilis*, N.; *Palæoniscus*, two species; *Polyrhizodus modestus*, N., and Conodonts of various forms.

To the palæontologist it is scarcely necessary to say that such a group of fossils as that enumerated above could only come from Carboniferous rocks; most of the genera here represented being exclusively confined to that formation. The only exception is that of *Ctenacanthus*, of which one or two doubtful species have been described from the Devonian rocks of the Old World, and we have obtained one well marked and beautiful species from the Huron shale (*Ct. vetustus*, N.).

In the sections opened by the valleys of the Cuyahoga and its tributaries, the Cleveland shale is underlain by a few feet of impure limestone and argillaceous shale. The limestone contains *Syringothyris typa*, *Macrodon Hamiltoniæ*, and other Waverly fossils. Beneath these strata are greenish shales, containing *Leiorhynchus mesacostalis*, *Spirifera disjuncta*, etc., Chemung fossils, characteristic of the upper layers of the Erie shale. Here, then, we have the base of the Lower Carboniferous series. The first of the Chemung fossils occur about sixty feet below the base of the Cleveland shale, and it is possible that the intervening mass may be an element in the Lower Carboniferous series, up to the present time not sufficiently well known to be identified and described. As has been stated, near the Ohio an interval of 147 feet separates the Cleveland shale from the Huron shale below, and the material filling this interval has similar lithological characters to the upper portion of the Waverly, but no fossils have been obtained from it, and it is therefore impossible at present to say whether it contains any representative of the Erie shale or not.

The following is a minute section taken at this point by Mr. R. D. Irving, one of the assistants on the Survey:

SECTION OF THE STRATA BETWEEN THE CLEVELAND AND HURON SHALES, SCIOTO COUNTY, OHIO.

Sandstone (City Ledge)	3′ 5″
Blue and drab shales	3′ 9″
Blue clay	1′ 7″
Black shale (Cleveland shale)	15′ 6″
Sandstone	1′ 4″
Shales and sandstone	1′ 9″
Sandstone	9″
Shale, with three layers of sandstone	6′ 6″
Sandstone	1′ 4″
Shale, with three layers of sandstone	6′ 9″
Sandstone	2′ 6″
Shale, with three layers of sandstone	9′ 11″
Sandstone	1′ 2″
Shale	5″
Sandstone	1′ 5″
Shale	3′ 9″
Sandstone	10″
Shale	3′ 1″
Sandstone	1′ 2″
Shale	1′ 11″
Sandstone	2′ 10″
Three layers of shale and sandstone	11′ 9″
Sandstone	1′ 4″
Shale	10″
Sandstone	1′ 10″
Shale	1′ 2″
Sandstone	11″
Shale	1′ 2″

Sandstone		11″
Shale	2′	2″
Sandstone		7″
Shale	1′	5″
Sandstone	1′	
Shale	1′	10″
Sandstone		9″
Shale	2′	3″
Sandstone	1′	
Shale	5′	4″
Sandstone	7′	2″
Alternation of fine-grained sandstone and shale	50′	
HURON SHALE	350′	

In southern Ohio the Waverly group is very largely developed, attaining a thickness of not less than five hundred feet, and being well exposed in the valley of the Scioto. For the most part the outcrops lie on the east side of the river, but the Waverly caps a great number of eminences on the west side of the valley, specially the group of hills known as the "Sunfish Hills," and these outliers extend as far west as the "mountains" of Highland county. The details of the extent and structure of the group in this part of the State will be found given in the reports of Professors Andrews and Orton. As a general rule, the formation is here composed of a series of alternations of sandstones and shales, and is not susceptible of division into distinct members, as in the northern part of the State. It is generally barren of fossils; but in certain localities, and at certain horizons, it is highly fossiliferous. At Sciotoville, Rockville, and Buena Vista collections of fossils have been made which rival in variety and interest those obtained from Richfield, Lodi, and Weymouth, in Medina county; alarge number of species being common to the two districts. Lists of the species collected at Rockville and Sciotoville are given in the report of Prof. Andrews, in his contribution to our first Report of Progress (1869). Prof. Andrews also mentions in his report that two fossils, *Lingula subspatulata* and *Discina capax*, are common to the Huron shale and the "Waverly black slate" (Cleveland shale). This is probably an error of identification, as, so far as yet known, the fossils of the two formations are quite distinct.

In the Waverly of Scioto and Pike counties certain layers of sandstone are found which furnish one of the most beautiful building stones known in the country. One of these, called the *City Ledge*, supplies a large amount of stone to the cities of the Ohio valley. This lies immediately above the black shale of the Waverly. Some of the flagging from the quarries of W. J. Flagg, in the Waverly hills near the Ohio, and known as the Buena

Vista flagging, is largely used and highly esteemed in the eastern cities. Here, as in the northern part of the State, the sandstone overlying the Cleveland shale is impregnated with petroleum derived from that carbonaceous mass. The collection of fossil fishes made from the Cleveland shale at Fairview, Kentucky, by Capt. James Patterson, has been already alluded to; further north, in Fairfield, Hocking county, the upper Waverly is composed of layers of fine-grained, buff sandstone, to which Prof. Andrews has given the name of *Logan sandstone.* Below this is a great mass of coarse sandstones and conglomerates, with alternations of finer material. In some places nearly the entire formation is coarse, and the beds of conglomerate rival in their massive character the true Conglomerate. These Waverly conglomerates are traceable north through Licking and into Knox county. Near Newark the cliffs at the narrows of the *Black Hand* are composed of Waverly conglomerate. In the valley of the Mohican, in Knox county, conglomerate beds are seen 220 feet below the top of the Waverly formation. The associated strata here are mainly blue, sandy shales, which weather yellow and ochery. This is the prevailing complexion of the Waverly group in the central part of the State. The Waverly conglomerate also appears at various points in Morrow and Richland counties—at Mt. Gilead, Richland Station, etc.—but it has not been recognized further northward. In passing from the south northward the red shale (Bedford shale), which is such a marked element in the Waverly of the counties bordering on the Lake, is first seen at Harlem, on Walnut creek, in Delaware county. The section at this point is as follows:

1.	Yellow and gray sandstones	10 feet.
2.	Gray sandy shale, with fucoids	16 "
3.	Red shale	15 "
4.	Black shale	60 "

The following list includes all the known fishes and plants, with the most characteristic mollusks and radiates, of the Waverly. A more complete enumeration of the Waverly fossils will be given in the palæontological portion of this Report:

FOSSILS OF THE WAVERLY GROUP.

PLANTS.

Annularia longifolia	Brong.
Lepidodendron Veltheimianum	Sternb.
Spirophyton crassum	Hall.
S. pectinatum	Newb.
S. vesiculosum	"
Dictyophyton Newberryi	Hall.
D. Redfieldi	"

FISHES.

Ctenacanthus formosus	Newb.
Ct. furcicarinatus	"
Ct. triangularis	"
Gyracanthus compressus	"
G. Alleni	"
Orodus variabilis	"
Cladodus Pattersoni	"
Cladodus horridus	"
Helodus coniculus	N. and W.
Palæoniscus Brainerdi	Thomas.
Polyrhizodus modestus	Newb.

MOLLUSKS.

Trematodiscus trisulcatus	M. and W.
Goniatites Andrewsi	Win.
G. Lyoni	M. and W.
G. Ohioensis	Win.
Orthoceras Indianense	Hall.
Conularia Newberryi	Win.
C. micronema	Meek.
C. byblis	White.
Producta semireticulata	Flem.
Producta Flemingi	Sow.
Producta Cora	D'Orb.
Productella Newberryi	Hall.
Lingula melia	"
L. Cuyahoga	"
L. membranacea	Win.
Discina Newberryi	Hall.
Hemipronites crenistria	Phil.
Chonetes Logani	Hall.
Orthis Michelini	L'Ev.
Spirifera camerata	Mort.
Spiriferina solidirostris	White.
Syringothyris typa	Win.
Rhynchonella Sagareana	"
R. Missouriensis	Swallow.
Aviculopecten Caroli	Win.
A. crenistria	"
A. Newarkensis	"
A. Winchelli	Meek.
Microdon reservata	Hall.
Macrodon Hamiltoniæ	"
Palæoneilo Barrisi	"
P. attenuata	"
Schizodus Medinaensis	Meek.
S. subtrigonalis	"

Sanguinolites æolus	Hall.
S. obliquus	Meek.
Grammysia Hanibalensis	Shum.
G. rhomboidalis	Meek.
G. ventricosa	"
Pterinea Newarkensis	"
Prothyris Meeki	Win.
Promachrus Andrewsi	Meek.
Platyceras Lodiensis	"
Pleurotomaria textiligera	"
Fenestella delicata	"
F. multipora var. Lodiensis	"
Ptilodictya Romingeri	"

RADIATES.

Actinocrinus Daphne	Hall.
A. helice	"
A. Eris	"
A. viminalis	"
Platycrinus contritus	"
P. graphicus	"
P. Richfieldensis	H. and W.
P. Lodiensis	H. and W.
Forbesiocrinus communis	Hall.
F. Kelloggi	"
Poteriocrinus crineus	"
P. pleias	"
P. (Scaphiocrinus) Corycia	"
Scaphiocrinus (Poteriocrinus) Ægina	"
S. (") Lyriope	"
S. subcarinatus	"
S. subtortuosus	"
Zeacrinus paternus	"
Z. Merope	"
Platycrinus Bedfordensis	H. and W.

LOWER CARBONIFEROUS LIMESTONE.

In the description which has been given of the Waverly group, its relations to the Lower Carboniferous rocks of Pennsylvania, Kentucky, Tennessee, and Illinois have been briefly referred to, and it has been said that the Waverly can be shown to be continuous with the mechanical sediments of the Lower Carboniferous series in all the surrounding States. But in all these States, except Pennsylvania, shales and sandstones form only a part of the Sub-Carboniferous formation, and in the region lying south and west of Ohio the calcareous member of the group becomes of greatly preponderating importance.

Until the commencement of the present survey it was supposed that the Lower Carboniferous limestone did not extend into Ohio, but that, rapidly thinning northward, in passing from central Kentucky to the Ohio river, the whole mass wedged out. The investigations of Prof. Andrews and his assistants in the south-eastern quarter of the State have shown, however, that the Lower Carboniferous limestone does reach into Ohio, and that it extends in a thin feather edge northward nearly to the National Road.

The best exposure of this limestone stratum—called by Prof. Andrews the Maxville limestone—is in the vicinity of Newtonville, Muskingum county, where it is from fifteen to twenty feet thick. It is also visible in a layer of eight to ten feet in thickness in Scioto, Jackson, Vinton, Hocking, and Perry counties.

In lithological character it is generally a gray, compact, partially crystalline rock, with few fossils, and these badly preserved. In certain localities, however, it contains considerable ferruginous coloring matter, by which it is striped and banded. In chemical composition it is a dolomite. Mr. Meek has examined the collection of fossils made from the Maxville limestone, and gives me the following memoranda upon them:

LIST OF FOSSILS FROM THE MAXVILLE LIMESTONE.

1. *Zaphrentis.*—A small, undetermined, curved, conical species.
2. *Scaphiocrinus decadactylus*, Hall?—Described from the Chester group.
3. *Productus pileiformis*, McChesney.—Described from the Chester group. Thought by Mr. Davidson to be the same as *P. Cora*, D'Orbigny.
4. *Productus elegans*, N. and P.—Described from the Chester group. Some of the specimens may be the form Prof. McChesney described from the same horizon under the name of *P. fasciculatus.*
5. *Chonetes.*—Undetermined species.
6. *Athyris subquadrata*, Hall.—Described from the Chester (Kaskaskia) group.
7. *Athyris trinuclea*, Hall, sp.—Described from the St. Louis (Warsaw) group.
8. *Spirifer* (*Martinia*) *contractus*, M. and W.—Described from the Chester group.
9. *Spirifer.*—Undetermined fragments of perhaps two species.
10. *Terebratula.*—An undetermined, small, oval species, showing the fine punctures under a lens.
11. *Aviculopecten.*—Undetermined species.
12. *Allorisma.*—Undetermined fragments, apparently like *A. antiqua*, Swallow. Described from the Chester group.
13. *Naticopsis.*—A small, undetermined species.
14. *Straparollus perspectivus*, Swallow, sp.—Probably a more elevated form of *S. planidorsatus*, M. and W. Both were described from the Chester group.
15. *Bellerophon sublaevis*, Hall.—Described from the St. Louis (Warsaw) limestone.
16. *Pleurotomaria.*—A small, undetermined cast.

17. *Nautilus.*—A small, undetermined, compressed, discoidal species, with the very narrow periphery truncated.
18. *Nautilus.*—A large, sub-discoid, undetermined species, with an open umbilicus, and only slightly embracing volutions, that are somewhat wider transversely than dorso-ventrally, and provided with a row of obscure nodes around, near the middle of each side. Very nearly allied to *N. spectabilis*, M. and W., from the Chester group, but more compressed, and having narrower and apparently one or two more volutions. Specimens mere fragments.

In his letter Prof. Meek adds:

"From these fossils it is clearly evident that the limestone from which they were obtained, belongs to the horizon of the Lower Carboniferous limestone series of the Western States. They also show that it does not belong to any of the inferior members of that series.

"Of the eighteen or twenty species of fossils sent me from this rock about one-half are represented in the collection only by specimens that are too imperfect for specific identification; though none of them, so far as their characters can be made out, appear to be allied to known forms from any horizon below the St. Louis limestone.

"Of the remaining species, five can be identified confidently with Chester forms, and three others are either identical with Chester species, or most closely allied to forms of that age. Hence we may safely say that eight of the species are *Chester types.* Two, however, seem to be identical with species described from the St. Louis limestone further west.

"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. They also seem to show that the old Carboniferous sea did not extend to this region during the deposition of any but the later members of the lower limestone series, although we know it had done so previously, that is, during the older Waverly period."

The last remark of Mr. Meek requires a little qualification or explanation, for inasmuch as the Waverly group is stratified, it is evident that all its layers were deposited in water; and as many of its fossils are identical with those found in the Carboniferous limestones of the South-west—and they are of marine origin—we may be sure that this water was the sea. But these mechanical sediments are shore deposits, and not such as accumulate in the deep basins of the open sea. Much of the Waverly group is composed of coarse sandstone, and, as we have seen in southern and middle Ohio, it contains heavy and extensive sheets of conglomerate, the product of shore waves. Hence, in the relations of the calcareous and mechanical sediments which make up the Lower Carboniferous formation, we have an indisputable record of another of the great continental submergences to which I have so many times referred.

In Ohio we have almost exclusively the shore deposits, the lowest member of the trinity; but by going into Kentucky and traveling toward the depths of the old Carboniferous sea, we find the series complete, and trace the record of a progressive but doubtless a very irregular submergence of southern Ohio in the last or Chester epoch of the Sub-carboniferous period.

In order that this interesting episode of our geological history may be fully comprehended, I will briefly review the phenomena presented by the Lower Carboniferous Limestone in the region south and west of that which it occupies in the State of Ohio.

In the hills bordering the Ohio river the limestone member of the group shows a thickness of from 30 to 40 feet; going southward it rapidly increases in force, until, in central Kentncky, it forms fully half of the Lower Carboniferous series.

In all this region the lower, or silicious, portion of the group consists of a series of fine-grained sandstones and shales, which, from the fact that they compose many of the hills left by erosion in the excavation of the valleys of the Ohio and its tributaries—hills which are known as the Knobs—have received the popular designation of the *Knobstones.* In the northern part of Kentucky, the "Knob rocks" are soft yellow, brown, or bluish shales, with some beds of sandstone, the whole resembling very closely our Waverly group as it appears in the central and southern portions of the State. On the southern line of Kentucky, near Burksville, this group of rocks is represented by a nearly homogeneous mass of blue and gray shales, capped above by the Lower Carboniferous limestone, and resting upon the "black slate," the equivalent of our Huron. From various localities in this region I have obtained abundant fossils, characteristic of the Lower Carboniferous series in Tennessee and Illinois, and these reach down quite to the black shale, so that we are compelled to regard all these as of Carboniferous age. We now know that our Waverly group, as exposed on the southern margin of the State, is the exact equivalent of these Lower Carboniferous shales of Kentucky.

In Michigan the Lower Carboniferous series, according to Prof. Winchell, consists of the Lower Carboniferous limestone above, the Michigan Salt group in the middle, and the Napoleon and Marshall sandstones at the base. The limestone has an average thickness of 60 feet, and, as Prof. Winchell shows, represents *the upper beds* of the limestone group. Above this series is found the Conglomerate; below it the Huron shales, regarded by Prof. Winchell as the equivalents of the Portage and Chemung in New York.

In Illinois the Lower Carboniferous formation is, for the most part, calcareous. It consists of—

1. The Chester or Kaskaskia limestone.		
2. The St. Louis limestone	250	feet thick.
3. The Warsaw limestone	50 to 100	"
4. The Keokuk limestone	40 to 50	"
5. The Burlington limestone	60 to 100	"

All of which are underlaid by the "Kinderhook group," consisting of shales and sandstones, with some local limestone beds having a thickness of about 100 feet. The Illinois series contains many fossils which are identical with those found in the Waverly of Ohio, and we have every reason to believe that the beds which include them are the equivalents of each other; the lithological differences which they present being due to the fact that the Waverly of Ohio is a shore deposit, while most of the Lower Carboniferous of Illinois was laid down in an open sea. The reach of this sea is indicated by the spread of its calcareous sediments; and since the Coal Measures of Michigan, Illinois, Kentucky, Tennessee, Alabama, and Virginia are underlaid by this calcareous stratum, we have in this evidence of a continuous ocean, which, during a portion of the Lower Carboniferous period, occupied the area of the States that have been enumerated, but which reached no farther (at least in sufficient purity to form limestones) than central Ohio and the southern line of Pennsylvania.

It is also evident that the Lower Carboniferous period was one of *progressive* continental depression, for the lower rocks deposited in this period over a great area are mechanical sediments, while the overlying calcareous deposits, thickest at the south and west, gradually thinning out toward the north and east, are by their volume a measure of the length of time during which, in any locality, marine conditions prevailed. Hence we must suppose that the thin edge of the calcareous member of the Lower Carboniferous series represents the uppermost, last formed portion of the mass; and this is more widely extended than the lower beds, because, at the time of its deposition, the sea had further encroached upon the land.

THE CARBONIFEROUS CONGLOMERATE.

In many parts of Europe, especially in England, and throughout most of the area occupied by Carboniferous rocks in America, the middle portion of the Carboniferous series is indicated by a mass of sandstone, of greater or less thickness, containing vast numbers of quartz pebbles, and forming a pudding-stone, or conglomerate. In England this rock is known as the "Millstone Grit," from the fact that its most compact portions have been used for the manufacture of millstones. In our own country the greatest development of this stratum is in the central parts of Pennsylvania and Virginia, where it attains a thickness of from 1,000 to 1,400 feet. East of the Mississippi it is found underlying the Coal Measures over the greater part of our coal fields, but varying much in thickness. In Ohio, where present, it ranges from 10 to 175 feet; in Kentucky, from 50 to 500 feet; in Indiana, from 50 to 100 feet; in Michigan, from 30 to 105 feet, etc. Thus we see that this peculiar rock is very widely spread alike over the calcareous sediments and the mechanical shore deposits of the Carboniferous sea. It occupies an area of not less than 200,000 square miles in our country, and from its occurrence in the same relative position on both sides of the Atlantic, apparently marks a change in the physical conditions of a large part of the northern hemisphere. We shall look in vain through the entire geological series for another stratum of rock so widely distributed, and presenting as strongly marked lithological characters as this. The coarseness of the material of which it is composed, and the uniformity and wide extent of its distribution, offer problems of no little interest and difficulty. The pebbles it contains are generally of quartz, but not exclusively so, for among them are found representatives of various other metamorphic and igneous rocks, but none that are not of a peculiarly hard, tough and resistant character. These pebbles are all well rounded, and bear evidence of a great amount of trituration.*

The sand which forms the paste that holds together the pebbles of the Conglomerate is generally coarse, and consists of angular or rounded grains of quartz, which differ from the pebbles only in size.

In attempting to analyze the process by which this material accumulated where we find it, we have to consider, first, its source, and second, the mechanical agencies by which it was distributed. In seeking for the source of the material we are compelled to look to such portions of our continent as were, during this period of geological history, raised

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* In the north-west corner of Holmes county the Conglomerate is thin, and irregularly deposited, but it contains, mingled with its quartz pebbles, rather rudely rounded masses of chert, generally from one to three inches in diameter, which contain *Lower Carboniferous limestone fossils*. This would seem to indicate that the Maxville limestone once reached nearly to the northern margin of our coal basin, but that the agency which transported and deposited the materials of the Conglomerate had, in the northern counties, broken it up and dissipated the greater part of it. The same causes have also severed the connection of the limestone areas, and have given the deposit the "patchy" character which it exhibits in southern Ohio.

above the ocean level, and contained an adequate supply of crystalline quartz. Tracing out the limits of the Palæozoic seas and lands, we find that a portion of the Alleghany belt, and the Eozoic area in Canada, New York, and Michigan, were the only regions which satisfy the conditions. Here the metamorphic rocks are every where intersected by veins of quartz possessing essentially the same mineral characters with that which forms the pebbles of the Conglomerate. This, then, is the source from which the material was derived. Second, as regards the manner of distribution of this material, we find in the present epoch that sands and gravel beds are the natural products of the action of shore waves upon the land, and that, in many portions of the geological series, such beds of gravel and sand were formed by the extension of ancient sea beaches. If, therefore, this sheet of sandstone and Conglomerate were spread over a continent consisting of crystalline rocks, of which quartz formed an important part, we should need to go no further for an explanation of the phenomena than to suppose that an invasion of the sea had leveled down and comminuted such materials as were encountered by the shore waves; and of these the most resistant, and such as possessed the highest specific gravity, were accumulated in a sheet which measured the reach of the sea. But when we examine the area over which the Carboniferous conglomerate is spread, we find districts where it exhibits its maximum development and coarseness many hundreds of miles away from any possible source of supply; as, for example, in western Kentucky, where the Conglomerate is in places 250 feet in thickness, and where it was 500 miles from any outcrop of crystalline, quartz bearing rock, at the epoch of its deposition. Between this district and the Eozoic highlands, or the Blue Ridge belt, lie unbroken sheets of Palæozoic sediments, the uppermost layers of which, at the time the Conglomerate was formed, were unconsolidated organic or mechanical mud.

It has been customary to suppose that the material forming the Conglomerate was washed down from the highlands of the continent, and transported by rivers to the localities where it is found; but the difficulties in the way of the acceptance of this explanation seem to be insurmountable. It is true that river currents have the power of rolling gravel and sand along the bottoms of the channels they traverse, even to a great distance from their sources; but no river action is adequate to explain the uniformity that marks the distribution of this great *sheet* of consolidated sand and gravel. Hence the approximate uniformity in thickness of the deposit, and its similarity of composition over all parts of the area it occupies, forbid the acceptance of river action as the agency of its distribution. Again, the action of narrow currents of water having sufficient velocity to transport such a mass of coarse material several hundred miles, would not be shown simply in such transportation, but these currents would deeply excavate the underlying beds over which they flowed, and which were at this time scarcely in any degree consolidated.

Shore waves acting upon this portion of the continent could not have effected such a distribution, as they have no power to create quartz pebbles except as they have quartz rock to work upon. Advancing shore waves could, therefore, not have deposited two or three hundred feet of sand and gravel several hundred miles out upon a flat, composed altogether of fine material; and retreating shore waves would have no power to carry with them from Canada to Kentucky such a mass as the Conglomerate forms there. We must, therefore, find some other process of distribution than any yet suggested for the explanation of the problem before us.

In looking through the geological series for some similar deposit which could serve as an explanation of this one, I have found none that seemed to offer so close a parallel as the later Drift deposits spread over the northern half of the Mississippi valley. Here we have in many localities a mass of material which, if consolidated, would form an almost perfect copy of the Carboniferous conglomerate—beds of gravel, in which the pebbles are for the most part quartz, undistinguishable from those of the Conglomerate and sheets of sand, nearly or quite free from pebbles. It is true that most of the Drift also contains bowlders of larger size than any found in the Conglomerate, but over large areas these are restricted to the summit of the series, and mark a distinct epoch in the chain of events. Throughout a wide area, too, we find the gravels and sands of the Drift resting upon the lower, fine Drift clays, precisely as the Conglomerate rests upon the mud stones of the Waverly and the Sub-carboniferous limestone. To explain the phenomena presented by the Drift deposits, I have been compelled to invoke the aid of floating masses of ice, and have suggested that the gravels and sand which form the upper layers of the Drift have been floated to their present resting places, frequently from points of origin 500 miles distant, and quietly dropped down upon the soft clays below; arguing that currents of water or currents of ice transporting these gravels, sands, and bowlders, could not have deposited them where they are found without tearing up the underlying clays.

All that we know of the present sea bottom on the banks of Newfoundland leads us to suppose that it is every where strewed with gravel, sand, and bowlders, spread with considerable uniformity over its surface by the icebergs that come down from the far north freighted with these materials, which are dropped into the water as the ice melts.

I also have under my eyes as I write a suite of specimens dredged up from the bottom of the ocean, off the Antarctic continent. These specimens, and the report of the Exploring Expedition, teach us that this sea bottom is every where strewn with pebbles derived from the neighboring continent, and scattered by icebergs. Hence, from the similarity of the deposits now being made by icebergs over various portions of the sea bottom with those made by the same agency during the Drift period, and of both to the materials composing the Carboniferous conglomerate, I have suggested the possibility that they might all be the products of the same agency; that is, that the materials of the Conglomerate may have been broadly and evenly *distributed*, as we find them, and subsequently triturated, comminuted, and rearranged by shore waves when the water was shallowed, and the surface was swept by tidal currents and storm waves. In this view the Conglomerate should be compared with the kames and eskers of the Drift. This theory, however, is not insisted upon, but is simply a suggestion which has sprung from a conviction of the entire inadequacy of any other solution of the problem yet offered. In many places in Ohio we find in the Conglomerate sheets of pebbles, many of which are two and three inches in diameter, and I have had much difficulty in believing that these large pebbles were ever spread as widely and evenly as they are by causes as local in their action as river currents. Should it be proved by further investigation that the Conglomerate is the record of a glacial or iceberg period, it would account for the occurrence of a similar deposit in the Old World; as the Conglomerate there holds the same place in the geological series, and is composed of the same materials. It evidently marks a corresponding period in geological time, and may have been deposited in an identical period in absolute time, since we know that the phenomena of the Drift period were similar in character and synchronous throughout the Drift area of the northern hemisphere.

Immediately succeeding the deposition of the Carboniferous conglomerate—we may perhaps say during the process of its accumulation—the Carboniferous sea shallowed over a large area, and that which was before sea bottom became dry land. In the retreat of the ocean waters every portion of the surface they had covered would in succession be exposed to the action of the retreating shore waves, and, as a consequence, the surface materials would be shifted, sorted, and still further comminuted. Precisely similar influences operated upon the Drift deposits, to which reference has been made, and the phenomena which they now present is in large part due to the action of the cause we are now contemplating; and we are justified in concluding that in these two geological periods similar causes produced similar effects.

In Ohio the outcrop of the Carboniferous conglomerate forms a narrow belt, which enters the State from Pennsylvania about the middle of the eastern line of Trumbull county; the formation having here a thickness of from fifty to sixty feet. Thence it extends in a line from three to five miles in width to the township of Howland; thence follows along down on either side, or forming the bottom of the valley of the Mahoning to and below Youngstown. Here it is greatly diminished in thickness, varying from six inches to twenty feet, and in some places is even scarcely perceptible. From the valley of the Mahoning the outcrop of the Conglomerate passes north and west through the southern part of Trumbull county, forms the banks of the Mahoning at Newton Falls, thence trends northward in a sinuous line through the eastern margins of Portage and Geauga counties, until its northern extension in two or three prominent headlands reaches over the line of Lake county. Little Mountain, near Chardon, is an island of the Conglomerate, and the one which approaches nearest to the Lake, above which it rises to the height of 750 feet. From this point the Conglomerate stretches away south and west, occupying a large area, which includes the greater part of the counties of Geauga and Summit, and the north-west corner of Portage. Throughout this region it underlies the highlands drained by the Cuyahoga and Chagrin, reaching out toward the north-west in a great number of promontories and islands, which form the divides between the branches of the streams I have mentioned, and which owe their isolation and relief to the excavation produced by this system of water-courses. The bed of the Cuyahoga lies in the Conglomerate throughout nearly all of its course to Cuyahoga Falls. Here it is cut through by the stream, and the cascades are produced by the water flowing over conglomerate ledges; thence, to the south line of Cuyahoga county, the Conglomerate forms the summits of the cliff bordering the valley on either side. In all this section of the State it is generally about 100 feet in thickness, being thickest in Parkman and Nelson, where it is 175 feet. It is usually composed of very coarse materials, lying in thick beds. Of these the lowest, with a thickness sometimes of twenty feet, is often a mere mass of pebbles, from half an inch to two or three inches in diameter, with just enough sand to fill the spaces between them.

South and west of Medina county the area underlaid by the Conglomerate is narrow, and its thickness is much diminished. In Wayne and Holmes counties it is very irregular, generally thin, and often wholly wanting. In Richland county the horizon of the Conglomerate passes through all the highlands of the "Loudonville hills," but the rock itself is often absent; sandstone No. 1 of the Coal Measures cutting out both the Lower Coal and Conglomerate, and resting directly on the Waverly. Both the absent members of the series were perhaps, and even probably, deposited here, and were subsequently swept away by the agent that brought the sand that now composes sandstone No. 1. This is not certain, however, as the highlands of Richland county apparently form the crown of one of the several arches of strata that traverse the State imperfectly parallel with the Alleghanies, and hence have always been relatively highlands; and it is quite possible that neither the Conglomerate nor Coal No. 1 was deposited over them. In Richland county the Waverly contains heavy beds of Conglomerate which have much the character of the Carboniferous conglomerate, and have been often mistaken for it. These are to be seen at Richland Station, and at various other points, even as far west as Mt. Gilead, in Morrow county. From Holmes county to the Ohio the Conglomerate forms an interrupted line of outcrop skirting the margin of the Coal Measures. Throughout this interval it is rarely more than twenty-five feet thick when found, and in many places it is scarcely perceptible. In Jackson county, however, it resumes its importance, and attains a thickness of one hundred feet. The exaggerated estimates which have been published of the development of the Conglomerate along its southern line of outcrop are due to the fact that the Waverly conglomerate attains unusual force in this region, and all its exposures have been credited to the overlying rock.

In speaking of the origin of the materials of the Conglomerate, I have referred to the balls of chert with Carboniferous fossils which it contains in Holmes county, and have suggested that the Lower Carboniferous limestone may have once existed in northern Ohio. This supposition is rendered probable by the relations which we find to exist between the Conglomerate and limestone in southern Ohio. There the latter rock seems to lie in patches, which were without doubt formerly connected, but the connections have been severed by the agencies that distributed the Conglomerate.

Though generally forming a very distinctly marked geological horizon, and entirely separated from the associated rocks, the Conglomerate in some places is more or less interstratified with the Coal Measures above and the Waverly beneath. In the northern part of Portage and Geauga counties it is difficult to draw the line between the Coal Measures and the Conglomerate, as the point of junction is formed by beds of passage; thin bands of conglomerate alternating with layers of shale containing the impressions of coal plants, and a bed of coal which is locally workable.

It is also true that at various places in the State vegetable matter accumulated in the Conglomerate in sufficient quantities to form thin and local beds of coal. These layers of coaly matter are, however, plainly composed of drifted material, are not superimposed upon fire-clay, as are the coal seams of the Coal Measures, and are not of such a character as to justify the assertion made by some geologists, that we have in Ohio a system of false Coal Measures lying in or below the Conglomerate.

In Trumbull and Medina counties, on the extreme edge of the coal basin, we occasionally find the roof-stone of Coal No. 1 containing patches of conglomerate, and this occurs in a still more marked degree near Sharon, Penn. These cases have led some geologists to suppose that our Coal No. 1 was located in or below the Conglomerate; but such is not the case, for this coal stratum is opened at a thousand places in the State, and its normal position is proven to be *above* the Conglomerate. The explanation of the cases I have alluded to seems to me simply this: When Coal No. 1 was formed, the marsh in which it accumulated was bordered on the north and overlooked by gravel hills which now form the Conglomerate, greatly developed in this direction. In the submergence which buried Coal No. 1 some of the gravel from these hills was washed down on to and over the coal, with large quantities of sand which now form the great bed of sandstone over the Briar Hill coal.

The fossils of the Conglomerate are almost universally plants, of species found in the overlying Coal Measures. Where the material composing it is coarse, they consist of fragments of tree trunks, branches of calamites, nuts, etc., all more or less broken, and showing evidences of transportation and accumulation in the same way that drift-wood is gathered by river currents or shore waves. In some localities these vegetable remains are crowded together so as to form a mass in the sandstone many feet in thickness, and extending over several square rods. Here the trunks, branches, reeds, etc., are intermingled in such confusion that it is difficult to extract an individual specimen of any considerable dimensions. Generally the fragments are broken and water-worn, and it is not at all uncommon to find far up in the interior of what were hollow calamites *Trigonocarpa*, which were the fruits of a different plant. At Cuyahoga Falls, where the Conglomerate is cut from top to bottom by the river, the plants which characterize this formation are found in great abundance, but always in the condition I have described; the trunks and branches of trees (*Lepidodendron* and *Sigillaria*) rarely of any great length, but frequently showing their markings with distinctness; the *Trigonocarpa* exhibiting only the nut with its nucleus, the external fleshy envelope and the delicate wings of the nut having been all removed by attrition. Occasionally the sandstones and pudding-stones of the Conglomerate are interstratified with layers of argillaceous shale, especially at the top of the formation, and here we sometimes find some fern fronds. Such exceptional cases as these are plainly the products of local causes, which, in the emergence of the continent and the supervention of the terrestrial on marine conditions—in other words, the succession of the Coal Measure epoch to the Conglomerate epoch—occasioned the Coal Measure conditions to be locally reached before they generally prevailed.

In western Pennsylvania—Warren, Kinzua, etc.—the Conglomerate contains great numbers of fossil mollusks near its line of junction with the Waverly, and I have noticed the same thing in a few localities in Ohio. These fossils include several species, all of which, so far as I know, are found in the underlying strata, and they simply indicate that in certain localities the change of physical condition recorded in the different lithological characters of the two deposits took place more gradually than elsewhere.

Some years since, at a meeting of the American Association, the geologists present were much puzzled by some specimens of the Conglomerate exhibited by Prof. Brainerd, of Cleveland, in which the impressions of the stems of plants were as distinctly transmitted to the quartz pebbles as to the interspaces of sand. Prof. Brainerd argued from these specimens that the pebbles were of concretionary origin, and that they bore the markings of the bark of plants because they had been formed in contact with such bark. The recent experiments of Thenard, which show that humic acid renders silica readily soluble, afford an easy solution of the problem, and confirm the view taken by the writer upon the occasion referred to above, viz., that the pebbles had been *dissolved away* where in contact with the plant. The proof that the pebbles of the Conglomerate are not concretionary is abundant and conclusive. In some localities many of them are composed of something else than quartz; silicious slate showing stratification being a common material. Conglomerate pebbles composed of chert containing fossils I have already referred to.

The economic value of the Carboniferous conglomerate is very great. Throughout the whole area occupied by its outcrop it furnishes a more or less desirable building stone, and almost exclusively supplies the want of such material to many of the communities resident on this area.

As a general rule, the stone which it furnishes is coarse, and though easily worked and durable, has little to commend it so far as regards its beauty. In certain localities, however, it presents very different characters. At Cuyahoga Falls some of the layers of the Conglomerate consist of a compact, homogeneous, rather fine-grained sandstone, largely impregnated with iron, and of a pleasing dark-brown color. At Akron apparently the same beds are still finer in texture, contain a larger percentage of peroxide of iron, and have a beautiful purplish red tint. These characters combined render this the most beautiful building stone with which I am acquainted.

The Conglomerate is also largely used for the production of glass, and its pebbles are employed by Mr. Alexander, at Akron, as an element in one of the varieties of fire-brick manufactured by him. Various localities might be cited where inexhaustible quantities of pure quartz may be obtained from this source, and this is a material sure to be in demand in the future for the manufacture of porcelain, glass, fire-brick, gannister, etc.

In a number of places in Knox and Licking counties *gold* has been found in the superficial gravel. This may have come from the Drift deposits only, but it is probable that in some cases it has come from the Conglomerate. Nearly all crystalline quartz, such as forms the pebbles and sand both of the Drift and Conglomerate, is auriferous, and we have every reason to believe that the materials which compose both these formations were in large part derived from the Eozoic highlands of Canada and the Alleghany belt. Nearly all the Laurentian rocks are traversed by segregated veins of quartz, which always contain more or less gold. Hence we could hardly fail to find traces of gold in the *debris* of these quartz veins; and so I venture to say that careful search will detect gold in *all* the quartzose materials of the Drift and Conglomerate. As, however, the quartz veins of the area of crystalline rocks in the north-east are perhaps never rich enough in gold to pay for working, and as from its gravity much of the gold must necessarily be left behind in transportation, I think we may be quite certain that our gold mines will never be remunerative, and that gold can hardly be reckoned as one of the mineral staples of Ohio.

I may mention, in this connection, that Mr. Glass, of Dayton, claims to have found gold in the Drift in various localities in Clermont county, and he is disposed to regard the deposits as pecuniarily important. Though fully satisfied that this *placer* gold of Ohio has no economic value, I regard its discovery as of great geological interest, as it affords an easy answer to the much discussed question, Where does gold occur in the geological series? viz., *every where.* It is found in considerable quantity in the oldest rocks known, the Laurentian; hence all the mechanical sedimentary strata derived from the erosion of the Eozoic rocks must contain gold. But it is generally so scattered here as to be practically inaccessible. When these rocks are metamorphosed, however, segregated quartz veins are found and the gold is collected into them. As they are of limited extent and communicate with no possible foreign source of gold, the gold in them must be indigenous.

THE COAL MEASURES.

The coal strata of Ohio, though constituting the most interesting and important feature in the geology of the State, have been so fully described in the reports of the Geological Survey already published, and in the various county reports which form parts of this volume, that but little space can, with propriety, be devoted to them here. It should also be said that the distribution, qualities, and uses of our coals will be discussed at length in the volume on Economic Geology. I shall, therefore, confine myself in this chapter to a brief review of the structure and extent of our coal field, referring the reader to the various reports on the local geology of the State for all detailed statements of the facts upon which the generalizations now made are based.

The upper division of the Carboniferous system, known among geologists as the Coal Measures, underlies the surface of the south-eastern third of the State. This, as has been before said, is, with the exception of the Drift, the highest member of the geological series in Ohio. In harmony with the general arrangement of the rocks which fill the great Alleghany basin, the Coal Measures form a series of sheets that, with a general easterly dip, lie on the slope of the anticlinal axis which traverses our State from Cincinnati to the Lake. Over all the eastern half of Ohio the dip of the rocks is toward the east, and all the strata which come to the surface along the middle line of the State are, on our eastern border, buried to the depth of 1000 feet or more. Sharing in this general arrangement, the different elements that compose our coal series form sheets of which the edges come to the surface in lines of outcrop further and further eastward as we ascend the geological scale. On the northern and western margin of the coal field, only the lower seams of coal and their associated rocks are found, while in going from this line southward or eastward toward the center of the basin the outcrops of one and another of the higher beds of coal are passed over, till on the Ohio, near Wheeling, the surface of the highlands is underlain by nearly 1200 feet of Coal Measure rocks, in which are included ten or twelve workable seams of coal. As a consequence of this arrangement, the amount of coal underlying any given county or town in the coal area depends on its proximity to the center and deepest portion of the basin. So that while we have an aggregate of about 12,000 square miles of territory underlain by coal, not all parts of this are equally endowed with this great source of wealth. Along the margin of the coal basin, in many places, only a single coal seam is present, but the peculiar excellence of this one compensates in part for the deficiency in quantity. The aggregate thickness of all the beds included in the section of the south-eastern and deepest portion of our coal basin is perhaps fifty feet. The average coal contents of our territory may, therefore, be taken as something like the mean between the minimum, a single seam four to five feet, and the maximum reported above, or, in other words, twenty-five to thirty feet of workable coal.

The coal seams which give character and value to the formation that includes them compose, therefore, but a small portion of the mass of strata with which they are associated. The other elements in the section are sandstones, shales, limestones, fire-clay, and iron ore. The nature of the materials forming the Coal Measures, their relations and relative quantities, will be best learned from an inspection of the engraved section of our Coal Measures which accompanies this chapter.

By referring to this section and the many others published in our reports, it will be seen that the elements composing the Coal Measures occur in an order of superposition that is so constant, or at least so frequently repeated, that it cannot be a matter of chance, but must be the expression of a general law. The order of sequence to which I have referred, and which will be noticed in these sections, is this, namely, that the coal strata almost invariably rest upon beds of fire-clay. They are also almost always covered with shale of greater or less thickness, and this in turn is overlaid sometimes with a sandstone, more rarely with limestone; and thus each section is susceptible of division into series of three or more members each, in which the elements hold nearly a constant relation to each other. These strata will be considered in the order of their occurrence, and as far as possible the history of their formation will be deduced from the facts which they present. For several reasons it is most natural and convenient to consider the fire-clays as forming the base of each series. In all ordinary circumstances, these are continuous sheets from one to twenty—generally three to four—feet thick, of nearly homogeneous, compact gray clay, which, possessing the property of resisting fire to a marked degree, has from this fact received the name it bears. The fire-clays are usually penetrated in every direction by the roots of plants, usually *Stigmaria*, formerly regarded as an entire aquatic plant, but now known to be the roots of trees which are characteristic elements of the coal flora, *Lepidodendron* and *Sigillaria*. Sometimes the stumps and spreading roots of these trees are found in unbroken connection buried in the fire-clay.

Upon the fire-clay we almost always find a stratum of coal of greater or less thickness. Sometimes this is very thin, sometimes, though rarely, entirely wanting, and in most such instances we can gather proof that it has been removed, either mechanically or by oxidation. This coal throughout its entire mass shows traces of vegetable structure, and it is now agreed among all good authorities that it has accumulated by plant growth in the locality where it is found. Various theories have been proposed to account for the formation of coal, viz., that it is of animal origin; that it was formed from petroleum; that it is derived from vegetable tissue transported by river currents and gathered in water basins; but these theories have already been sufficiently discussed and so clearly disproved that no further reference to them is needed here. All those who have carefully studied the phenomena presented in our coal fields have been satisfied that the beds of coal have been formed where they are now found by the bituminization of vegetable tissue, which accumulated precisely as peat does now. Peat beds usually occupy marshes, and are produced by the bituminization of the various plants that grow in water or on moist surfaces. In making a section of a peat bog we almost always find beneath the peat a layer of clay very much like the fire-clay, and by an examination of many of these peat-producing marshes it has been discovered that they have generally been pools of water in which a fine sediment accumulated at the bottom, and that these pools have been invaded by vegetable growth until they are more or less filled up by the accumulation of the bituminized leaves, trunks, etc., of different generations of plants.

The effect of the growth of aquatic plants on the soil in which they are rooted is to abstract the alkalies, sulphur, phosphorus, and a portion of the silica, and leave a fine homogeneous clay containing a large percentage of alumina and highly resistant to fire. This we learn by analyses of clays under our peat bogs. Hence, from the great similarity, almost identity, which they exhibit with the fire-clays of the Coal Measures, we may fairly conclude that their histories are essentially the same. The coal seams in our State vary in thickness from one inch to twelve feet, and as the material composing them has been greatly condensed by pressure, we may infer that they represent beds of peat of from one to fifty feet in thickness. These were formed by the gradual, perhaps annual, accumulation of the leaves, twigs, fruits, etc., of the plants which covered the coal marshes. This we learn from a careful microscopic study of the coal itself.* Hence the coal beds, though of insignificant thickness as compared with the associated strata, probably represent long intervals of time. These intervals, however, ultimately ended, and the peat bogs, the growth of which took place at or above the water level, were submerged generally at considerable depth, for we find them overlaid by sedimentary strata many feet in thickness. Usually the water which flowed over them transported and deposited clay or sand. When the change took place quietly the sediment was fine, and we now find it as a clay shale; when attended with more violence the motion of the water was quicker, its transporting power greater, and it spread thick sheets of coarse material sometimes over large areas. Oftener than otherwise, this turbulent flood or rapid current succeeded a period of quiet submergence, as we generally find shales succeeding the coal, and this in turn overlaid by sandstone, this sandstone locally cutting out the shale or coal, or both, and forming what are known in miners' language as *horsebacks*, which are simply beds of sand deposited in channels cut by water currents in the then soft materials, now forming our beds of shale and coal. Where the subsidence, greater than usual, resulted in the extension into the coal basin of an arm of the sea, this quietly deposited calcareous sediments, which now form limestones. In process of time the water basins in which the sediments I have described—shales, sandstones, and limestones—were deposited, were, sometimes by elevation, sometimes by filling up, shallowed until they were again pools and marshes, where fire-clays and beds of coal were again formed, again to be submerged. In this way the whole 1,000 feet of our Coal Measures have been built up and form a record of a subsidence along the center of the coal basin (which passes near Pittsburgh) of more than 2,000 feet. That this subsidence was local we learn from the fact that the upper coal beds occupy narrower limits than the lower. Erosion may have done something to contract

* By Mr. E. W. Binney, of Manchester, England, the theory has been advanced that coal was mainly formed from the spores (microspores and macrospores) of cryptogamous plants, such as *Lepidodendron*, *Sigillaria*, etc.; but a searching examination of our coals has shown me that though sporangia and spores are common enough in the coal beds, they make up no considerable portion of the mass. In all classes of plants living at the present day the organs of fructification are insignificant in volume as compared with the organs which belong to the vegetative system of the plant (*i. e.*, roots, stems and leaves), and we may infer that such has always been the case.

the area of the upper coals, but had they ever reached as far as the lower ones they would certainly be found elsewhere than they are, *i. e.*, only in the center of the basin. In the western coal fields we find that the subsidence was progressive in one or another direction, the upper coal seams then reaching in this direction far beyond the lower. In the Ohio portion of the Alleghany coal field, however, the basin seems to have narrowed as it deepened. That intervals of elevation alternated with those of subsidence seems proven by the fact that beds of fire-clay and coal sometimes rest directly upon limestones which must have been deposited in somewhat clear and deep water. This water must have been withdrawn to make the growth of a bed of coal on its sediment possible. Proofs of greater elevations are also not wanting in the Coal Measures, such, for instance, as is furnished by the following case, reported by Mr. M. C. Read: In Clarke township, Coshocton county, is a channel, now filled with sandstone, 280 feet deep. This cuts out in a narrow belt all the lower coals from No. 5 down. Complete sections in the vicinity show the coal seams to be regular and undisturbed on either side. This is the result of sub-ærial erosion, and proves that during the Coal Measure epoch this region was elevated several hundred feet above the sea level. Thus we see that our Coal Measures form the record of a subsidence of the great geosynclinal lying between the Blue Ridge and the Cincinnati axis, a subsidence which carried the central portion of the trough down at least 2,000 feet. This would have formed here a deep synclinal valley, but that, being a comparatively narrow trough and receiving the drainage of a continent lying north and east, it was filled nearly as fast as formed. That the sinking was unequal we learn from the unequal distribution of the limestones, which are the most distinct marks of the reach and continuance of the successive submergences. The great limestone associated with the Pittsburgh coal, for instance, occupies only the central portion of the basin, and thins out both east and west, while some of the lower limestones have their line of greatest development quite within our State and are unknown in Pennsylvania. The same thing is taught by the coal strata, some of which are quite local; others are very extensive, but none cover the whole breadth of the basin. But the best proof of unequal subsidence that we find in the Coal Measures is afforded by the great variation which is observable in the interval which separates the different seams in the series (examples of which will be given hereafter) and in the splitting up of our coal seams into two or more subordinate seams in their extension in one or another direction from localities where they are found forming nearly a homogeneous mass. Such instances occur in all known coal fields, and some which have come under our observation will be referred to in another place.

In the shales which overlie the coal seams we very frequently meet with the casts of the bases of the trunks of trees which were once rooted in the coal. These are generally short, showing that the upper portions of these trees rotted away before clay and sand were deposited around them; but in one instance I have seen a trunk of *Sigillaria* which projected fifteen feet above the carbonaceous mass in which it grew. The sections of these trunks are frequently seen in the roofs of our coal mines, each traced by a circle of carbonaceous matter. These circles are sometimes called "pot-bottoms" by the miners, and they are regarded by them with some dread, as from the conical form of the stump it sometimes drops out, and falls with sufficient force to crush any one beneath it. The first layer of the shale above the coal is generally filled with the impressions of the trunks, leaves, and fruit of the forest that was growing over the coal marsh at the time of its submergence, while the superincumbent layers of shale and sandstone may be entirely barren of plant impressions.

The alternation of sheets of vegetable matter with rooted trunks and other indications of the growth of a sheet of vegetation on a land surface, with layers of limestone full of marine shells, may be accepted as conclusive proof of great and repeated changes of physical condition in the area of our coal basin, and we may generally find evidence that these changes were produced by elevations and depressions of the bottom of the basin. The number of such alternations, however, is so great that some persons have found it difficult to believe that so many oscillations of level could have taken place in our *terra firma* during one chapter of geological history. It should be remembered, however, that the lapse of time recorded in our Coal Measures would, if expressed in years, be almost infinite as compared with the epochs of human history. We know, too, that warpings of the surface are now constantly taking place in all parts of the globe, and though accomplished so slowly that they are scarcely perceptible to our observation, evidences of recent changes of level have been gathered from many localities on the margin of our own and the European continent. The shores of the Mediterranean afford many examples of local elevation and depression. The coast of Sweden is known to be now slowly rising, but most toward the north, and Lyell makes the average rate of movement four feet in a century. On the North American coast similar local changes are going on. In Greenland a slow subsidence is taking place; at St. John's, in New Brunswick, the land is rising; sinking at the island of Grand Manan;

rising on the coast opposite, at Bathurst, and rising at Prince Edward's Island. (J. D. Dana.) According to Prof. G. H. Cook, the coast of New Jersey and Long Island is slowly sinking. On the coast of California I have observed several raised beaches marked by lines of marine shells—some of which still retain their colors—and rocks bored by *Pholas*. It is also plainly shown that the elevations have been local and unequal. There is, therefore, no inherent improbability in the view that the alternations of marine and terrestrial conditions, of which we find records in the Coal Measures, were produced by the sinking and rising of the bottom of the great geosynclinal trough of the Alleghany coal field. It is possible, however, that some of the influxes of the sea, of which we have record in the phenomena described, were produced by the breaking down of barriers by which the sea had been excluded. In such cases effects may have been produced similar to those that have been witnessed in the inundations of Holland. On the low coast of the Netherlands the sea is carefully excluded by artificial embankments, and large areas have by this means been wrested from its grasp. On the marshy surface within the dykes by which the land is now protected beds of peat have grown. From time to time storms have broken over the barriers by which the sea is kept out, and it has rushed in, covering many square miles with its waters and the sediments they have transported. In such localities the sea has been again excluded by restoring the dykes, and peat is now dug in some of these districts, where it forms several strata separated by beds of gravel and sand which mark successive irruptions of the sea. In these peat beds, with the strata that divide them, we have a very close imitation of the phenomena presented by the beds of coal. This instance is cited as a possible, though not as a probable, explanation of the facts observed in our coal field. Some local submergences may have occurred in the manner suggested, but most of those recorded have been on too grand a scale, as it seems to me, to be the results of bursting of barriers without changes of level.

The chemical processes which have been concerned in the formation of coal have been quite fully described in our former reports, and I shall give here only a brief review of the subject. Coal is now considered by all good chemists and geologists as of organic origin, and it may easily be demonstrated that it has been derived from the decomposition of vegetable tissue. It forms only one of a group of carbonaceous substances which begins with woody fibre and ends with graphite. These are all derived from vegetable tissue in the changes which it undergoes when buried under water or earth. The different products of the progressive change through which vegetable matter passes under such circumstances—and which is a kind of distillation—are, peat, lignite, bituminous and anthracite coal, graphite and asphaltum, which are solids; carbonic acid, carburetted hydrogen, etc., which are gases. Of these, all the solids, excepting asphaltum, are residual products, while that substance and the liquids and gases are the evolved products, or distillates. Neither of these substances has any definite formula of composition, as each individual specimen may represent a distinct stage of the process of bituminization. The first mineralized solid formed from vegetable tissue is usually called lignite, if derived from wood; peat, if from herbaceous vegetation. These terms are, however, somewhat vaguely employed; for while the term peat is used only for the brown, spongy mass—mostly derived from mosses—which is found in our surface bogs and is now forming, the name lignite is given not only to bituminized woody tissue, but to the Tertiary and Cretaceous coals, even though they may have been formed of the same materials and in the same way as our recent peat beds.

Such being the relations of the carbon series, it is manifest that to express each one by a distinct formula, as though they were mineral species or definite chemical compounds, is a miss atement of the truth of nature, and is calculated to create misapprehen-ion. This will be obvious to any one who will compare the hundreds of careful analyses which have been published of the different hydrocarbons. The nature of the changes which take place in the formation of peat and lignite from vegetable tissue will be seen by the comparison of typical examples of each given below:

	Vegetable tissue.	Loss.	Peat.
Carbon	49.1	21.50	27.6
Hydrogen	6.3	3 50	2.8
Oxygen	44.6	29.10	15.5

	Wood.	Loss.	Lignite.
Carbon	49.1	18.65	30.45
Hydrogen	6.3	3.25	3.05
Oxygen	44.6	24.40	20.30

In this process the evolved products represented by the loss are water, carbonic acid, and carburetted hydrogen, or petroleum.

Where peat or lignite have been long buried in the earth they have suffered still further loss and change, and are converted into what is termed *bituminous coal*, as will be seen in the following example:

	Lignite.	Loss.	Bituminous Coal.
Carbon	30.45	12.35	18.10
Hydrogen	3.05	1.85	1.20
Oxygen	20.30	18.13	2.07

This is the condition in which we find most of the beds of peat and lignite that accumulated in what is called the Carboniferous age, millions of years ago, and which, deeply buried, have been subjected to a slow and general distillation, resulting in the different varieties of bituminous coal. Where exposed to peculiar influences, as to heat from volcanic eruptions, or from the elevation of mountain chains, where all the strata are metamorphosed, the volatile constituents of bituminous coal are partially or perfectly driven off, giving us, first, *semi-bituminous* coal, then *anthracite*, and finally *graphite*. The process by which graphite and anthracite are formed from ordinary bituminous coal is indicated in the succeeding formulæ:

	Bituminous Coal.	Loss.	Anthracite.
Carbon	18.10	3.57	14.53
Hydrogen	1.20	0.93	0.27
Oxygen	2.07	1.32	0.65

	Anthracite.	Loss.	Graphite.
Carbon	14.53	1.42	13.11
Hydrogen	0.27	0.14	0.13
Oxygen	0.65	0.65	0.00

All the varieties of coal mentioned above shade into each other, and we have lignites that exhibit every degree of approach to bituminous coals; semi-bituminous coals intermediate between bituminous coal and anthracite and graphitic anthracite, by which the anthracites are connected with graphite.

The geological portion of the different varieties of coal accords with the theory of their origin given above. For example: the oldest rocks known, contain only the residual products of the distillation of vegetable tissue, graphite and anthracite. In the Carboniferous age the terrestrial vegetation was luxuriant over large areas, and conditions prevailed favorable to the formation of beds of peat.* These, submerged and deeply buried under sediments which were deposited upon them, have, as a

* Judging from the circumstances in which the most extensive deposits of peat are produced at the present time, we may infer that the climate was moist and equable, but neither very hot nor cold, since in tropical climates vegetable tissue runs through all its changes so rapidly that but but little accumulates in a bituminized state, while in a cold climate vegetation is stinted, and there is but little of it to be preserved. It has been suggested that in the Carboniferous age the atmosphere contained much more carbonic acid than now. But of this no proof is given except the succulent and luxuriant vegetation, while the great numbers of air-breathing animals represented by remains found in the Carboniferous rocks indicate that the atmosphere was not greatly different from what it now is.

general rule, been changed to our beds of bituminous coal—to anthracite where local causes have carried the distillation further. In formations more modern than the Carboniferous, the accumulations of bituminous vegetation are, as before stated, usually classed as lignites, though they have been formed in the same way as our coals. These contain more water and oxygen, and are less valuable as fuels than the true coals, but they shade into them imperceptibly, and locally nature has accelerated her processes, and by volcanic heat has distilled lignites to anthracite, as at the Placer Mountain, New Mexico, and on Queen Charlotte's Island, where excellent anthracite has been produced from Cretaceous lignites, and at Los Bronces, in Sonora, Triassic coal is converted into anthracite by a similar cause. In China there are extensive deposits of Mesozoic coal, which have been converted into good anthracite throughout considerable districts. At the present time we see the formation of coal only in its initial periods, viz., the growth of vegetation and the accumulation of bituminized vegetable tissue in marshes where oxidation is prevented or retarded by water. By artificial processes we can, however, hasten the changes in vegetable matter, and by distillation produce lignite, bituminous coal, and anthracite. In eastern America all the coal strata, excepting the small Triassic basins of Virginia and North Carolina, are of Carboniferous age. In the valley of the Mississippi, where they have suffered no local metamorphosis, they are all of the bituminous class. In the Alleghanies the same strata, having been somewhat affected by the causes which resulted in the upheaval of the mountains, have lost a portion of their volatile matter, and have become what are known as semi-bituminous coals. To this group belong the coals of Frostburgh, Broad Top, Blossburgh, etc. Still further east the Carboniferous strata are more metamorphosed, and all the coal of eastern Pennsylvania is anthracite. In Rhode Island a coal basin of limited extent of the same age with those of Pennsylvania seems to have been still nearer the focus of metamorphic action, and here the coal is partially converted into graphite, forming the variety known as graphitic anthracite.

All the coals within the Ohio coal field are classed as bituminous coals, but among them we find those which form several different varieties when classified by their physical structure, their chemical composition, and their uses in the arts. These are, first, the dry, open-burning, or furnace coals; second, cementing, or coking coals; third, cannel coals. Of these the first and second varieties are sometimes classed as cubical, or block coals, from their tendency to break into more or less cubical blocks.

The first variety enumerated includes those that do not coke and adhere in the furnace, and such as can be used in the raw state for the manufacture of iron. They have generally a distinctly laminated structure, and are composed of bituminous layers, separated by thin partitions of cannel or mineral charcoal, materials which do not coke. Hence the bitumen in them—relatively small in quantity—is held in cells, and cannot flow together so as to give the mass a pasty, coherent character. In Ohio the lowest stratum of this series (Coal No. 1, the Briar Hill, Massillon and Jackson coal) is generally a furnace coal. As it occurs in the Mahoning valley, it is a type and standard of the class to which it belongs, and is one of the best furnace fuels known, half the iron produced in the State being made with it. In consequence of the structure of our coal basin (Coal No. 1 underlying all the others, and dipping toward the south and east), it is for the most part covered by the underlying rocks, and whether it extends beneath the center of the basin is yet uncertain. Coal No. 6—the "*Great vein*," the *Straitsville*, the Steubenville shaft seam, etc.—has locally this open burning character.

The second class, or cementing coals, are such as have few partitions, but show upon fracture broad surfaces of pitch-like bitumen. These, to a greater or less degree, melt or agglutinate by heat, forming what blacksmiths term a hollow fire. This property causes them to choke up the furnace and arrest the equal diffusion of the blast through the charge; hence they cannot be used in the raw state for the manufacture of iron, but must be coked. This process of coking consists in burning off the bituminous or gaseous portion, which leaves the coal in the condition of anthracite, except that as this change is effected without pressure the resulting material is cellular and spongy. Coals of this character, when free from sulphur—their great contaminating impurity—are used for the manufacture of gas; the volatile portion driven off in the retorts serving the purpose of illumination, while that which remains is coke, and may be used as fuel. By far the greater portion of our coals are of the coking variety. Up to the present time they have been but sparingly used as furnace fuels, from the fact that they generally contain an objectionable amount of sulphur. Many of them are capable, however, by proper treatment, of yielding an excellent coke, and the future industries of the State largely depend upon the degree of intelligence and energy shown in the utilization of our cementing coals.

The cannel coals are more compact and homogeneous in texture, and contain a larger percentage of volatile matter than the others; also, the gas they furnish has higher illuminating power; hence they would be used to the exclusion of all others for the manufacture of gas, but that the coke yielded by them is of inferior quality. They are, therefore, chiefly employed as household fuels, for which they are specially adapted, and, in small portions, for enriching the gas from inferior varieties.

The marked differences which are observable in the varieties of coal which I have enumerated are due, as I conceive, mainly to the circumstances in which they were deposited. By Prof. Lesquereux they are ascribed to differences in the character of the vegetation from which they were formed; but this can be accepted as only a very partial explanation. Nearly all of our coal seams exhibit considerable variation of quality at different localities and in different parts of the same bed. Our cubical coals show changes in the relative quantities of volatile matter and fixed carbon which they contain, and in their tendency to cement in the fire; they also sometimes merge into cannel, in part or entirely, in passing from one township or county into another. But these differences, striking as they are, are not accompanied by any appreciable change in the vegetation, so far as we can judge by examination of the coal itself, or from the impressions of plants contained in the roof-stones or fire-clays. It is possible that the open burning character which the Briar Hill seam so generally exhibits may be in some degree due to the kind of the vegetation from which it was formed; but this is a mere conjecture, which derives no support from the plant remains found with it. As has been already stated, the open burning coals have a distinctly laminated structure which is recognizable at a glance. This is so characteristic that it may be always accepted as proof that a coal which possesses it is not cementing, whatever its chemical composition may be. The distinction between coking and open burning coals is evidently not dependent upon the relative proportions of volatile matter and fixed carbon, since the semi-bituminous coals of Pennsylvania and Maryland, which contain only from 17 to 20 per cent. of volatile matter, are eminently coking, while the typical furnace coals, such as the Briar Hill and Brazil, contain nearly twice as much volatile matter, and yet do not coke. All the cubical coals are more or less laminated—*i. e.*, exhibit alternations of bright and dull lines. In the cementing coals the pitchy layers are broad, and the lines of separation between them are thin and broken; hence these coals exhibit on their cleavage planes smooth surfaces of a black, pitchy appearance, by which an experienced eye can at once identify them. The cause of the lamination of our coals is as yet unknown, but I have supposed it possible that it was dependent upon an annual contribution of vegetable debris, or a periodical variation in the quantity of water in the coal marsh. This is an interesting subject, but one which will be really understood only when it shall have received more attention than has yet been given to it.

The peculiarities of the cannel coals, which have been already referred to, have also been ascribed to the vegetation from which they were derived; but I think it can be plainly shown that they owe their characteristic features to the method in which they have been formed. As the result of many years' study of our coal strata, I suggested, in a paper published in the *American Journal of Science* in 1857, that cannel coals were formed in lagoons of open water in the coal marshes, and that in these lagoons the completely macerated vegetable tissue—probably for the most part parenchyma—accumulated as a fine carbonaceous mud, and all my subsequent observation has tended to confirm this conclusion. The evidence upon which it rests is briefly as follows:

1st. The cannel coals in their intimate structure are more homogeneous than the cubical coals, and show nothing of the alternations of bright and dull lines to which reference has been made, and which we may consider as proofs of changing *surface* conditions in the coal marsh.

2d. Though not laminated in the sense that the cubical coals are, the cannels are more distinctly stratified like other rocks which are deposited from aqueous suspension.

3d. The cannel coals generally contain a greater percentage of volatile matter than the cubical coals, and the gas made from them consists more largely of hydrogen, and has higher illuminating power. All of which is a natural result of their deposition in a hydrogenous medium which prevented oxidation.

4th. Cannel coals, as a class, contain more ash than the cubical coals, and they frequently pass into bituminous shale. This occurs where the water from which they were deposited had a more rapid motion and greater transporting power. It then carried and mingled with its carbonaceous sediment an increasing and ultimately preponderating amount of mineral matter.

5th. Cannel coal contains, as characteristic fossils, aquatic animals, such as mollusks, fishes, amphibians, and crustaceans. These are sometimes so abundant and of such a character as to prove conclusively that they inhabited pools of water in which cannel coal was deposited as a sediment. Where plant remains are found in cannel, they are usually floated fragments which show the effect of long maceration—fern fronds, for example, being usually skeletonized.

6th. In the lagoons of open water found in our modern peat marshes fine carbonaceous mud accumulates, which, when dried, closely resembles in appearance and properties our cannel coal.

With such evidence before us, it seems that there should be no great difference of opinion as to the origin and mode of formation of cannel coal.

STRUCTURE OF THE COAL BASIN.

One of the most important results of our study of the Coal Measures of Ohio is the discovery that instead of forming one symmetrical basin with a uniform dip toward the south-east, they lie in a series of subordinate troughs which are in a general way parallel with the axis of the great one of which they are parts. In other words, that the western slope of the basin exhibits a series of undulations which locally neutralize or reverse the general easterly dip. Such a series of subordinate basins have been shown to exist in western Pennsylvania, and those traced by our Corps, though less strongly marked, are similar in character to those described by Prof. Rogers and his assistants, and evidently belong to the same system. The outlines of these basins have not been fully traced, but those which lie on the northern half of the State are described in our Report of Progress for 1870.

Their existence may be demonstrated by a few profiles drawn across the coal area from west to east. For example, beginning on the western margin of the coal basin at Nashville, in Holmes county, and tracing a line directly eastward, we find that the dip is rapid to the valley of the Killbuck, at Millersburg; thence eastward the strata rise gently in a fold which lies between the valleys of the Tuscarawas and the Killbuck. Passing this, the dip is again eastward to Dover, from which place the strata gently rise over an arch in Carroll county, thence descend rapidly to the Ohio. Owing to this arrangement, the section of the rocks exposed in the valley of the Tuscarawas, at New Philadelphia, is precisely the same as that seen in the valley of the Ohio at the mouth of Yellow Creek, and in the valley of the Little Beaver, on the Pennsylvania line. Further south we find indications of similar undulations. From the west line of Coshocton county to Coshocton, the dip is over 500 feet, and this continues till the bottom of the trough is reached near Jacobsport; thence the strata rise easterly until at Bridgeport they lie 135 feet higher than in the bottom of the trough further west. In carrying the line further east, two narrow synclinal basins are passed before reaching that in which the Ohio flows. In the reports of Prof. Stevenson on Harrison, Guernsey, and Muskingum counties, the folds which traverse the Coal Measures in this region are described at some length, and he there refers to localities where the westerly dip amounts to as much as 100 feet to the mile. In following the line of the Pittsburgh, Cincinnati and St. Louis Railroad from Coshocton to Steubenville, traces of the folds referred to are distinctly seen, although they are not crossed at right angles. For example, taking coal No. 6, the most continuous and important seam in this region as a guide, we find that its altitude at Coshocton is 248 feet; at Newcomerstown, 293; at Port Washington, 260; at Lock 17, 295, and at Urichsville, 275 feet above Lake Erie. East of this point it dips rapidly, and at Steubenville is below the level of the Ohio. The profile section of the Central Ohio Railroad shows a series of similar undulations which are in part identical with those already named. For example, from Bellaire to a point within two miles of Campbell's Station the dip is uniformly south-east, though varying somewhat in its rapidity at different places. At the point last mentioned the dip changes to the west, but recovers its normal direction before reaching Campbell's. From Campbell's to the quarry east of Cambridge the dip continues south-east. It there changes locally to the west, but recovers itself before reaching the tunnel. The dip is again reversed at a point between the tunnel and Castle's. From this latter point it is variable to within a mile of Concord, where the south-easterly dip is very rapid, and continues so—diminishing from 100 to 50 feet per mile—to Norwich. It is there reversed to 35 feet per mile west for four miles, thence it undulates greatly, though the westerly dip prevails until within one mile of Coaldale, where it again becomes south-easterly, and so continues to Newark. (Stevenson.)

A knowledge of the undulations which traverse our Coal Measures is of great practical importance, as they render utterly abortive any attempt to ascertain the position of coal seams by any system of triangulation or calculation based on a supposed uniformity of the dip. Such methods are worse than worthless, since they are liable to mislead. It is scarcely necessary to say that the only way in which the dip of the rocks, in any larger or smaller division of the State, can be determined, is by careful local observation; and the only reliable method—aside from boring—of ascertaining the position of beds of coal which lie below the surface, is to acquire a knowledge of the succession of the strata, and judge of what is concealed by its known relations to what is exposed.

The arches and troughs which have been described above affect other portions of our geological series beside the Coal Measures, and their connection with the general structure of the rocks which underlie the State is shown in the discussion of the causes of our topography, Vol. I., Part I., p. 39.

IRREGULARITIES OF THE BOTTOM OF THE COAL BASIN.

The folds described in the last section are plainly the result of disturbances which have affected the Coal Measures after the deposition of the entire series. They are proximately parallel with the Alleghanies, and are undoubtedly the gentler waves produced by the upheaval of this mountain chain at points remote from the center of action. We find, however, in the coal basin proofs of disturbances which took place long anterior to the elevation of the Alleghany Mountains, by which the parallelism of our coal seams was in many places destroyed. We also have evidence that before the deposition of the lower coals the surface in which they accumulated was quite irregular, and by these irregularities their continuity was locally broken, and their extent north and east, definitely limited. We know that the Alleghany Mountains proper had no existence till after the close of the Carboniferous age; but the Blue Ridge is much older, and our Alleghany coal field, during the deposition of the Carboniferous rocks, was a broad, low plain—sometimes above and sometimes below the water level—which stretched across from the Cincinnati arch to the base of the Blue Ridge. This plain, or bay, or lake—for it was all three at different times—had at the dawn of the Coal Measure epoch a somewhat uneven bottom and irregular margin. Gravel hills which now form masses of conglomerate bounded it on the north and were scattered irregularly over its surface, and here and there along its western margin were ridges and knolls of Waverly rocks, partly formed by erosion during the deposition of the Conglomerate, and partly due to folds which belong to the period of the Cincinnati arch. Over this surface the Coal Measures were deposited layer after layer, like a fall of snow, filling all its valleys and burying its hills, and producing finally an even and monotonous surface. The progress of this series of events was, however, not uniform, for, as we have seen, the Coal Measure plain was at times elevated and deeply scored by surface erosion; but the irregularities produced at such times were all obliterated by subsequent submergence and depositions.

The uneven character of the bottom of the coal basin is well shown by the interruptions of the lowest coal seam, which was apparently deposited in a marsh of which the margin was fringed with points and headlands, and the continuity broken by ridges and knolls which rose above its surface. Hence we find this seam occupying a series of channels and basins separated by barren intervals of greater or less extent. These are fully described in the reports on Trumbull, Portage, Stark and other counties, through which the outcrop of coal No. 1 passes.

The buried hills of Waverly and Conglomerate rock which interrupt the coal seams in the southern portions of the State are frequently referred to in the reports of Prof. Andrews. They also occur along the western margin of the coal field north of the National Road, in Licking, Knox, Richland, and Holmes counties. The most striking of these is that seen along the line letween Richland and Holmes, where the Loudonville hills, composed of Waverly rock, seem to have presented a somewhat abrupt declivity toward the coal basin, against which the Coal Measures were horizontally deposited to the depth of several hundred feet. This is shown by the sections exposed on opposite sides of the valley of the Mohican. On the east, the hills which bound the valley contain seven workable seams of coal, while on the west there are none.

BOUNDARIES OF THE COAL FIELD.

The margin of the coal basin forms a tortuous line which enters the State in the northern part of Trumbull county, passing thence south-westerly to the valley of the Mahoning, where it is carried far to the south-east. West of Youngstown it runs through the southern townships of Trumbull county; it is there deflected north nearly to the center of Geauga county, where it incloses a long tongue and two or three small islands. Thence returning into Portage, it passes south-easterly through the southern part of Summit to New Portage, where it bends around to the north-west and incloses a considerable area in south-eastern Medina. Thence it runs south-westerly again through the corner of Wayne to the south-western corner of Holmes. Thence it passes nearly southward along the western margin of Holmes and Coshocton; thence south-westerly through the eastern part of Licking nearly to Newark. Its course is thence for fifty miles nearly south to the center of Hocking, where it turns slightly westward and passes through Vinton, Jackson, the eastern portion of Pike and Scioto to the Ohio, which it crosses a little above Portsmouth. The counties of which the surface is wholly or mostly underlain with coal are Mahoning, Columbiana, Portage, Stark, Holmes, Carroll, Tuscarawas, Jefferson, Harrison, Belmont, Guernsey, Coshocton, Muskingum, Perry, Noble, Morgan, Washington, Monroe, Meigs, Athens, Jackson, Gallia, and Lawrence. Valuable deposits of coal are also contained in some of the townships of Trumbull, Summit, Medina, Wayne, Licking, Hocking, Pike, and Scioto. Patches of Coal Measure rocks occur in Geauga, Richland, and Knox, but it is doubtful if they contain any valuable seams of coal.

CLASSIFICATION OF THE COAL STRATA.

The brothers Rogers (Profs. W. B. and H. D.) and J. P. Lesley, who have studied most carefully that portion of the Alleghany coal field which lies in Pennsylvania and West Virginia, have divided the Coal Measures into four groups, viz., the Lower Coal Measures, the Lower Barren Measures, the Upper Coal Measures, and the Upper Barren Measures. Of the upper division — a series of sandstones and shales nearly 1,000 feet in thickness, which are found in the central portion of the basin—we have no representatives in Ohio; but of all the others the equivalents are found in the different parts of our coal field. These will be briefly described in the order of their superposition, beginning with the lowest.

THE LOWER COAL MEASURES.

In Ohio we have, immediately above the Conglomerate if it be present, if absent, resting on the Waverly, a series of six to eight workable coal seams interstratified with sandstones, shales, limestones, fire-clay, and iron ore, the whole forming a mass having an average thickness of about 400 feet, which corresponds in a general way with the Lower Coal Measures of the Pennsylvania geologists. The coal seams of this group have been numbered from 1 to 7, beginning with the lowest. These are in part identical with the coal seams which have been enumerated by Profs. Rogers and Lesley in western Pennsylvania, our Coal No. 1 being the Sharon Coal of Rogers, Coal A of Lesley*; No. 2, the Brookville (?) Coal of Rogers; No. 3, the Clarion Coal of Rogers, Coal B of Lesley; No. 4, the Kitanning Coal of Rogers, Coal C of Lesley; No. 5, the Lower Freeport of Rogers, Coal D of Lesley; No. 6, the Upper Freeport of Rogers, Coal E of Lesley; No. 7, perhaps the Elk Lick Coal of Rogers, Coal F of Lesley. We also have, in the Lower Coal Measures two beds of limestone—underlying Coals Nos. 3 and 4—which are remarkably constant elements in the group. These deserve special mention, as they may be traced almost uninterruptedly from the Pennsylvania line to the Ohio, and are the most reliable and useful guides in the exploration of the geology of the country traversed by them. Higher up in the group are two other limestones, which, though less constant, are wide-spread and conspicuous members of the series. Of these, one underlies Coal No. 6 in the eastern part of the State, and is the Upper Freeport limestone of the Pennsylvania geologists; the other overlies Coal No. 7 in Stark, Tuscarawas, and Coshocton counties, and is the associate—frequently the representative—of the important Blackband stratum of this horizon. Although the Lower Coal Measures exhibit many changes in the thickness and character of the beds which compose them in passing from county to county along their lines of outcrop, still their general structure remains the same, and certain elements which they contain are so nearly constant as to serve as a skeleton or framework by which the various sections may

* This is *above*, not under the Conglomerate, as represented by the Pennsylvania geologists.

almost always be satisfactorily correlated. This will be so apparent on an examination of the sheets of grouped sections which accompany this volume, that no further argument will be needed to prove the unity and system which pervades our lower coal series.

The general arrangement of the strata which form the Lower Coal Measures in Ohio will be seen at a glance by reference to the section given below:

SECTION OF THE LOWER COAL MEASURES OF OHIO.

No.	Strata.	Feet.
36	Red and gray shales of Barren Measures	....
35	Stillwater sandstone, often conglomerate	0–50
34	Gray shale, alternating with No. 35	0–50
33	Buff limestone, nodular and ferruginous ("Mountain ore")	0–10
32	Blackband iron ore, often replacing No. 33	0–14
31	Coal No. 7, "Cambridge," "Sheridan" and "Groff" coal	2–7
30	Fire-clay	3–5
29	Limestone, in eastern and southern counties	0–10
28	Shale and sandstone	40–50
27	Coal 6*a*, "Norris" coal, sometimes a limestone over it	0–6
26	Fire-clay	3–5
25	Mahoning sandstone, often conglomerate	0–50
24	Gray or black shale, alternating with No. 25	5–50
23	Coal No. 6, "Straitsville," "Big vein" and "Upper Freeport" coal	3–12
22	Fire-clay	3–5
	Limestone, "Freeport," or "White" limestone, in eastern counties	2–8
21	Gray or black shale, with nodular iron ore at base	25–50
20	Coal No. 5, "Mineral Point," "Newberry," "Roger," "Lower Freeport" coal	2–5
19	Fire-clay, often non-plastic and excellent	3–6
18	Shale and sandstone	20–40
17	Limestone, "Putnam Hill," or "Gray"	2–8
16	Coal No. 4, often double, "Flint Ridge cannel," "Strip vein," "Kittanning"	1–7
15	Fire-clay	2–12
14	Shale and sandstone, sometimes containing Coal 3*a*	20–90
13	Limestone, with iron ore, blue, often cherty "Ferriferous" of Pennsylvania	2–6
12	Coal No. 3, Lower limestone coal, "Creek vein"	1–4
11	Fire-clay, extensively used for pottery	5–15
10	Shale and sandstone, "Tionesta" sandstone	30–50
9	Coal No. 2, generally thin, "Strawbridge" coal	1–5
8	Fire-clay	1–3
7	Shale	20–50
6	Massillon sandstone	20–80
5	Gray shale	5–40
4	Coal No. 1, "Brier Hill," "Massillon," "Jackson" coal	3–6
3	Fire-clay	3–5
2	Sandstone and shale	10–50
1	Conglomerate	....

The following notes on the lower group of coals and some of the strata associated with them will not be without interest and value to those who desire to acquaint themselves with our coal geology:

Coal No. 1.

This is probably Coal A of the Pennsylvania geologists, and is popularly known in north-western Pennsylvania, where it is largely mined, as the Sharon, or Ormsy coal. It is there sometimes covered with heavy patches of Conglomerate, and has been regarded as a sub-Conglomerate coal, but, as I have shown elsewhere, its true position is above the Conglomerate. In Ohio it is the lowest seam in the series, usually from twenty to fifty feet above the Conglomerate. It is best known here as the "Briar Hill," "Mahoning Valley," or "Massillon" coal. In Jackson county it is largely mined, and in the southern part of the State is known as the "Jackson coal." This has heretofore been regarded as the most valuable coal seam in the State, from the fact that in many localities it is of good thickness, of remarkable purity, and well adapted in the raw state to the smelting of iron ores. It is, indeed, a typical furnace coal, and forms the fuel by which fully one-half the iron produced in the State is manufactured. Proof of its purity is furnished by the fact that a large amount of iron is made with it which is used for the manufacture of Bessemer steel, car wheels, etc. Unfortunately, this is an exceedingly irregular seam. This peculiarity is due to two causes, which have been already referred to, viz., it was the first accumulation of carbonaceous matter in the great peat bog that subsequently became our coal basin; as a consequence, it occupies only the lower portions of the irregular bottom of the basin, and was never deposited over the ridges and hummocks which fringed the margin, or, as islands, dotted the surface of the old coal marsh. The second cause of its absence is that it was extensively cut away by currents of water in rapid motion which swept over the coal marsh in a submergence that followed its formation. The channels excavated by these currents were generally filled with sand, and this now converted into sandstone forms the "horsebacks" which cut out the coal. They are connected with the great stratum of sandstone which I have called the Massillon sandstone, and which is generally separated from the coal by a bed of shale ten to forty feet in thickness. Coal No. 1 has its best development in the Mahoning Valley. It is here very compact, working in large blocks, from which fact it has received the name of *Block coal*, and is remarkably pure, as is shown by the series of analyses given below.

In Geauga county the Briar Hill coal reaches as far north as Burton, but only in a narrow strip and detached islands, and is there of little value.

In Portage county it is mined at Palmyra, but its line of outcrop is here concealed by heavy beds of Drift, and what its development is has not yet been determined. It has been struck in borings made in the valleys of

Bull Creek and Little Beaver, in Columbiana county, and at Limaville, near the south line of Portage county; and it therefore seems probable that important basins of this coal will be found in Mahoning, Columbiana, and Portage, south of its line of outcrop.

In Summit county Coal No. 1 underlies a considerable portion of the townships of Tallmadge, Coventry, Franklin, and Greene. It also reaches, in a narrow basin, so far into Medina county that its northwestern outcrop is within eight miles of Medina village. From Wadsworth, Medina county, the western line of outcrop of Coal No. 1 pursues nearly a southerly course to Fairview, in Wayne county, where it is largely mined. At Clinton, Fulton, and Massillon, Coal No 1 has been extensively worked for many years, and the mines in this vicinity supply a large amount of coal for the Cleveland market, as well as for ironmaking and other industries at home.

In Summit and Stark counties this coal is generally more bituminous than in the Mahoning valley, breaks more irregularly, and has less of the block character. These physical differences are associated with a slightly different chemical composition, as is shown by the table of analyses. It is still, however, a very pure and highly esteemed coal. It is used in the raw state in the furnaces at Massillon and Dover, with satisfactory results; but from its inflammable character its combustion is not quite so easily regulated as that of the Mahoning valley coal, and somewhat more of it is required to smelt a ton of iron. As a household fuel it has no superior, and is preferred by those who use it to every other variety of coal, even to the best cannel.

From Massillon to the Ohio river, along its line of outcrop, Coal No. 1 is, as a general rule, of little importance. It appears of workable thickness at frequent intervals, but is usually thin, of inferior quality, and often absent, or present as a mere trace.

In Holmes county it is worked at Spencer's Mill, and at Mote's mine, two miles north of Napoleon. It is in these localities 2 to 4 feet in thickness, and of good quality. It is also opened at Crawford's mine, in Coshocton county, where it appears well.

In Jackson township, Muskingum county, north of Frazeysburgh, Coal No. 1 is from 18 to 50 inches thick, open-burning, and of excellent quality.

In Madison township, Licking county, two miles south-east of Newark, Coal No. 1 was formerly worked by Dr. Wilson. It is 30 inches in thickness, and fairly good. Coal No. 2 and the Zoar limestone are in position above it. South of this point its line of outcrop has not been carefully traced, but it is apparently of no great value between Holmes and Jackson counties. In Jackson it regains somewhat of its traditional character and value, and is quite extensively mined and used as a furnace coal. It is here from $3\frac{1}{2}$ to $4\frac{1}{2}$ feet in thickness, is black and pure, resembling in appearance, as it does in properties, the coal of the Mahoning valley. It is, however, somewhat more laminated, and, perhaps, approaches nearer to the "block coal" of Brazil, Indiana.

How far Coal No. 1 extends through the coal basin, south and east of its line of outcrop, has not yet been fully learned. It is reported to have been reached in borings made at Cameron's Mill, on Bull Creek, Middleton township, Columbiana county, at the depth of 166 feet, and is there said to be four feet in thickness. It is also said to have been struck in two wells bored in the valley of the Little Beaver, near Williamsport; but in the oil wells bored at Smith's Ferry and Island Run no traces of it seem to have been obtained. This is not positive proof, however, that it was not passed through by all of them, as the boring was usually done with a rope, and no attention was paid to anything struck in boring unless it was oil. I have myself seen abundant particles of coal brought up in the sand-pump from a well at Smith's Ferry; but in other borings made at a distance of only a few rods no coal was reported to have been penetrated. At Limaville, on the line between Stark and Portage, the Briar Hill coal was unquestionably reached in the boring of Dr. Dales. In a well bored by Mr. Swalm, at Canton, Stark county, Coal No. 1 is reported to have been struck at a depth of 160 feet below the Zoar limestone. It is said to be there 6 feet in thickness. Quite a number of borings made in the vicinity of Canton in search of this seam passed through it, but in all these cases it is reported to have been thin—from 6 to 30 inches.

In borings made at the mouth of the Nimishillen, near Sandyville, and at the Goshen salt well, above Dover, Tuscarawas county, the Massillon coal is said to have been struck, but I have not yet been able to ascertain the truth of the report. In the boring made at the Sugar Creek salt works the place of Coal No. 1 was distinctly marked, but it was very thin.

In the two wells bored at Urichsville two thin seams of coal were passed through under that of the Zoar limestone (No. 3); and at the distance of 165 feet below No. 3 a mass of coal and slate, several feet in thickness, was passed through. This may represent Coal No. 1, as no coal was found below it.

On the Ohio, below the mouth of Yellow Creek, a number of borings indicated a coal seam of remarkable thickness, some 80 or 90 feet below Coal No. 3, but when a shaft was sunk to it it was found to be mostly black shale, and worthless.

From these facts it is apparent that Coal No. 1 does not form a continuous sheet in the central part of the coal basin, but that it underlies a considerable portion of the area east of Massillon and south of Youngstown is almost certain. Due caution should, however, be observed in making expensive explorations for this coal. It is proverbially irregular and patchy, even where best developed, along its outcrop, and borings for it, therefore, are always uncertain.

One or two shafts sunk to the coal, some distance from its line of outcrop, and opening up prosperous mining enterprises, will stimulate investigation, and lead ultimately to the thorough exploration of the area of this coal.

ANALYSES OF COAL NO. 1.

No. 1. Chestnut Hill, Trumbull county .... Wormley.
" 2. Veatch's mine, Mahoning county .... "
" 3. Tallmadge, Summit county .... Mather.
" 4. Franklin township, Summit county .... Wormley.
" 5. Willow Bank, Massillon, Stark county .... "
" 6. Burton's mine, Lawrence, Stark county .... "
" 7. Mote's coal, Knox township, Holmes county .... Potter.
" 8. Jackson shaft coal, Jackson .... Wormley.
" 9. Dr. J. A. Dales's coal, Limaville, Stark county .... "

		2.	3.	4.	5.	6.	7.	8.	9.
Specific gravity.	1.284	1.260	1.264	1.256	1.247	1.250	1.276	1.282	....
Moisture	3.60	2.47	5.06	2.70	6.95	4.10	5.55	7.75	3.20
Volatile combustible	32.58	31.83	39.23	37.30	32.38	32.90	40.10	31.27	33.40
Fixed carbon ...	62.66	64.25	53.40	58.00	57.49	61.40	51.79	58.95	59.20
Ash	1.16	1.45	2.29	2.00	3.18	1.60	2.56	2.03	4.20
	100.	100.	100.	100.	100.	100.	100.	100.	100.
Sulphur	0.85	0.56	0.55	0.92	0.88	1.07	1.21	0.53	0.82

COAL NO. 2.

Coal seam No. 2 lies from 40 to 100 feet above No. 1. This difference is occasioned by inequalities in the lower coal, which was evidently more or less folded and disturbed previous to the deposition of the second seam. Usually this is a thin coal, and one that has no economic importance, but it is an almost constant feature in the sections of the rocks of the northern portion of the coal field, and in a few localities becomes of practical value.

In Trumbull, Mahoning, Summit, and Stark this coal is usually from 12 to 18 inches in thickness, and is generally known as the "15-inch seam," occasionally swelling to two or two and a half feet.

In Holmes county it is a cannel, usually two to two and a half feet thick, but at the Strawbridge mine locally expanding to a thickness of six feet. In this particular locality it is a typical *splint* coal, having the aspect of a cannel, but containing a relatively small amount of volatile matter and a large percentage of fixed carbon. It is to be regretted that recent explorations indicate that the unusual expansion of this seam near Millersburg is quite local, as from its quality it would have proved a very useful coal if the quantity had been large.

In the southern portion of the State two or more small coals lie near the horizon of Coal No. 2, but it is not probable that either should be considered identical with it.

It should also be said that in Holmes county another seam, generally thin but sometimes workable, lies between Coals No. 1 and No. 2. This is called the "iron coal," because of a bed of iron associated with it, but it is so local that I have not thought proper to enumerate it among our workable coals. On Michart's farm, two miles north of Napoleon, Holmes county, this seam appears in greater force than any where else that it has come under my observation. There it is composed of two benches of one foot each, separated by iron ore, said by the owner—for it was not fully shown—to be three feet thick. Other parties represent it as one foot of ore in two of shale.

It will be noticed by reference to the reports and sections published by Prof. Andrews, that a coal seam with which iron ore is associated is sometimes found in Jackson county, holding nearly the same position to Coal No. 1 that this does.

ANALYSES OF COAL No. 2.

No. 1. Millersburg, Holmes county, three miles south-west, Strawbridge cannel .... Wormley.
No. 2. Millersburg, Holmes county, three miles north-east........ "

	1.	2.
Specific gravity	1.370	1.293
Moisture	2.15	1.30
Volatile combustible	28.65	41.66
Fixed carbon	52.70	41.20
Ash	16.50	15.90
	100.	100.
Sulphur	2.13	1.55

Coal No. 3.

This coal underlies the lower of the two limestones which I have spoken of as remarkably constant features in the sections of our Lower Coal Measures in different parts of the State. It is more generally found directly beneath the limestone, but is sometimes separated from it by as much as twenty feet of shale. Like the second limestone coal, this is a very variable seam, prone to become a cannel, and exhibiting marked changes of thickness within limited areas. Near the eastern border of the State it is usually a coking bituminous coal, from two to four feet in thickness, of fair quality, but containing considerable sulphur. In Columbiana county it lies near the bottom of the valley of the Little Beaver, dipping to the south-east with the fall of the stream. It is quite extensively worked in the vicinity of New Lisbon. At the latter locality it is also coked, and the fire-clay beneath it is used for the manufacture of fire-brick.

In the valley of Yellow Creek this is the lowest workable seam, known as the "Creek vein." It is here from three to four feet thick, a bituminous, coking coal, containing somewhat more sulphur than the seams which overlie it. Along the Ohio in this vicinity it is opened in many places, but in value it is completely overshadowed by the important bed of fire-clay that underlies it, and which is the basis of a very extensive manufacture of pottery and fire-brick. This fire-clay is one of the most important in the series, and one which at its different outcrops supplies the material from which stone-ware, fire-brick, etc., are manufactured to the value of more than a million dollars per annum.

In the Mahoning valley Coal No. 3 is thin and of no value; but the limestone over it is visible at a great number of localities, and is a useful guide in searching for Coal No. 1, as it lies at an average height of about 160 feet above it. It also furnishes a considerable portion of the limestone used as flux in the furnaces of the valley. Though nowhere showing a single bed of greater thickness than three or four feet, this limestone is sometimes doubled, and it is probably the equivalent of the "Ferriferous limestone" of the Pennsylvania geologists. In all parts of Ohio more or less iron ore is found associated with the limestone over Coal No. 3, and the deposit frequently has great economic value.

In Summit county this coal, with its limestone and iron ore, is found in the south-eastern townships. The coal is here thin, and has no practical importance; but the underlying fire-clay is largely worked, and supplies some forty potteries.

Through Stark and Tuscarawas counties Coal No. 3 lies for the most part below the surface. It is exposed, however, in the valley of the Nimishillen, below Canton; in the valley of the Tuscarawas, at Zoar;

and at Zoar Station. In all this section it is rarely more than two feet in thickness. In the south-western corner of Stark, however, in Sugar Creek township, it becomes a bright, clean, and excellent coal, partially open-burning, from three to three and one-half feet in thickness, and is the seam mined at Fisher's bank, on the Tuscarawas Valley Railroad.

In Holmes county Coal No. 3 becomes locally of much value. It is the seam worked at Mast's, Collier's, and Chambers's mines; is about four feet thick; a semi-cannel, and good. At Harger's mill, in the eastern part of Holmes county, it is five feet thick, part cannel, part bituminous. In Mechanic township it is a true cannel, said to be eight feet thick; but is not worked, nor so exposed that its value can be determined.

In descending the Tuscarawas river the coal seam under consideration is seen at a great number of localities, which will be found described in the reports on Coshocton and Muskingum counties. It dips nearly with the fall of the stream, and is seen for the last time at the water level in the base of Putnam Hill, near Zanesville, where it is an impure cannel from six inches to one foot in thickness. Throughout this region the limestone which overlies it is nearly continuous, and is often very cherty.

In southern Ohio Coal No. 3 is a less constant feature in the geology than further north. Its horizon is apparently marked, however, by a limestone which, in Licking, Muskingum, Perry, Vinton, and Jackson counties, lies from 120 to 170 feet above the Jackson coal. The coal itself, however—of which the place is below the limestone—is generally wanting, and where present is very thin. Nearer the Ohio, in Lawrence and Scioto counties, as I learn from the reports of Prof. Andrews, both the coal and limestone have disappeared.

Analyses of Coal No. 3.

No. 1. Glasgo's, near Nashville, Holmes county; cannel .... Wormley.
" 2. Mast's coal, N. E. of Millersburg, Holmes county; semi-cannel...... "
" 3. Collier's coal, " " " " ...... "
" 4. "Creek vein," Yellow Creek; bituminous................................ "
" 5. Green's coal, New Lisbon, Columbiana county; bituminous............ "

	1.	2.	3.	4.	5.
Specific gravity	1.292	1.282	1.305	1.290	1.301
Water	3.90	4.20	3.85	2.50	1.30
Volatile combustible	40.50	32.20	33.95	36.60	37.10
Fixed carbon	49.95	56.60	56.40	56.30	57.15
Ash	5.65	7.00	5.80	4.60	4.45
	100.00	100.00	100.00	100.00	100.00
Sulphur	1.55	3.34	2.06	2.05	1.95
Coke	Pulv'lent.	Compact.	Compact.	Compact.	Compact.

Coal No. 4.

Throughout the greater part of the belt of outcrop of the Lower Coal Measures in Ohio, at a distance varying from 20 to 90 feet above Coal No. 3, another coal, another limestone, and another ore bed are found, which are no less marked and constant features in the series than those just described. The resemblance between the two groups is so close that it is not always easy to discriminate between them, and this has led to some errors in our earlier reports.

The great variation in the interval which separates them has also led to some difference of opinion, and has been considered by those who hold to the theory of the strict parallelism of coal seams as proof of a want of continuity and identity in one or both groups. These strata have, however, been traced with great care through many counties by several members of the Corps who have had much experience as coal geologists, and they are all agreed in regard to the relations of these limestone groups to each other and to the associated strata. They also coincide with me in the opinion that the kind of parallelism here shown is an argument against the theory which has been referred to, rather than against the continuity and identity of each group throughout the region it traverses.

Where the interval between the limestones is considerable, two and sometimes three coal seams are found between them. With the exception of Coal No. 4, these are generally quite local in their extent, and rarely attain workable thickness. One of these may be seen in the northern part of Tuscarawas county, between Dover and Mineral Point. It occupies about the middle of the space between the limestones, has a maximum thickness of about three feet, and is of inferior quality. In the Report of Progress for 1870 this seam is described and enumerated as Coal No. 4, but subsequent observation proved that it was so local and unimportant that it was regarded as unworthy to be numbered as one of our series of lower coals. It has, therefore, been designated in our later reports as Coal 3*a*.

In the valley of the Killbuck and that of the Tuscarawas the limestones over Coals No. 3 and No. 4 may be traced almost continuously for nearly 100 miles, where their relations to each other and the associated rocks are so apparent that no one can mistake them. Here the distance between the limestones is found to vary from twenty to ninety feet, affording an excellent illustration of the local subsidences which took place during the formation of our Coal Measures.

Like the lower limestone seam, Coal No. 4 is exceedingly variable, as regards both its quality and thickness. It is also prone to divide into two or more benches, which are generally separated by fire-clay, though sometimes by shale. These partings may increase in thickness in short distances, so as to form two workable seams illustrations of which may be seen at Glasgo's, in Holmes county, and in the shaft at Uhrichsville.

In Licking and Coshocton counties Coal No. 4 is locally from four to six feet in thickness, and is cannel of good quality. This is the Flint Ridge cannel, and that which is mined in Bedford and Jefferson townships, Coshocton county.

Along the line of the Pittsburgh, Cincinnati and St. Louis Railroad, between Coshocton and Trenton, Coal No. 4, with its limestone, generally lies at the base of the hills, though sometimes carried beneath the surface by local waves. At Uhrichsville Coal No. 4 is found nearly seventy-five feet below the level of the Stillwater, as has been proved by borings and a shaft. It is here double, the two portions being separated by from six to twelve inches of fire-clay. In borings made at Dennison, three miles distant, they are reported as separated by fifteen feet of fire-clay.

From Trenton Coal No. 4 may be traced up the valley of the Tuscarawas as far as Navarre, in Stark county, up the Sandy as far as Minerva, and up the Nimishillen to the summit in Green township, Summit county. In all these valleys it lies above the streams, dipping with them, and is exposed almost continuously, and the great changes which it exhibits may be accurately noted.

Between Trenton and Zoar it is generally a cubical coal, from one and a half to three feet in thickness, and is of little value. At Navarre, on the west side of the river, it becomes five feet thick, with two clay partings, and looks well. On the east side it is two and a half feet thick, and poor. At Zoar station it is two feet thick, a cubical coal. Five miles above, in the valley of the Connotton, it is five feet thick, very slaty, and worthless. At Sandyville it has been mined by J. A. Saxton, Esq., is a fairly good coal, but varies in thickness from two to five feet. At Kelley's Point it is an excellent cannel, two and a half feet in thickness. At the mouth of Indian Run, below Waynesburg, and on the Trumbull Company's property, it is from four to seven feet in thickness, in two benches, of which the upper is an open-burning coal closely resembling the Briar Hill. In the valley of the Nimishillen, below Canton, Coal No. 4 is usually a cubical coal, too thin to be worked. At Browning's Mill, however, it swells to a thickness of six feet, is partly cannel, and very impure. About Canton it is largely mined, is a soft, bituminous coal, four feet thick, and of fair quality. At Ruthauff's Mill, five miles further north, it is seven feet in thickness, with two slate partings. At Greentown it is four to five feet thick, a bituminous coal of good quality.

At Alliance, on the eastern border of Stark county, Coal No. 4 is reached and worked in the Alliance Fire-Clay Company's shaft. This is also the coal which is mined at Atwater, and penetrated in the shaft sunk at Edinburgh. In the former locality it is from four to five feet in thickness, with a parting in the middle. It is here an open-burning, semi-cannel coal, much like what it is at Uhrichsville, and in the shaft of the Trumbull Company on the Sandy, below Waynesburg. Its limestone is here wanting.

In the valley of Yellow Creek Coal No. 4 is represented, as I have supposed, by the Hammondsville "Strip vein," here as at Atwater without its limestone.

On the eastern border of the State Coal No. 4 is probably represented by the remarkably pure bituminous coal of Letonia and the cannel of Canfield and Darlington, and hence is identical with the Kittanning coal of Pennsylvania.

The limestone over Coal No. 4 is that called by Prof. Andrews the *Putnam Hill limestone.* It is also frequently referred to in our reports as the *gray limestone,* to distinguish it from that over Coal No. 3, which is designated as the *blue limestone.* The difference in color indicated by these names prevails over several counties, but is not universal. As has been before stated, both limestones are highly ferriferous. The iron ore which accompanies them is sometimes in the form of tiers of nodules of "kidney ore," which lie just above them; sometimes as "plate ore," or sheets of calcareous clay, iron stone resting on them; or, finally, "block ore," a stratified mass of ore, more or less completely replacing the limestones.

It often happens, also, that these limestones become earthy or bituminous, and are converted into blue or black calcareous shale, full of the fossil shells which abound in the limestones when purer.

The Putnam Hill limestone locally assumes still another phase which I have not observed in the lower or Zoar limestone, *i. e.*, it is converted into a hydraulic lime by the addition of a considerable percentage of earthy matter. In such circumstances it becomes somewhat laminated, but retains its hardness, and frequently becomes almost as sonorous as phonolite. Its thickness is usually increased. When freshly broken it is still blue, but when weathered, its lime superficially dissolved out, and its iron oxidized, it becomes brown, or even yellow, and would hardly be recognized as a limestone. When assuming this phase it is sometimes highly fossiliferous, and has then supplied us with by far the largest portion of the Coal Measure mollusks obtained in the prosecution of the Survey. At Flint Ridge, at New Philadelphia where the road to the

Goshen salt well leaves the valley, and on the hills south of the Kokosing, where it joins the Mohican, on the west line of Coshocton county, the Putnam Hill limestone assumes the character I have described.

Both the limestones under consideration, like most others contained in the Coal Measures, yield a brown lime on calcination (and yet one which produces an excellent mortar). This is undoubtedly due to the quantity of iron and clay they contain, and is one of the results of their formation in shallow and circumscribed bodies of water, which received the drainage of surrounding land surfaces carrying both iron and clay.

Another striking characteristic of these and some other limestones of the Coal Measures is the quantity of silex which they locally contain. This is a marked feature in the Zoar limestone, and it becomes so cherty as to be called flint, or buhr-stone, in many parts of Tuscarawas, Coshocton, and Muskingum counties. In other portions of the Alleghany coal field the higher limestones exhibit the same phenomena, and buhr-stone—the calcareo-silicious rock of Hildreth—is met with in a great number of localities in Ohio, West Virginia, and Kentucky, aside from the famous one at Flint Ridge.

The origin of the silex in these flinty limestones has never been satisfactorily explained. It has sometimes been attributed to hot springs, of which the water contained much silica, but the general distribution of the flint and the immense number of fossils sometimes contained in it, seem to me insurmountable objections to this view. It appears to me more probable that the silica was derived from microscopic organisms, such as the diatoms. It is well known that at the present time very extensive deposits of silicious earth ("infusorial earth") are being made in our lakes and lagoons. These are frequently associated with shell marl and sometimes bog iron ore. In the Tertiary age, even more extensive beds of diatomaceous silica were formed than any belonging to the present age yet discovered, the polishing slate of Bilin ("tripoli"), Monterey and Nevada "infusorial earths," etc.. In the older formations no such strata are found, and yet it is hardly probable that the low forms of life from which these beds of silica are derived are of modern date. From some experiments recently made by Mr. Henry Newton at my request, we learn that the silicious shields of diatoms are more soluble than almost any other form of silica known, and it seems to me quite possible that in the older diatomaceous earths the individual forms have disappeared by solution, and the mass has been converted into compact amorphous silica, such as we find in our beds of chert. I would, therefore, suggest, that in many parts of the lagoons which, from time to time, occupied the coal area, the shields of diatoms accumulated in beds of considerable thickness, and these, now blended and consolidated by solution, form our Coal Measure buhr-stones.

In this view, the wide diffusion of the silica and its blending with and shading into purer limestone as though deposited in the quieter nooks of the broad lagoon, its association with fossils and iron, are all harmonious and confirmatory facts. If hot springs had furnished the silica, we should be pretty certain to find it impregnating other strata than the limestone, and should probably find some masses or accumulations heaped up about the source of supply but we have discovered nothing of the kind; and the careful observation of the facts in the case has convinced me that the silica, like the lime, is indigenous and not exotic; that is, that it accumulated particle by particle as a sediment at the bottom of water, where it was slowly drawn from solution and fixed by some vital agency.

ANALYSES OF COAL NO. 4.

No. 1. Sharples's bank, Bedford township, Coshocton county; cannel...Wormley.
" 2. Lyman's, Jefferson towhship, " " ... "
" 3. Trumbull Company's shaft, Stark county; bituminous............... "
" 4. Greentown. Summit county, " .... "
" 5. Porter's coal, Hopewell township, Muskingum county; bitum.... "
" 6. Flint Ridge cannel .... "

	1.	2.	3.	4.	5.	6.
Specific gravity......................	1.149	1.357	1.322	....	1.294	1.431
Moisture..............................	1.50	1.75	7.00	3,25	....	2.60
Volatile combustible	44.40	38.45	30.80	38.75	38.60	40.20
Fixed carbon	44.50	41.55	59.50	55.05	53.70	44.00
Ash	9.60	18.25	2.70	2.95	7.70	13.20
	100.00	100.00	100.00	100.00	100.00	100.00
Sulphur	1.72	1.34	0.65	1.73	....	1.34

COAL NO. 5.

In the western part of Holmes county the distance between the Putnam Hill limestone and its underlying coal (No. 4) and Coal No. 6—to be described further on—is little more than twenty feet, and no coal seam occurs in the interval. In going toward the east from this point this interval rapidly expands, until in Tuscarawas county it becomes as much as one hundred feet, and one, sometimes two, coal seams are found in it.

Where there are two, the upper of these is an impure cannel, which is nowhere of workable thickness. This is referred to in our reports as Coal No. 5*a*. Below this is another seam, first seen at Harger's Mill, in Holmes county, where it begins with a feather edge. In northern Tuscarawas county this has become one of the most important coals in the series, and one that is traceable over a large area toward the south and east. It is well shown about Mineral Point, where it is the coal chiefly worked.

This coal seam was numbered 5*a* in our first reports from the supposition that it was quite local, but proving to be wide-spread and valuable, it is, in our later publications, designated as Coal No. 5. Here it lies about fifty feet above the gray or Putnam Hill limestone; is a bright, handsome, rather open-burning coal, four feet in thickness. It is roofed with black shale, which contains a notable quantity of kidney ore. This has been quite largely worked by stripping in the vicinity, and is a marked ore horizon in all this region.

Another distinguishing characteristic of Coal No. 5 in the vicinity of Mineral Point is the fire-clay which underlies it. This is very pure, and locally non-plastic. It is similar in appearance and properties to the Mt. Savage fire-clay, and, like that, is largely used for the manufacture of fire-brick of superior quality.

In Stark county this coal is found in all the southern and eastern townships, and is there known as the "30-inch" seam, being thinner than at Mineral Point, but retaining its good qualities, and being generally mined.

On the Tuscarawas Branch of the Cleveland and Pittsburgh Railroad, Coal No. 5 is worked at the tunnel, where it lies below grade, and is known as the "tunnel" seam. It is also mined on the Trumbull Company's property, below Waynesburg.

At Alliance this is the seam worked in the shaft above the Pittsburgh, Fort Wayne and Chicago Railroad. It has here a thickness of 3½ to 4 feet, and is somewhat softer and more sulphurous than at Mineral Point.

In the valley of Yellow Creek this coal is known as the "Roger vein"—the next one below the "Big vein"—has a thickness of 3½ to 4 feet, and is a fairly good coking coal.

In eastern Columbiana county Coal No. 5 is probably represented by the "Whan seam," a coal of very variable thickness, but locally swelling to 5 feet, and of excellent quality.

In western Pennsylvania this is known as the Lower Freeport coal.

Tracing Coal No. 5 southward from our starting point in Tuscarawas county, we find it at Dover mined on the hill above the Sugar Creek salt well, having a thickness of about 3 feet, and of good quality. In the southern part of Tuscarawas county Coal No. 5 is generally thin, but of good quality. At Urichsville it lies 30 feet below Coal No. 6, is 2½ to 3 feet thick, and not worked. At Port Washington it has been opened on the property of the new furnace company, and its fire-clay, there plastic, is used for the manufacture of fire-brick. It is here 3 feet thick, and lies at about the level of the base of the furnaces. On the bank of the river, in the same vicinity, it is 4 feet thick, and lies 45 feet above the gray limestone, and 65 feet below Coal No. 6.

In northern Muskingum and Guernsey, Coal No. 5 thins out and disappears over quite a large area. Here the interval between Coals No. 4 and No. 6 diminishes locally to 20 feet, just as at Fredericksburg, Wayne county, and we have in these two localities the opposite sides of the basin in which Coal No. 5 and a great thickness of associated strata were deposited; a good example of local subsidence during the formation of our Coal Measures. "Twelve miles north of Zanesville Coal No. 5 appears again, thickening to the south." (Stevenson.)

In central and southern Muskingum county, Coal No. 5 is the first workable seam above the Putnam Hill limestone, distant from it from 25 to 65 feet in different localities. It varies in thickness from 4 inches to 4½ feet, and is generally esteemed as a good coal. It is the lower bed at Rocky Point, 22 feet below the Nelsonville seam, with iron ore over it. At Joseph Porter's, Hopewell township, it is 3 feet thick, 47 feet above the Putnam Hill limestone, and 45 feet below the Nelsonville coal. At Fork's Mill Run, near Zanesville, it is 4 feet thick, 28 feet below the Nelsonville coal, and 65 feet above the Putnam Hill limestone.

"In Perry county this is known as the lower New Lexington seam. It is here quite persistent, and has been considerably mined. At the mines of the Miami Company, on the branch of the Zanesville and Cincinnati Railroad, it is 3 feet 10 inches thick, and is 22 feet below the Nelsonville coal." (Andrews.)

About Nelsonville, Coal No. 5 seems to be generally present, though scarcely at all worked. It is from 3 to 4 feet in thickness, and is said to be of good quality.

"At the mines of the Hocking Valley Coal Company, York township, Athens county, this seam is found at a distance of 27½ feet below the main Nelsonville seam. It was not measured, but is there popularly called the "3-feet vein." (Andrews.)

On the west line of Ames and Trimble townships, Athens county, Coal No. 5 lies 35 feet below the "Great vein" (No. 6), and 30 feet above the Putnam Hill limestone. It is said to be here 4 to 5 feet in thickness.

10

ANALYSES OF COAL NO. 5.

No. 1. Tunnel seam, Tuscarawas county.
" 2. Whan seam, New Lisbon, Columbiana county.
" 3. Roger vein, Elliottsville, Jefferson county.
" 4. R. Miller, Liberty township, Guernsey county.
" 5. Roger vein, Salineville, Columbiana county.

	1.	2.	3.	4.	5.
Specific gravity	1.375	1.474	1.300	1.267	1.304
Moisture	3.20	1.15	1.00	3.00	1.65
Volatile combustible	39.70	40.45	31.60	36.20	37.35
Fixed carbon	52.95	53.75	64.40	58.00	53.80
Ash	4.15	4.65	7.00	2.80	7.20
	100.	100.	100.	100.	100.
Sulphur	3.64	3.51	2.60	1.97	2.03

COAL NO. 6.

This is probably the most interesting and important of all our coal seams. It attains greater thickness, occupies a wider area, and in its different outcrops and phases supplies a larger amount of good fuel than any other. It also seems destined to make in the future still more important contibutions to the wealth of the State. In the remarkable section which terminates the coal field at its north-western corner, in Holmes county, Coal No. 6 is only two feet in thickness, but it is here partially cut away by the heavy sandrock (Mahoning sandstone) which overlies it in so many localities. A few miles further east, near Millersburgh, at the mine of Judge Armor, it is six feet thick, in two benches, the parting being near the middle. Here it exhibits a character which it generally holds through northern Ohio, viz., it is a rather soft, but very bright and black coking coal, containing a moderate amount of sulphur, but too much to permit its employment for the manufacture of gas. Throughout Holmes county Coal No. 6 is almost constantly present, running from three to six feet in thickness, and is the source from which most of the fuel used by the inhabitants is supplied. In Tuscarawas county it is likewise the most important seam. On Stone Creek it is thin, but in adjoining localities it ranges from four to five feet thick. At Port Washington it is seven feet thick. Elsewhere, as at Trenton, Urichsville, Dennison, Pike Run, New Philadelphia, the Goshen salt well, and in the valley of the Connotton, it is nearly of the same thickness, from four to five feet. At

Urichsville it is quite largely mined and coked by Mr. Andreas. The Trenton mines have supplied a large amount of this fuel to the Cleveland market for the last five-and-twenty years. Throughout all this region it is a typical coking coal, which will make an excellent coke if properly washed.

In Stark county Coal No. 6 runs through all the southern and eastern townships. It is the coal mined at Osnaburgh, and highly esteemed in all parts of the county for blacksmiths' use. Throughout Mapleton, Robertsville, and Paris this coal is from four to six feet in thickness, and fully up to its average of excellence. Near New Chambersburgh it crosses the line of the Cleveland and Pittsburgh Railroad, and stretches thence continuously through the highlands of the watershed far into Pennsylvania. At Salineville, Hammondsville, and Linton it is called the "Big vein," and ranges from five to seven feet in thickness; a coking coal, not quite as pure as further west. At Linton it is underlaid by four or five inches of cannel, which is full of the remains of aquatic animals, and is plainly the carbonaceous sediments of an open lagoon in the coal marsh. About fifty species of fossil fishes and salamanders have been taken from one mine at this locality.

Just above Steubenville Coal No. 6 dips below the river, and this is the seam mined in the shafts at this point—Mingo, Lagrange, Rush Run, etc. At Steubenville it is about four feet in thickness; a partially open-burning coal of great excellence. It has been considerably used in the raw state for the manufacture of iron, but is now more generally coked. At Rush Run it is from seven to eight feet in thickness, but is not quite so pure as at Steubenvile, and is more broken by partings.

In all the northern part of Columbiana county this coal is found in an almost unbroken sheet. Near New Lisbon it is the coal mined on the Shelton, Arter, Teagarden, and Marten farms, ranging from four to seven feet thick. About Achor and Palestine, on the eastern line of the county, the coal of No. 6 becomes purer, but somewhat thinner than further west. This is the seam mined at Carbon Hill, and in this region is generally known as the "four-foot" or "Carbon Hill seam." At Achor it is mined by Isaac Dike, Burt, Burson, Booth, and others; the coal is from three and a half to four and a half feet thick, and very clean, bright, and pure. At the Sterling mines Coal No. 6 is worked by Freeman Butts, Esq., and is largely sold as a gas coal.

Throughout eastern Columbiana county, and over a large area in western Pennsylvania, Coal No. 6 is underlaid by a bed of limestone of from two to eight feet in thickness; but this disappears, or is only occasionally seen toward the west. By the Pensylvania geologists our Coal No. 6

is called the *Upper Freeport* seam, and the limestone under it is called the *Freeport limestone.*

Going southward from our starting point in Holmes county, we find that Coal No. 6, in Coshocton, exhibits an excellent development. It is mined in a great number of places, for the most part retaining the characters that have been alraady attributed to it. Here, as elsewhere, it usually lies in two benches, with a parting usually below the middle. At Coshocton, and in that vicinity, it is harder and purer than further north; is largely mined and shipped on the Pittsburgh, Cincinnati and St. Louis Railroad. Though not yet used for iron-making, if properly coked, the coal of this seam in Coshocton county would supply a very large amount of good furnace fuel.

South of the National Road Coal No. 6 acquires such magnitude and excellence that it quite overshadows all the other coal seams of the State.

In Muskingum county it has much the appearance it has further north, but is not so thick and pure as in Coshocton. In the adjoining county of Perry it expands to a maximum thickness of nearly thirteen feet, and is the "Great vein" of the Straitsville region. It is also of excellent quality, is open-burning furnace coal, containing a small amount of sulphur, and is successfully used for the manufacture of gas. The identity of the Straitsville coal with No. 6 will hardly be questioned by any one who follows the seam down through its line of outcrops and mines by which it is connected with the No. 6 of Coshocton, Holmes, and Tuscarawas. It is almost always recognizable by its dimensions, its partings, and by its relation to the Putnam Hill limestone and Coal No. 5, below, and to the Cambridge coal and the Crinoidal limestone (Ames limestone) of the Barren Measures, above.

What the reach of Coal No. 6 toward the east and back from its line of outcrop in Perry and Athens may be, we do not know; but it has been struck in borings in numerous localities where it had passed 100 feet below the surface, here maintaining a thickness of from 8 to 12 feet. It is highly probable that it extends beneath a large tract of country east of where it is now mined, where it is, far below the surface, readily accessible by shafts. It will be remembered that in passing southward on the Ohio, Coal No. 6 becomes thicker than further north, and we are thus encouraged to hope that its greatest development is in this direction.

The Straitsville coal has not been certainly recognized south of Athens county. If extending further in this direction, it is, on its western outcrop, much diminished in thickness and value.

ANALYSES OF COAL NO. 6.

No. 1. Arter farm, New Lisbon, Columbiana county.
" 2. Isaac Dike's mine, Camp Run, Columbiana county.
" 3. Salineville, Big vein, Columbiana county.
" 4. Linton, " "
" 5. Carbon Hill, " "
" 6. Saunders', Millersburg, Holmes county.
" 7. Andreas' mine, Urichsville, Tuscarawas county.
" 8. Steubenville shaft coal, Steubenville, Jefferson county.
" 9. A. B. Hamilton, Waynesburg, Stark county.
" 10. Keith's mine, Coshocton county.
" 11. Muskingum Valley Coal Company, Rock Run, Muskingum county.
" 12. New Straitsville, Perry county.
" 13. Nelsonville, Athens county.

	1.	2.	3.	4.	5.	6.
Specific gravity	1.260	1.276	1.280	1.276	1.280	1.369
Moisture	3.45	1.525	1.40	2.60	1.60	5.10
Volatile combustible	35.56	38.425	34.60	35.17	29.29	39.00
Fixed carbon	56.36	57.925	59.55	55.80	64.50	51.70
Ash	4.63	2.125	4.45	6.43	4.00	4.20
	100.00	100.00	100.00	100.00	100.00	100.00
Sulphur	2.50	1.22	2.11	2.63	2.80	2.26

	7.	8.	9.	10.	11.	12.	13.
Specific gravity	1.244	1.305	1.273	1.339	1.293	1.269	1.28
Moisture	3.20	1.40	3.30	4.00	3.47	6.90	5.95
Volatile combustible	34.20	30.90	33.30	36.20	37.88	30.25	32.38
Fixed carbon	58.00	65.90	60.00	54.70	53.30	58.19	57.12
Ash	4.60	1.80	3.40	5.10	5.35	4.66	4.55
	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Sulphur	1.54	0.98	0.66	2.69	2.235	0.79	0.77

THE MAHONING SANDSTONE.

Coal No. 6 is immediately overlaid by a greater or less thickness of shale. This is sometimes argillaceous, with many impressions of coal plants; in other localities—as in Holmes county—it is black, bituminous, and is crowded with fossil shells. Neither the plants nor shells, however, are peculiar to this seam, but are species widely distributed throughout the Coal Measures, both vertically and laterally. Occasionally the shale bed above Coal No. 6 is thick, and runs up to the next seam; but more generally, at a distance of from three to twenty feet, comes in a massive sandstone, which is a marked feature in the Coal Measure series. In Pennsylvania this is called the *Mahoning sandstone*, and is a conspicuous and much used landmark in all descriptions of the stratigraphic geology of that region. It is there made the dividing line between the Lower Coal Series and the Barren Measures. In Ohio it is not quite so important an element in the geological column, but it is still of sufficient consequence to deserve special notice. It is usually a coarse, brown or yellow sandrock, holding the same relations to Coal No. 6 that the Massillon sandstone does to Coal No. 1, and it is evidently the product of a similar change of physical condition. Like the Massillon sandstone, too, it occasionally dips down and cuts out the coal along the line of the currents of water by which its materials were distributed. The Mahoning sandstone is, however, distinguished from its lower representative by being occasionally a conglomerate, a character which I have never seen the Massillon sandstone assume. The quartz pebbles of the Mahoning sandstone are usually small—from the size of a grain of wheat to that of a bean—rarely becoming as large as a cherry. This will serve to distinguish it from the Carboniferous Conglomerate, which lies three hundred feet below, in which the pebbles are sometimes several inches in diameter. This will not serve, however, as an infallible diagnostic feature, since some of the sandstones higher in the series—especially one over Coal No. 7—occasionally take on this character of the Mahoning. The best exibitions of the conglomerate phase of the Mahoning sandstones which have come under my observation are in southeastern Columbiana county, and in northern Tuscarawas county, about Zoar. I may say in this connection that, in my judgment, far too much importance has been assigned to the Mahoning sandstone as a guide in the identification of our coal seams. Though very frequently, perhaps generally, found over Coal No. 6, it is by no means constant throughout even the Ohio portion of the Alleghany coal field; and if it would be unsafe to trust to it as a means of determining the position of the associated strata here, it must be much more so over a larger area. It is plainly the effect of causes that were local in their action, and it is far less constant and useful as a geological guide than the limestones of the Coal Measures, some of which were the products of general submergences, and are continuous over very wide areas. The statement that the Mahoning sandstone is common to both the Alleghany and Illinois coal fields is rendered improbable by strong *a priori* reasons, and it has not been confirmed by the latest and most careful observations.

Coal No. 6*a*. (Norris Coal.)

In the northern portions of the Ohio coal field we often find a trace of coal, or a thin coal seam, about 50 feet above Coal No. 6, but this very rarely becomes of workable thickness. In going southward it is first seen in southern Tuscarawas and northern Guernsey county. It is there local, but when present is thin and overlaid with a mottled brecciated limestone, such as occurs higher up in the Barren Measures, but which is quite unlike anything found below.

South of the National Road, in Perry and Athens counties, a coal comes in from 30 to 50 feet above the "Great vein," called by Prof. Andrews the "Norris coal," which locally attains a thickness of six feet, but apparently has not a very wide lateral extension. It is a coking coal, softer and more sulphurous than that of the "Great vein," but in its best phases is a good smith's coal, and one that will probably make a serviceable coke.

Coal No. 7.

Throughout Tuscarawas county, and in parts of Coshocton, Holmes, Stark, and Carroll, we find a strongly marked coal and iron horizon about 100 feet above Coal No. 6. The coal is here of no great value—from eighteen inches to three feet in thickness—and is usually soft and sulphurous. Resting upon it, however, is the most valuable deposit of iron ore in the northern part of the State, and, indeed, one that is, locally, richer than any other found in our Coal Measures. This is a *blackband* ore, which sometimes reaches a thickness of twelve feet, but is oftener three to six feet. It is not a continuous deposit, however, within the territory it occupies, and it runs out in every direction, so that it can be detected in but few localities outside of Tuscarawas county.

In some places, overlying this blackband ore—in others taking its place—is a limestone which is usually nodular and so highly charged with iron that it becomes a valuable calcareous ore. This is popularly called *Mountain ore*, from the fact that it occurs in the summits of the hills. It is also, locally, a limestone without ore, but containing some iron, so that it weathers buff.

The group of strata I have described is best shown in Tuscarawas county, in the hills above Zoar Station, and those on the head of Stone Creek and near Port Washington. In the first mentioned locality the coal is three feet thick, but poor. The blackband and nodular calcareous ore both appear above it, and have been extensively worked. At Wilhelmi's ore bank, on Stone Creek, and at Port Washington, the coal is from one and a half to two feet thick, is taken out with the ore and used in calcining it.

In Stark county Coal No. 7, with its blackband ore, occurs only in the hilltops in Robertsville and Osnaburg, and in Carroll county only in Ross township, between Waynesburg and Morges, where it is worked by Messrs. Rhodes and Card, of Cleveland.

In Holmes county Coal No. 7 is found in the tops of the hills both east and west of the Killbuck. It has here a thickness of from four to six feet, and is of good quality, but it has little cover, and is sparingly worked. No blackband ore is found over it. It here varies from 43 to 100 feet above Coal No. 6. In the eastern part of Carroll county Coal No. 7 is worked in various places near Mechanicstown and Waltsville. Thence it is traceable continuously down Big Yellow Creek to Hammondsville, and into the valley of the North Fork of Yellow Creek at Salineville. In all this region the coal is of excellent quality, and is extensively mined and shipped. At Salineville it lies 54 feet above No. 6; near Yellow Creek, from 50 to 70. At Salineville it is known as the "Salineville strip vein." It is here the highest workable coal in the series, and is overlaid by 300 feet of the Barren Coal Measures, strongly marked by heavy beds of red shale. The crinoidal limestone (Ames limestone) here lies 250 feet above it, and a nodular, earthy limestone occurs a few feet below it.

Toward the eastern margin of the State, Coal No. 7 lies from 50 to 60 feet above Coal No. 6, and is there the uppermost workable seam, the gray and red shales of the Barren Measures reaching to the tops of the hills. In this section it is about three feet thick, and, as at Salineville, is an excellent coal. Its relations to Coal No. 6 may be well seen at Palestine, where it is the seam worked by Burnett and Joy, while the next lower coal (No. 6, "Upper Freeport,") is the Carbon Hill seam. About the mouth of Yellow Creek Coal No. 7 is known as the "Groff vein," and a few miles below, on the Ohio, it has been extensively worked at New Cumberland, in West Virginia, and on the Ohio side opposite. Here it is four to four and a half feet thick, and of superior quality. Near Steubenville this seam appears to run out, and no workable coal is found between the Steubenville shaft coal, No. 6, and the Pittsburgh seam, No. 8, an interval of over 500 feet.

In the southern part of Carroll county, about Leesburgh, Coal No. 7 is well developed, acquiring a thickness of four and even locally five feet, and is of fair quality. It is quite largely mined in this vicinity, and in the corner of Harrison along the railroad. Thence it is traceable by a continuous line of outcrop into the valley of the Stillwater, and up that valley to Freeport, near which place it dips to the south and east below the surface and disappears. In all this region it is practically without the blackband, but is covered with a black shale which is highly ferruginous, and sometimes contains a few inches of good ore. On the Stillwater and in northern Guernsey county Coal No. 7 is generally overlain, not immediately, but at a distance of a few feet, by a heavy bed of sandstone, which is often a conglomerate coarser than that over No. 6, the pebbles sometimes attaining the size of a hickory nut. This conglomerate may be seen in Tuscarawas county, overlying the blackband and No. 7, in the hills between New Philadelphia and in the valley of the Connotton. It is here succeeded above by the brilliantly colored shales of the Barren Measures, which are never found below Coal No. 7.

By Prof. Stevenson, who has traced all the lower coals through from the Tuscarawas valley to the National Road, the coal so largely mined at Cambridge, Guernsey county, is supposed to be our Coal No. 7. It is also the "Alexander" coal of Muskingum county, which is thought by Prof. Andrews to be the "Sheridan," or "Bayley's Run" coal, which reaches through, almost uninterruptedly, to the Ohio river. By many persons this seam is believed to be further extended into north-eastern Kentucky, and there to be the famous "Coalton," or "Ashland" coal, so much used in iron-making. This identification is, however, somewhat conjectural.

In Muskingum county the Alexander coal (No. 7) is of varying thickness and value, but it is reported by Prof. Andrews to attain in some localities—Brush Creek and Wayne townships—a thickness of six feet. At the mines of Mr. William Alexander, in Washington township, it is extensively worked, and has a good reputation. In this region it lies from eighty to ninety feet above the horizon of Coal No. 6, and is represented by Prof. Andrews to have a limestone with iron ore a few feet below it. In Perry county this is the second seam above the "Great vein," from which it is separated by an interval of from seventy to ninety feet, the "Norris coal" (6*a*) lying from forty to sixty feet below it. On Snow Fork the three seams may be seen in the same section at various places. Coal No. 7 is here from three to five feet in thickness, with limestone and iron ore generally visible below it. In Athens county Coal No. 7 is apparently represented by the Bayley's Run coal. This is the seam most extensively worked, and regarded as the most important in the county, though hereafter it may be overshadowed by the working of the Nelsonville seam below drainage. The Bayley's Run coal has been very fully described by Prof. Andrews in his reports on Athens county, and it is recognized as one of the most valuable coal seams of southern Ohio. Its thickness in Athens county is generally from four and a half to five feet. It is a coking coal, which usually contains considerably more sulphur than Coal No. 6, but in many localities it seems to be pure enough to make an excellent coke. Prof. Andrews regards the Ferriferous limestone, with its coal, as representing, in Jackson, Gallia and Lawrence counties, the horizon of the Nelsonville seam, and recognizes the "Alexander" and "Bayley's Run" coal in the "Sheridan" coal, which lies seventy or eighty feet above. If this identification is correct, the "Newcastle" coal, which is the first seam above the Ferriferous limestone, and from twenty to thirty feet above it, holds about the position of the "Norris" coal of Perry county, and may be identical with it.

ANALYSES OF COAL NO. 7.

1. Joy and Burnett, New Palestine, Columbiana county.
2. Salineville Strip vein, Salineville, "
3. New Cumberland coal, Elliotsville, Jefferson county.
4. Taylor's coal, Holmes county.
5. Jacob Buckstone's coal, Mechanicstown, Carroll county.
6. Cambridge coal, Guernsey county.
7. E. D. Nyce, Center township, Guernsey county.
8. Alexander coal, Perry township, Muskingum county.
9. Bayley's Run coal, Trimble township, Athens county.
10. Sheridan coal.

	1.	2.	3.	4.	5.
Specific gravity	1.302	1.299	1.323	1.269	1.288
Moisture	1.40	1.70	0.90	7.30	2.80
Volatile combustible	36.80	34.30	31.10	34.90	30.20
Fixed carbon	56.80	59.50	60.70	54.40	64.10
Ash	5.00	4.50	7.20	3.40	2.90
	100.	100.	100.	100.	100.
Sulphur	2.00	1.62	5.49	2.14	1.23

	6.	7.	8.	9.	10.
Specific gravity	1.316	1.281	1.252	1.341	1.288
Moisture	3.00	3.30	6.15	4.75	5.35
Volatile combustible	34.15	32.30	30.97	34.90	33.00
Fixed carbon	57.39	60.30	58.47	54.95	58.65
Ash	5.46	4.10	4.41	5.40	3.00
	100.	100.	100.	100.	100.
Sulphur	2.57	2.80	0.41	2.40	1.44

THE BARREN COAL MEASURES.

By the Pennsylvania geologists the term *Barren Measures* was given to the strata lying between the Mahoning sandstone and the Pittsburgh coal, in western Pennsylvania. These consist of alternations of sandstone, shale, and limestone, to the thickness of about 400 to 500 feet. For the most part this series consists of shales which are peculiarly high-colored, being often bright yellow, red or blue, or red and yellow mottled. These constitute a peculiar feature in the geological column, and one which serves to identify the horizon at a glance, as no such shales are found above or below. With these are interstratified numerous layers of nodular, frequently ferruginous, limestone. Here and there streaks of coal run through the strata, but they rarely become of workable thickness; and this is emphatically, as its name indicates, barren ground. At the summit of this series lies the Pittsburgh limestone, and above this the great Pittsburgh coal seam (Coal No. 8, or H), the first and lowest of the upper coals.

Coming westward into Ohio, we find the Barren Coal Measures holding for a long distance almost precisely the character I have described. They are found to contain, however, in Columbiana county, even at the Pennsylvania line, a workable seam of coal, our No. 7, above the place of the Mahoning sandstone. This may be the representative of the Elk Lick coal of Pennsylvania, or, as likely, a new element introduced into the series. In either case it is so continuous and important a coal seam, and is so closely associated with our group of lower coals, that I have classed it with them. Near Steubenville, however, we find the Barren Measures as completely barren as they are in Pennsylvania. Coal No. 7 has there run out, and throughout the entire interval of 502 to 564 feet between Coal No. 6—the Steubenville shaft coal—and the Pittsburgh seam, which crowns the hills in the vicinity, no coal of workable thickness is found. Just at this point the Barren Measures are mostly shales, but on the opposite side of the river, and on the Virginia side of the Ohio for some miles above, they are replaced by heavy beds of sandstone.*

* I may here remark in passing that this region was peculiar for the formation of sandstones almost throughout the Coal Measures, as will be seen by reference to the sections given by Mr. Briggs in the annual report of the Geological Survey of Virginia, under Prof. William B. Rogers. From these we learn that at New Cumberland, below Coal No. 7, sandstones fill nearly the entire space and cut all other coals to Coal No. 3, while on the opposite side of the river, a little above, this interval is filled for the most part with shales, and contains three workable seams of coal. A little further down the river, in Vineyard Hill, opposite Steubenville, which lies entirely above the place of Coal No. 7, that coal is cut out, and the Barren Measures are composed mostly of sandstone, as remarked above.

In western Columbiana county the Barren Measures are finely shown in the range of high hills which border Yellow Creek. The section here shows most of this lower coal group well developed; about Hammondsville, Nos. 3, 4, 5, 6, and 7, all of workable thickness; at Salineville, coals Nos. 6 and 7 only above drainage. Over these the hills rise to the height of 350 feet, and are for the most part composed of gray, yellow, and red shales; the latter predominating and giving a marked character to the landscape. Two thin seams of coal are here seen in the Barren Measures, but neither more than a few inches thick. Of these the upper lies just over the crinoidal limestone at a distance of about 250 feet above the Salineville Strip vein (No. 7). This crinoidal limestone is one of the most constant elements in the Barren Measures, as it runs through the entire series of counties underlaid by this group. This is Prof. Andrews's *Ames limestone*, and is frequently mentioned in his reports on the southern counties. Its normal place is 140 to 150 feet below the Pittsburgh coal;* and in the central and southern portions of the State it is so constant in its presence and position that it forms a most useful guide. This is illustrated by the fact that the late Prof. Hodge, when connected with the survey, in making a reconnoisance of Jefferson, Harrison, and Carroll counties, used to call it the "blessed little limestone," thereby expressing his appreciation of its usefulness and reliability as a geological guide. In south-eastern Ohio the Ames limestone is reported by Prof. Andrews to be as universal in its distribution and as inflexible in its position as farther north. It also has considerable palæontological interest, as it has furnished us a long list of fossils, which will be found enumerated in the reports of Prof. Stevenson. These are for the most part species common to other portions of the Coal Measures, but among them are some fish teeth which I have obtained from no other stratum. These are *Petalodus Alleghaniensis* and *Peripristis*, n. sp. I have also collected these fossils from the same limestone at Pittsburgh, and they may perhaps be characteristic of it.

In central and southern Ohio the Barren Measures are less barren than farther north and east. The beds of coal which occur in them are more numerous, and they locally attain, in several instances, workable dimensions. They are, however, much smaller and less continuous than those of the lower or upper groups. In Carroll county one of these coals is seen at Harlem Springs, and is called the Harlem coal. It is mined in

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* This interval increases, however, toward the east. At Steubenville the crinoidal limestone is 225 feet below the Pittsburgh coal, and in western Pennsylvania it becomes 350 feet before the limestone is lost sight of.

several places; is a little over two feet in thickness—a very pure, semi-cannel coal, but, like all the coals of the barren group, it is unreliable. This is found directly beneath the crinoidal limestone, and is numbered coal 7*b* by Prof. Stevenson. Coal No. 7*a*, in the same region, is 65 to 90 feet below the last mentioned, and is usually but a few inches in thickness.

In Jefferson county two seams of cannel coal are found high up in the Barren Measures, but they are of poor quality, and are local.

In Muskingum and Guernsey counties the Barren Measures contain more coal and limestone than farther north and east; but none of the coals have any considerable value or constancy. The thickness of the group is here from 300 to 350 feet, or about 100 feet thinner than on the Ohio at Steubenville. In this estimate I include only the strata between the Sheridan and Pomeroy coals—*i. e.*, between No. 7 and No. 8. This interval in southern and central Ohio can hardly be called the Barren Measures; but it contains no seams of coal which in permanence and dimensions compare with those above and below. Prof. Andrews reports a limestone which traverses the Barren Measures in central and southern Ohio at a distance of about 225 feet below the Pomeroy coal. This he calls the "Cambridge" limestone. It is not distinctly recognizable in the counties lying north of the National Road.

THE UPPER COAL MEASURES.

In Ohio, as in Pennsylvania, the interest in the Upper Coal Measures centers mainly in the Pittsburgh seam, as this is by far the most important both as regards thickness and persistence. By the Pennsylvania geologists it has been denominated Coal No. 8, or H, according as numbers or letters were used to designate the seams in ascending order. As has been already learned from the preceding pages, the Pittsburgh coal forms No. 8 of the Ohio series, being the first workable seam of the upper group. Above this we have on the Ohio three workable coals, with three or four smaller ones distributed through three hundred feet of strata, which have the same general character with those that compose the Lower Coal Measures—*i. e.*, they are alternations of fire-clay, coal, shale, limestone, and sandstone. In the interior of the State the Upper Coal Measures form a group of equal or greater thickness, but they contain a smaller number of workable coal seams. That which has been called by Prof. Andrews the "Cumberland" seam is almost the only one that deserves to be classed with the strongly marked and wide-spread seams which compose the lower group. There are also comparatively few deposits of iron ore in the Upper Coal Measures, and none of the fire-clays are, so far as yet known, equal to those under Coals No. 3, No. 5 and

No. 1, which in Scioto, Columbiana, Jefferson, Tuscarawas, and Summit rival the coal seams in economic value, and supply the materials by which great industries are sustained. It will be noticed also that none of the upper coals, so far as yet examined, are open-burning, and capable of use in the raw state as furnace fuels. In one respect only can superiority be claimed for the Upper Coal Measures over the Lower, and that is, in their hydraulic lime. As has been before mentioned, some of the limestones of the lower group occasionally become earthy, and are capable of furnishing hydraulic lime of fair quality. The locks of the Sandy and Beaver Canal were laid up with cement manufactured from one of the lower limestones. In the Upper Coal Measures, however, under Coal No. 9, is a stratum of hydraulic limestone, from which is manufactured a large amount of cement, proved by ample tests to be fully equal in quality to any other made in this country.

The following section of the Upper Coal Measures, as they appear along the Ohio, has been prepared at my request by Prof. Stevenson:

SECTION OF THE UPPER COAL AND BARREN MEASURES.

No.	Strata.		Feet.	No.	Strata.		Feet.
36	Limestone		7	9	Shale and sandstone.		50 to 100
35	Sandstone		40	8	Shale		2 to 10
34	*Coal No.* 13....................		1 to 2	7	*Coal No. 7a*		1 to 6
33	Sandstone and shale........		70	6	Fire-clay		1
32	*Coal No.* 12		1 to 6	5	Sandstone and shale.	Barren Measures.	50
31	Sandstone and shale........		20 to 40	4	*Coal No.* 7 (F).........		0 to 5
30	*Coal No.* 11 (Waynesburg)..		1½ to 4	3	Fire-clay		3
29	Fire-clay		1	2	Limestone		2 to 10
28	Sandstone and shale........		50	1	Mahoning sandstone		....
27	Limestone		6		In Belmont county the		
26	Sandstone		45		section between coals Nos.		
25	*Coal No.* 10....................		3 to 6		8 and 9 differs somewhat		
24	Fire-clay		3		from the above, owing to		
23	Sandstone		35 to 40		intercalated beds, and is		
22	*Coal No.* 9....................		2½		as follows:		
21	Fire-clay		½	11	*Coal No.* 9....................		2½
20	Limestone		30 to 70	10	Limestone		70
19	Black shale		2 to 10	9	*Coal No.* 8*c*		2 to 4
18	*Coal No.* 8 (Pittsburgh, H)		4 to 8	8	Fire-clay		2
17	Fire-clay		3	7	Sandstone		5 to 35
16	Limestone		4 to 30	6	*Coal No.* 8*b*, with shale		
15	Shale and sandstone.		110		(Sewickley)		1
14	Shale	Barren Measures	5 to 10	5	Limestone		20
13	Crinoidal limestone..		2 to 8	4	*Coal No.* 8*a* (Redstone).....		1½
12	Shale		1 to 17	3	Limestone		25
11	*Coal No.* 7*b* (G).......		½ to 4	2	Shales		5
10	Fire-clay		2	1	*Coal No.* 8 (Pittsburgh) ...		8

Coal No. 8.

Coal No. 8, or the Pittsburgh seam, enters Ohio in Jefferson county, where it caps the hills north and west of Steubenville, about 500 feet above the river and Coal No. 6, and reaches to about the south line of Carroll. Going thence southward, it exhibits two lines of outcrop, one in the valley of the Ohio, the other traversing the interior in a tortuous but generally south-west direction. At Knoxville and Richmond the coal seam is from three to four and a half feet in thickness, generally with little cover and of poor quality; thence to Steubenville it is interrupted, but southward from this point it is mined almost continuously to and below Wheeling. The dip is here rapid. At Mingo it lies 360 feet above the river, 513 feet above Coal No. 6, where mined in the shaft. At Lagrange it is a little higher than at Mingo, being 378 feet above the Ohio. At Rush Run it is 306 feet above the river, 511 feet above Coal No. 6. At Tiltonville it is 230, Martin's Ferry 148, Kirkwood 135, and at Bellaire 120 feet above the river level. At Wegee it is 15 feet, and at Moundsville 80 feet below the Ohio. Throughout this region its thickness varies from five to nine feet, the coal varying somewhat in quality, but always highly coking. It is generally a double bed, consisting of two or more beds separated by partings of fire-clay or shale.

Along its western line of outcrop Coal No. 8 passes through Jefferson, Harrison, and Belmont into Guernsey, where it crosses the Baltimore and Ohio Railroad. It also forms several outliers, or small islands, in Guernsey, produced by the folds in the strata, to which reference has been already made. South of the railroad it passes through Muskingum, Morgan, Athens, and Meigs to Pomeroy, where it crosses the Ohio, and is extensively mined. Throughout this long line of outcrop the Pittsburgh coal may be said to be continuous, though it exhibits considerable local diversity of dimensions and character. In Muskingum county it is quite thin, sometimes not more than one foot in thickness, and it is evident that we are there on the extreme western margin of the great basin in which it was formed. In Morgan, Athens, and Meigs counties, the Pittsburgh, or Pomeroy, seam assumes much greater importance, varying from five to nine feet in thickness. It is there often divided by one or several partings, as it is so prone to be elsewhere. In Homer township, Morgan county, it is reported by Prof. Andrews to have an aggregate thickness of eight to nine feet in two nearly equal benches, with a clay parting of one foot. On Federal Creek, Bearne township, Athens county, the Pomeroy seam is from eight to nine feet thick, exclusive of a parting of shale and clay one foot or more in thickness. The coal is here bright, black, and of a very serviceable quality. It has the typical character of the Pittsburgh coal, being highly coking, but with more sulphur than at Pittsburgh or Pomeroy. In other localities in Athens and Morgan the seam is smaller, is frequently without partings, and furnishes a very pure and useful coal.

In Meigs county Coal No. 8 underlies a large part of the surface, maintains a thickness of from four to six feet, and yields a coal which is highly esteemed as both a steam and mill coal. It is very largely mined at Pomeroy and vicinity, and many thousand tons have been annually shipped from this point for many years. The coal from this region is so well known that no description is required of it.

In the report on Belmont county by Prof. J. J. Stevenson a detailed description will be found of our upper coals, and some facts of special interest are there reported in regard to the Pittsburgh seam. He apparently demonstrates that while in western Belmont county it is a single seam, on the Ohio at Bellaire it is represented by four coals, three of which occupy the space between Coal No. 8 and Coal No. 9, this interval having been increased from fifty feet at Barnesville to one hundred and fifty feet on the river. By carefully tracing Coal No. 8 and its associated strata along their western line of outcrop to Steubenville, and thence down the valley of the Ohio to Bellaire, he demonstrated the continuity of the large coal at Bellaire with that at Salesville and Barnesville; and since Coal No. 10 certainly, and Coal No. 9 probably, are continuous, each on its proper horizon, the three coals above the Pittsburgh in the Bellaire section seem to have no representative in the western part of Belmont county, unless Coal No. 8 is the equivalent of the entire group below No. 9 on the Ohio. It is Prof. Stevenson's opinion that Coals Nos. 8*a*, 8*b*, and 8*c*—the three seams above the Pittsburgh in the Bellaire section—are offshoots from Coal No. 8, and that they all run together. From the facts which he reports this would seem to be an almost necessary conclusion.

Whether they are connected with the Pittsburgh coal or are independently intercalated seams, they afford evidence of unequal subsidence of neighboring portions of the coal area during the deposition of the Pittsburgh coal. This has occasioned immense disparity in the intervals between Coals No. 8 and No. 10 at the east and west ends of Belmont county, and gives us fresh proof of the fallacy of the theory of the parallelism of coal seams.

Analyses of Coal No. 8.

No. 1. Lagrange (average), Jefferson county.
" 2. David Brown, Pease township, Belmont county.
" 3. R. Crawford, " "
" 4. J. Culderhead, Short Creek township, Harrison county.
" 5. Allison's bank (average of 3), Harrison county.
" 6. Federal Creek, Athens county.
" 7. Pomeroy coal, Pomeroy, Meigs county.

ANALYSES OF COAL NO. 8.

	1.	2.	3.	4.	5.	6.	7.
Specific gravity.........	1.302	1.290	1.348	1.266	1.285	1.304	1.358
Moisture..................	1.45	1.00	1.10	2.80	2.44	2.70	4.10
Volatile combustible..	36.35	34.20	32.50	34.20	32.36	35.30	33.90
Fixed carbon............	57.95	59.40	63.50	59.40	59.92	55.05	56.10
Ash	4.25	5.40	2.90	3.60	5.28	6.95	5.90
	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Sulphur	2.72	2.63	0.68	1.80	2.62	5.24	0.46

COAL SEAMS NO. 9 TO NO. 13.

The coals higher than the Pittsburgh seam have, in Ohio, comparatively little value. In this respect our Upper Coal Measures exhibit a marked contrast with those in West Virginia, where locally the *Redstone*, *Sewickley*, and *Waynesburg* seams are all of great importance, and locally rival in value the Pittsburgh bed, magnificent as it is in its proportions. Prof. Stevenson, who has spent some years in the study of the Coal Measures of West Virginia, thinks that the coals I have mentioned are represented respectively by Coals Nos. 8*a* (Redstone), 8*b* (Sewickley), and 11 (Waynesburg) of the section in eastern Belmont county. Of these, the Redstone and Sewickley have their greatest development at the east, thin out rapidly westward, and scarcely pass the Ohio, as, though recognized in the Bellaire section, they are there less than one foot in thickness, and have disappeared at Barnesville. The *Waynesburg* coal Prof. Stevenson finds represented by an exceedingly variable seam which passes through the highlands of Belmont county, and from its changeableness is called locally the "jumping six-foot seam."

Coal No. 8*c*, of the Bellaire section, is what is known as the "Glencoe coal." This is supposed by Prof. Stevenson to be a bed of very limited extent. Along the east front of Belmont county it is generally workable, and attains a maximum thickness of four feet; but it thins out rapidly northward along the Ohio, and is scarcely known beyond the county line. At Barnesville, on the Central Ohio Railroad, it has entirely disappeared; and it is also said by Prof. Stevenson to grow thinner passing eastward from Wheeling.

Coals No. 9 *and No.* 10 of Prof. Stevenson's section are both thin along the Ohio, but are persistent, and No. 10 thickens toward the west. This shows that they were formed in a basin of which the deepest portion lay in that direction. Traced on the north and west to the limits of the area of the upper coals, one or both of them are usually present, except where locally cut out by beds of sandstone. Coal No. 9 lies immediately upon the limestone over the Pittsburgh coal, and this limestone thins toward the north and west, letting down Coal No. 9 on to Coal No. 8. At Cadiz, Harrison county, Coal No. 9 is two feet thick; at York, Jefferson county, it is one and a half feet thick; at Unionport and Knoxville, in Jefferson county, it has disappeared, and Coal No 8 is covered in one place by 85 feet and in the other by 100 feet of sandstone and shale, upon which Coal No. 10 rests. Toward the west from Wheeling, Coal No. 9 seems to disappear, and the interval between the Pittsburgh seam and Coal No. 10 is represented by Prof. Stevenson to be, in western Belmont and Harrison counties, filled by a great mass of sandstone, in places more than 100 feet in thickness. This sandstone, he says, has been deposited by currents which have extensively cut away Coal No. 9 and, locally, Coal No. 8.

Coal No. 10 is a very persistent seam, and locally attains considerable importance; but in Harrison, Jefferson, and Belmont it is of far less value than the Pittsburgh seam. It is frequently a double bed. At Badgersburg the coal is six feet seven inches thick, in two benches, separated by one foot eight inches of shale and clay. At Flushing the upper bench is one foot two inches, the parting one foot four inches, and the lower coal three to four feet in thickness. At New Athens, Harrison county, the seam is divided into three benches, of which the upper is ten inches, the middle four feet eight inches, and the lowest four inches, the partings being respectively two feet and three feet in thickness. In Jefferson county Coal No. 10 becomes much thinner, and it is little more than a bituminous shale, two to three feet thick. (Stevenson.)

What the extension of Coal No. 10 toward the south and west is, cannot be accurately stated. We have reason to believe, however, that it is the same as that mined at Cumberland, Muskingum county, called by Prof. Andrews the *Cumberland coal.* This lies, according to his description, about 100 feet above Coal No. 8, and runs through the counties of Morgan, Athens, and Meigs, to the Ohio river. In this region it varies from two to six feet in thickness, and is frequently divided by one or more partings of clay or shale. It usually is associated with much limestone, above and below, and Mr. W. J. Herdman, who traced it through nearly to the Ohio river, has furnished me a section from Morgan county, in which the Cumberland seam is overlaid by 160 feet of strata, largely made up of limestone.

Coal No. 11 has been referred to in a preceding page as the representative of the Waynesburg and the "jumping six-foot seam." It is locally of some economic value in Belmont county, but both in quality and dimensions is very unreliable. Its characteristic features are well shown in the cut west of Barnesville, where my attention was called to it by Prof. Stevenson. At one end of the excavation it is barely six inches in thickness, while at the other it shows a total of five feet four inches, consisting of coal, one foot; shale, four inches; coal, four inches; shale, four inches; coal, four inches; shale, two feet; coal, one foot. Seven miles east from Barnesville, where it is exposed in a railroad cut, it is about one foot thick, and parted in the middle by a thin layer of limestone. Near St. Clairsville, in the same county, it is rudely worked, and shows three feet of very impure coal, resting almost immediately upon a foot of limestone. Near Bridgeport, opposite Wheeling, it is three feet six inches thick, roofed by six inches of impure blackband, which is overlain by two feet of alternating bands of bituminous and ordinary shale. On a run four miles west from Bellaire, and just south of the railroad, it suddenly thickens out and becomes a confused mass of coal and shale, not less than fifteen feet thick, and totally worthless.

In Harrison and Jefferson counties it is never more than two feet thick, and is seen only near the tops of the highest hills, and has no economical value. (Stevenson.)

Coal No. 12 is generally found in the highlands which border the Ohio opposite Wheeling. It is usually from a few inches to two feet in thickness, but is locally, near the Ohio, developed into a dry coal six feet in thickness, but heavily charged with pyrites.

Coal No. 13 lies some seventy feet above the last, is very thin, and has no practical value. It is limited to the summits of the divide east of the Ohio, on and south of the Baltimore and Ohio Railroad.

DISTRIBUTION OF THE LIMESTONES OF THE UPPER COAL MEASURES.

If it is true, as has been supposed, that Coal No. 10 of the Belmont section is the Cumberland coal of the south-eastern counties of the State, it will be seen to thicken toward the west, and its basin may be said to lie west of the Ohio. This is also indicated by the limestones with which this coal is associated, and which are thinner and less numerous in the Upper Coal Measures of West Virginia and Pennsylvania, after passing above the "Great limestone," which there lies over the Pittsburgh seam. We are in these facts furnished with evidence of another change of the center of gravity, if we may use the term, in the progressive subsidence of the Alleghany coal field. Following back the history we have traced, and measuring the spread of marine conditions by the reach, and their continuance by the thickness of the limestones, and tracing the local depressions of the different epochs by the thickening of the deposits toward the bottom of each basin, we find that in the epoch of the Putnam Hill limestone the basin in which it was deposited lay almost entirely in Ohio, and that in its center the blue or Zoar limestone is buried ninety feet deeper than on its sides.

In the epoch which succeeded the deposit of the Freeport limestone the locality of greatest depression was east of Ohio, as this limestone, while covering a large area in western Pennsylvania, reaches continuously through but one tier of counties in Ohio.

The center of the basin continued to be east of Ohio during the deposition of the Barren Coal Measures, as they are thickest and contain most limestone on or near our eastern border; are thinner, with less limestone and more coal, toward the west.

During the Pittsburgh epoch, or that which immediately preceded and followed the deposition of the Pittsburgh coal, the area of open water was, as in the Upper Freeport epoch, nearly in the line of the center of the basin. The proof of this we find in the great deposit of limestone beneath and over the Pittsburgh coal at Wheeling, and other localities in West Virginia and western Pennsylvania. After passing the Ohio line these limestones rapidly thin out and are replaced by mechanical shore deposits. It is also shown by the thickening toward the east of the mechanical materials which separate the Pittsburgh, Redstone, Sewickley, and Waynesburg seams. And yet, after the filling up of the water basin in which the Pittsburgh limestone was deposited, but little more limestone accumulated at the east up to the close of the Carboniferous age, the open water and calcareous sediments preponderating, as we have seen, in Ohio.

By tracing our Coal Measures into Pennsylvania, it will be found, as was shown by Prof. Rogers, that our most important coal seams thicken toward the east; as the Upper Freeport—which becomes in West Virginia twenty feet in thickness, though nearly half slate—the Pittsburgh, the Redstone, the Sewickley, and the Waynesburg; while the greatest development of the limestones lies relatively further west in the basin. This fact led Prof. Rogers to conclude that the limestones of the Coal Measures thickened westward toward the open sea, and he supposed that their relative importance constantly increased until the mechanical sediments ceased to have any place in the series. Yet, as we learn by examination of the Coal Measures in Ohio, the limestones do not continue to increase in thickness indefinitely toward the west, but, on the contrary, toward the western margin of the coal field they thin out and disappear. The reason of this I have given in the analysis of the structure of the Cincinnati arch (Vol. I., Part I., p. 93), where I have shown that its elevation took place long anterior to that of the Alleghanies, and at the close of the Lower Silurian. Hence, during the Devonian and Carboniferous ages, it constituted a long, narrow island, which extended as far south as Tennessee, and the basin in which our coal beds were formed was bounded at the west by that ridge. This proves that there was no connection between the Illinois and Alleghany coal fields, and therefore our limestones, beds of coal, and even sheets of mechanical material—sandstones, shales, and conglomerates—all came to an edge, or ran out on the flanks of the old Cincinnati arch. For a very good reason, therefore, the limestones could not thicken in that direction indefinitely.

The reason why the limestones lie nearest to the western margin of the great trough which stretched from the Blue Ridge to the Cincinnati arch is, in my judgment, simply this: on its eastern and northern sides the coal basin received the drainage of quite an extensive continental surface, and great quantities of mechanical sediments were brought down and spread along that shore. The western border, however, was formed by a narrow ridge, composed of lime rock, from which the drainage was insignificant and calcareous; therefore, on this side, the clear and quiet water necessary for the deposition of limestone set close up to the shore. On the north and east, deltas and mud-flats were forming like those on the shores of the Bay of Fundy, and at the mouths of our great rivers. A still better example of the mode of accumulation of clay, sand, etc., on that shore is seen about the head of the Gulf of California, where the physical condition is not unlike that of the Alleghany trough in Carboniferous times. There the head of the bay is filling up with sediment, and shallows and mud-flats, many miles in width, line the shore, over which it is next to impossible to pass from ship to land or land to ship.

THE EXTENT OF COAL SEAMS.

Two very different, and even antagonistic, theories are entertained by geologists in regard to the area over which any individual coal seam may be traced. One of these is that advocated by Mr. Leo Lesquereux, who claims that certain coal strata extend not only across the entire breadth of the Alleghany coal field, but that these may be identified in Indiana, western Kentucky, and Illinois.*

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* Geological Survey of Illinois, Vol. I., p. 208; American Journal of Science, 2d Series, Vol. XXX., p. 367.

The other theory to which I have referred is, that the coal seams lie in a series of basins of limited extent, and that the identification of any one seam—except, perhaps, the Pittsburgh—throughout an area of several counties, is a stretch of the imagination. After somewhat extended observations in the Alleghany and Illinois coal fields, and careful comparison of the reports made by others, I am led to believe that, as is so frequently the case with strongly opposed theories, the truth lies between the two.

In tracing these different beds of coal from town to town and from county to county, they are seen to exhibit marked changes in their thickness, character, and relations to each other; and a section formed by the coal strata in one district is never quite the same as that furnished by another. Some of the seams are extremely local, occupying an area of perpaps not more than a few hundred acres, while others, like the Pittsburgh and Nelsonville seams, underlie many thousand square miles. Whoever will take the trouble to examine the sections of the coal strata of western Pennsylvania, given by Prof. Rogers in the second volume of the Geology of Pennsylvania, and compare them with those now published, beginning at the east and passing to the west and south, will be forced to conclude either as I have claimed, that a skeleton or frame-work runs through the entire series, and that some of the strata are continuous over the greater part of the breadth of the north end of the Alleghany coal field, or that the sections taken at different points present a remarkable and incomprehensible series of coincidences.

The classification of our coal strata has grown entirely out of our experience. On first entering one of the valleys which traverse the coal area, the number, order, and characters of the coal seams, with their relations to each other and the associated strata, were learned as an independent lesson in local geology. In passing to another valley another series of outcrops was studied, and the differences and coincidences were compared. The system of sections now published is simply the record of observations made in the manner I have described. The classification of our coal seams, reported in the preceding pages, has been tested in various ways, and by different geologists, who have had much experience in this kind of work, and its general accuracy may be considered as demonstrated.

But all this shows simply the structure of the northern end of the Alleghany coal basin. How far the central and southern portions of this great trough—750 miles in length—correspond with the northern end remains to be accurately determined by further investigation. The facts reported by Prof. Safford, and my own observations in Kentucky and Tennessee, lead me to believe that great, and perhaps radical, differences will be found to exist between the northern and southern portions of the Alleghany coal field.

Prof Andrews has shown that important modifications have taken place in our northern system, even within the limits of our own State.

In West Virginia, Kentucky, and Tennessee these changes seem to be still more strongly marked, for there a lower series of coals appears to come in within and even beneath the Conglomerate; and it is very doubtful whether our leading seams can be identified there at all. The geological survey which has been recently revived in Kentucky, and committed to the able supervision of Prof. N. S. Shaler, will undoubtedly throw much light upon this question. When he shall have filled the great geological blank which has heretofore existed in eastern Kentucky, and the mysteries of the rich and intricate coal fields of West Virginia shall be unraveled, the work done in Pennsylvania and Ohio can be connected with that of Prof. Safford in Tennessee, and the broad and interesting problems of the structure and history of the Alleghany coal field will approach solution. Till then our generalizations on this subject must be largely speculative, and such as are liable to be greatly modified by future observation.

In regard to the community of structure between the Alleghany and Illinois coal fields, I am compelled to say, that after some time spent in the examination of the coal strata of Indiana, Illinois, and western Kentucky, and a careful reading of the excellent reports of Professors Cox and Worthen, I have failed to find any proof of the identity that has been claimed. I have not been able to satisfactorily co-ordinate the series of coal beds of the two basins, nor can I identify any individual seam of the Illinois coal field by its position, its dimensions, its quality, its fossils, or its associated strata, with any one of ours.

Mr. Lesquereux also claims to be able to identify the Mahoning sandstone in the Coal Measures of Illinois and Kentucky. But in tracing it even through our portion of the Alleghany coal field I find it so often absent that it becomes entirely unreliable as a geological guide. That it has been so to Mr. Lesquereux is evident from the fact that he has supposed that he recognized the Mahoning in the heavy sandstone which overlies the Pomeroy coal, and in that which contains the silicified trunks of *Psaronius* on Shade river. As a consequence, he has regarded the Pomeroy coal as the Upper Freeport seam,* whereas it is well established that it is No. 8, or the Pittsburgh coal.

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*American Journal of Science, 2d Series, Vol. XXX., p. 368.

We see that in Ohio the forces that distributed the Mahoning sandstone were local in their action, and it seems hardly probable that this epoch should have been so strongly marked over so great an area as Mr. Lesquereux supposes, and yet have left so inconstant a record here.

The Cincinnati arch is also a serious impediment to the acceptance of the theory that the Alleghany and Illinois coal fields are identical in structure. We have learned in the progress of the Survey that this is a very old topographical feature; that it has existed since the close of the Silurian age, and that during the Coal Measure epoch it was a barrier which somewhat widely separated the two coal basins. It seems almost impossible, therefore, that they should have anything more than a general similarity of structure.

It should be remembered that both these great troughs have been filled for the most part by mechanical sediments washed from their margins. The Alleghany coal field was filled to the depth of at least 3,000 feet at its center, mainly by materials washed from its eastern and northern shores; the Illinois coal basin to only half that depth, and it received its clays and sands—now sandstones and shales—from the north. Its structure must necessarily, therefore, be very different.

As I have shown on the preceding pages, the Pittsburgh coal thins to an edge on the north and west within the margin of our coal area, and this is also true of its associate, the "Great limestone"—facts which afford us ocular demonstration that these strata never reached through to Illinois. It may be said that the two coal basins were once united at the southern end of the Cincinnati arch—that is, in Alabama; but there are strong geological reasons for doubting this. The Illinois coal field terminates in western Kentucky several hundred miles further north than the extremity of the Alleghany basin, and we have no proof that the connection has been cut away by erosion. But even if this were true, Safford shows that the southern extremity of the Alleghany coal field has a very different structure from that which we find in the Coal Measures of Pennsylvania and Ohio and in Illinois. Hence, if the coal basins were once united at the far south, the connecting links in structure—such as the "Great limestone," Pittsburgh coal, Nelsonville coal, and Putnam Hill limestone—were never formed there. It is true that in the Cumberland Mountains we have only the lower coal seams, but these are certainly very different from ours. Our Coal Measure limestones are there entirely wanting, and they have almost disappeared in Kentucky. This is a fact which has somewhat surprised and puzzled me, for we have heretofore supposed that the limestones of the Coal Measures marked periods of subsidence when more or less of the Alleghany coal basin was an arm of the sea opening into the Gulf of Mexico, and broadening and deepening toward the south. This could not have been the case, however, as we should have found the limestone sheets becoming wider and thicker in that direction. It therefore seems necessary to suppose that the sea water had access to our coal basin from the south, through a long, narrow channel or strait, or, what is quite as probable, by some lateral inlet. In either case the broadest space of open water in periods of submergence was as far north as southern Ohio, and while the limestones were forming the northern part of the trough was a land-locked bay something like that of San Francisco, rather than an arm of the sea.

Prof. Stevenson informs me that in the "oil break" of West Virginia and southern Ohio, where the Barren Measures are extensively exposed, they contain no coals, and that the lower coal group is apparently absent, with the exception, perhaps, of the upper Freeport seam. This gives farther illustration of the great diversity which prevailed in the physical condition of different portions of the Alleghany basin, and it may indicate, as Prof. S. suggests, that our lower coals were deposited in a series of circles around the margins of the basin, only the upper coals stretching across. This question can only be settled, however, by a long series of patient and careful observations.

THE PARALLELISM OF COAL SEAMS.

In the "Conclusions" appended to his report contained in Volume I., Prof. Andrews advances the theory that our important coal seams are parallel to each other; and that where, among seams supposed to be continuous, an absence of such parallelism is discoverable, this is evidence of a want of continuity and identity in one or the other of those compared. Prof. Andrews accounts for this claimed parallelism by supposing that the different coal seams were formed at or near the line of water level, and that the subsidences which have caused the accumulation of successive layers of carbonaceous matter were continental and uniform. To these views I have been unable to subscribe, inasmuch as I have failed to detect the parallelism claimed, and, on the contrary, have, as it seems to me, in numerous instances, discovered very marked inequality in the distances that at different localities separate coal seams which are unmistakably continuous.

This matter is plainly one for observation, not for theory or argument, and as the question will be inevitably settled by an appeal to facts, I shall confine myself to a brief statement of some of these which appear to me incompatible with the view to which I have referred. So much as this seems to be required of me; as, if this view were accepted, it would destroy all confidence in the classification of our coal seams which I have adopted, and if true, a large part of what I have written on this subject is necessarily false. For the proof of the general truth of the order of sequence which I have reported as prevailing over most of Ohio, I must appeal to the series of sections published on the sheets that accompany this report, and to the several experienced geologists who have carefully gone over the ground where these sections were taken. Some of the specific facts which seem to me to be incompatible with the theory of the inflexible parallelism of coal seams I give below.

In tracing the outcrop of Coal No. 1 throughout all the counties where it is worked in northern Ohio, I have found this seam to be exceedingly variable in its level. It often shows a series of waves, or folds, in which the arches are sometimes as much as 50 feet higher than the basins, within the limits of a few hundred acres. This irregularity is well shown in a large number of mines that are opened in this coal in Trumbull, Mahoning, and Stark counties. Perhaps no better illustration of it could be offered than that described by Mr. Read in his report on Trumbull county (Vol. I., Part I., p. 498); since he there shows that on a tract of land held by one company the variation in the distance between coal seams No. 1 and No. 2 amounts to more than 50 feet. In this case there can certainly be no question in regard to the identity of the two seams passed through.

A similar variation in the interval between Coals No. 3 and No. 4 is revealed in the shaft and borings, thirteen in number, made on the property of Tod, Stambaugh & Co., in the north-west corner of Carroll county. Here, within an area of which the diameter is 1200 feet, the distance between these coals varies from 20 to 45 feet. Here, also, there can be no question of identity, as each of the coal seams is marked by its overlying limestone, and both are well known throughout all this section of the State. I have myself traced these coals (Nos. 3 and 4) over more than two hundred miles of outcrop, and have taken sections which include them in many hundreds of localities. Within the range of my own observation I have known the interval between them to vary from 20 to 90 feet, and Prof. Stevenson reports them to be even 110 feet apart in one locality in north-western Guernsey county.

The interval between Coals No. 4 and No. 6 exhibits nearly as great a variation as that between Coals No. 3 and No. 4. The horizon of Coal No. 4 is one of the most distinctly marked of any in the Coal Measures, since it underlies, generally immediately, the Putnam Hill limestone. Coal No. 6 is equally unmistakable, as it is the thickest and most continuous of all the lower group of coals. In the valley of the Killbuck, above Millersburgh, Coals No. 4 and No. 6 are not more than 25 feet apart, but in tracing them down the Killbuck to the Tuscarawas this space constantly increases until it reaches a maximum of 100 feet. In the valley of the Tuscarawas I have traced these coals from Zanesville to near Massillon. Along this line of observation the variation in the distance between them does not exceed 25 or 30 feet, as it follows nearly the center of the local basin to which reference has been made on a preceding page. But on either side of this basin the interval diminishes to one-fourth of its maximum.

The intervals between Coals No. 6 and No. 7 I have found to vary, at localities examined by myself, from 54 to 100 feet, diminishing toward the east.

The distance between Coals No. 6 and No. 8 has been shown by our measurements to vary in Jefferson county alone from 498 to 564 feet. Along the western line of outcrop of these coals the interval is from 400 to 430 feet.

The distance between the Pittsburgh coal and the Crinoidal, or Ames, limestone is, in central Ohio, from 140 to 150 feet, while in Jefferson county it is 225 feet. The two last-mentioned members of the series are so continuous and so strongly marked by individual characters that there can be no mistake about their identification; and it is also true—here as in the lower intervals—that the increase or diminution is found to be progressive, according as the line of observation is carried in one or the other direction. This could be shown by reporting the intervals at various points intermediate between the maxima and minima which I have given, but this is scarcely necessary here, since many of these facts have been given on the preceding pages.

The remarkable variation in the interval between Coals No. 8 and No. 10, described in the report of Prof. Stevenson on Belmont county, has been alluded to in the sketch given of the Upper Coal Measures. The accuracy of the observations reported by Prof. S. has been called in question, but justice to him requires that I should state that they have been fully confirmed by tracing the coals which overlie the Pittsburgh seam at Bellaire north and west to the points of their successive disappearance; while the identity of Coals No. 8 and No. 10, in their outcrops in eastern and western Belmont county, has been demonstrated by following them around through Guernsey, Harrison, and Jefferson counties, from one locality to the other. It has thus been proved that between Barnesville and Bellaire the space between Coals No. 8 and No. 10 increases by more than 100 feet; establishing a fact which is fatal to the theory of the parallelism of coal seams.

Between Bellaire and Wheeling the cliff which borders the valley has been so much quarried away that its structure is visible almost at one view. The Pittsburgh coal is here very near the grade of the railroad, and three coal seams are seen above it. A want of parallelism is visible among all of them, but the most conspicuous deviation is seen in the first two seams above the Pittsburgh. The interval which separates these varies locally from twelve to thirty-five feet. Cases similar to those I have cited may be found in every county within the coal basin, but enough have been given to show that our coal seams are never absolutely parallel over any considerable area. That they are sometimes approximately parallel for long distances is true; and this fact serves as an important general guide in tracing them. For passing from one series of outcrops to another, not too far away, when one well-marked member of the series is found we know *about* where to look for the others; but to hold rigidly to the theory of parallelism, and to deny the continuity of all coal seams which do not exhibit uniformity in the distance that separates them, would be to throw our whole system of coals into confusion, and render every effort for their classification abortive.

Although this subject has, perhaps, already occupied more space than it deserves, I venture to call the attention of those who are interested in it to the results of the wide experience in coal geology which has been gained in other states and countries than ours. These will be found in the valuable papers of Prof. Dawson, contained in his "Acadian Geology," the reports of Profs. Worthen and Cox on the geology of Illinois and Indiana, and those of Profs. Rogers and Lesley on the geology of Pennsylvania. I would also specially cite the Report of the British Coal Commission, Vol. I., pp. 121 and 141, and the Memoirs of the Geological Survey of the United Kingdom, Geology of Wigan, by Edward Hall, p. 17.

The economical bearings of this question will also be referred to in the volume of this Report devoted to Economic Geology.

"TROUBLES" IN COAL SEAMS.

Faults in which the displacement amounts to more than one foot are very rare in the Ohio coal field. Smaller ones are not at all uncommon, and almost every coal mine of any considerable extent will show one or more. These are in all respects except dimensions exact copies of the great faults by which the coal strata of England are so much broken up. The coal is frequently found cut by them more smoothly than it could be done by art, since the sides of the fault are often beautifully polished, and present the glazed and striated surfaces which are technically called *slickensides.* Occasionally the slickensided faces are not in apposition, but a "clay seam" of greater or less thickness is interposed between them.

The most considerable fault which has come to my knowledge in Ohio is one mentioned by Prof. Stevenson. This occurs in Coal No. 8, at Neff's Siding, in Belmont county. Here the down-throw is about three feet. The peculiar polished surface so often exhibited by the sides of the fissure in a fault which cuts through a soft and friable coal has excited considerable wonder and speculation among miners. The laminæ of the coal are generally curved downward on one side and upward on the other, and they are blended together as though by the action of heat. The whole aspect of the slickensided surface is such as would naturally lead one to suppose that the coal had been fused along the line of fracture, and yet it is quite evident that it has been affected by no greater degree of heat than that excited by friction; and it is not even certain that heat has had any agency in producing slickensides in coal or other rocks. That a soft coal fractured without heat should not have been crushed and pulverized, appears at first sight somewhat remarkable; but it should be remembered that it has been held, as it were, in an immense vise, and that the masses on the opposite side of the fracture have been pressed together with incalculable force. This has not only held the particles in close juxtaposition, but has condensed and compacted them. By the action of a powerful hydraulic press, many substances reduced to a fine powder can be rendered as dense and hard as stone or ivory. Such pressure, combined with motion, has, as I conceive, produced the polished surfaces called slickensides.

Horsebacks.—This name is somewhat vaguely applied to obstacles encountered in mining. In coal mines it is generally used to designate a mass of rock which rises from the bottom, or (much more frequently) comes down from the roof and cuts out the coal. The "horsebacks," which consist of swells of the bottom, usually represent knolls or ridges in the coal marsh, on which little or no peat accumulated. In some cases, also, the pressure of superincumbent rock seems to have partially squeezed out the softer carbonaceous sheet over a ridge or swell of resistant material underlying it. Such cases are, however, extremely rare. Nearly all the "horsebacks" met with in our coal mines have been produced by currents of water, which have more or less completely cut away the coal, and have deposited in its place sand, afterward hardened into sandstone. When, however, the current which produced the excavation did not carry sand, the channel was filled with a finer sediment, now forming shale or fire-clay.

Sometimes a sheet of rock is encountered in working a coal seam, which evidently consists of material washed into a fissure that was at one time opened through the coal and associated strata. Where this material was sand, we now find a wall of sandstone—perhaps a foot or more in thickness—and this is also, though improperly, called a horseback. Where clay was deposited in the fissure, this forms what is known as a "clay seam," a troublesome but not serious impediment in mining. As might be expected, these sheets of clay and stone very frequently occupy the space between the walls of a fault.

Duplication of Coal Seams.—We occasionally hear of a coal seam suddenly swelling to two or three times its normal thickness. Two marked instances of this kind have come under my observation. Both of these are in Coal No. 5, in Tuscarawas county—one in the mine of Mr. Holden, at Mineral Point, the other on the lands of the Zoar Community, two miles west of the village of Zoar, and five miles distant from the first-mentioned locality. The normal thickness of Coal No 5 in this region is three and a half to four feet, but along the line of disturbance it is found to be entirely removed over a narrow belt, and on the south side of this it is thickened to nine or ten, and even, in one place, to thirteen feet. Here it is plain that the phenomena were produced by lateral pressure, by which the coal was slipped from the fire-clay and pushed over on to an adjacent belt, where it is, of course, doubled in thickness. These interesting cases will be described more in detail in the report on Tuscarawas county.

Bowlders in Coal Seams.—Quite a number of bowlders of rock foreign to the localities where found have been met with in the coal seams of Ohio. One of these is mentioned by Prof. Andrews in the Report of Progress for 1870, p. 78. It was a rounded bowlder of quartzite, seventeen inches in its longer and twelve inches in its shorter diameter, and was found partially imbedded in the surface of the Nelsonville coal, at Zaleski. Another bowlder was found by myself in the blackband iron ore, which forms a parting in Coal No. 1, at Mineral Ridge, Mahoning county. This was some four inches in diameter, angular, and not rounded, and was composed of talcose slate.

These and similar stones found in the coal I have supposed were entangled in the roots of trees, and thus floated and dropped. The blackband ore which contained the bowlder found in Mahoning county is simply a highly ferruginous, bituminous shale or cannel, which marks a local and temporary submergence of the marsh where Coal No. 1 was forming. This is proved by the fact that the blackband is full of the shells of *Estheria*, a bivalve, aquatic crustacean. We know that at the time of the formation of Coal No. 1 rivers flowed down from the north into the coal basin, and there is little doubt that a tree uprooted on the banks of one of these streams carried with it a fragment of the rocky ledge on which it grew. Floating trees, holding stones in their roots, are often noticed in our great rivers at times of flood; and I have seen a mass of gold-bearing quartz taken from the alluvial deposits of the Mississippi, near Memphis, which must have been brought from Wyoming or Montana in the way I have described.

On the preceding pages I have reviewed the geological structure of our portion of the Alleghany coal field. The subject is one of considerable interest, and it has been treated somewhat in detail, and yet it is so suggestive and fruitful that it is necessarily imperfectly presented in this chapter. The reports on the different counties that lie within the coal area are more properly the media through which details of geological structure are described. These are filled with facts which it is hoped will serve to make this sketch somewhat more comprehensible than it would be if it stood alone.

The series of sections of the Coal Measures which I have prepared for publication with this volume will, I think, make it easy to follow the descriptions traced, and it is hoped that they will themselves afford evidence in favor of the truth and fitness of the classification of our coal seams which I have adopted, that will be far more satisfactory and influential than any argument. I think no one can follow with the eye the common elements that run through these sections without being convinced that there is more system and harmony in the structure of our coal field than some of our writers on the subject have been willing to concede.

I should say further, that the economical aspects of the subject now considered—*i. e.*, the arrangement, connection, reach, and identity of coal seams, as also their chemistry and technology—will form an important part of the volume on Economic Geology, which, in due course, will follow next in order to those now published.

THE FAUNA AND FLORA OF THE COAL MEASURES.

So much space has already been allotted to the geology of our Coal Measures that little remains for their palæontology. But this is a subject that belongs properly in another volume, and it will be considered there more fully than would be possible in any circumstances here. I shall, therefore, confine myself in this chapter to a few words in reference to the strictly geological bearing of the fossils contained in the Coal Measures.

The question is often asked how far the plant impressions that are found associated in such abundance with the coal strata are characteristic of the different seams; and hence, how far can they be used as means for their identification. This is a subject which has engaged my attention through many years, during which I have collected fossil plants from most of our Coal Measure area and strata. The result of my observations is the conviction that comparatively little use can be made of fossil plants in the classification of coal seams. Many species run entirely through the series, and most are common to two or more coals. With the exception of Coal No. 1, which has a very abundant flora, and one that contains many plants not yet found elsewhere, I know of no one of our coal strata that can be certainly identified by its fossil plants. In a general way, our Carboniferous flora may be divided into three stages, as follows:

1st. The Lower Carboniferous flora, represented chiefly by the remarkable group of fossil plants collected by Prof. Andrews, and described in the Palæontological portion of this Report. This flora has the greatest affinity with the Sub-Carboniferous and Devonian floras of West Virginia described by Prof. Fontaine, and of New York, Maine and Canada, so fully illustrated in the admirable reports of Prof. J. W. Dawson.

2d. The flora of the Conglomerate and Coal No. 1. This comprises probably one-half of all the species of fossil plants found in Ohio. In the Conglomerate the more delicate plants are rarely preserved, as in the coarse sandstones they have been destroyed by the trituration to which they were subjected. Trunks of *Lepidodendron*, *Sigillaria*, *Calamites*, and nuts (*Trigonocarpon*) are, therefore, what we generally find in this formation. In some localities, however, beds of shale, intercalated with the upper layers of the Conglomerate, have yielded me several species of ferns, all of which are identical with those found over Coal No. 1. The flora of the lower coal is, as has been said, exceedingly rich. No careful enumeration of its species has been made, but they amount to not less than one hundred and fifty. This is the special home of the giant lycopods—*Lepidodendron*, *Lepidophloios*, and *Sigillaria*. The number of species of these genera has been greatly multiplied by describing under distinct names different portions of the plant—as root, stem, branches, leaves, and fruit—and also their stages of growth and varietal phases; but we may safely say that three-fourths of all the species of these genera found in Ohio are peculiar to the lower coal. The same is true of the *Calamites*.

and the fruits, such as *Trigonocarpum*, *Cardiocarpum*, and *Rhabdocarpum*. Among ferns this flora is specially rich in *Sphenopteris* and *Hymenophyllites*, of which several new species will be found described in the palæontological portion of this volume. Many well-known species found here may be mentioned—*Sphenopteris latifolia*, Brong.; *S. macilenta*, L. and H.; *S. obtusiloba*, Brong.; *S. Gravenhorstii*, Brong.; *S. Dubuissonis*, Brong.; *S. artemisiæfolia*, Brong.; *S. Newberryi*, Lesq., etc. Of *Odontopteris* the only species I have seen in Ohio—with the exception of a new one that occurs at a higher level—are found with the lower coal. *Alethopteris* is represented by a great number of individuals, the roof-shales in some places being thickly matted with them, but the number of species is small. In Ohio *A. lonchitica*, Brong., is found abundantly in connection with the lower coal, and, so far as my observation has extended, nowhere else. But in Indiana it occurs at a higher level; and in Nova Scotia, according to Dawson, it runs through the entire series. *A. Serlii*, Brong., I have never seen in the flora of the lower coal, but it is found abundantly in some localities over Coal No. 5. The Neuropterids are common in the flora of the lower coal and comprise a number of species, such as *Neuropteris cordata*, Brong.; *N. hirsuta*, Lesq.; *N. acutifolia*, Brong.; *N. tenuifolia*, Sternb.; *N. Loshii*, Brong. *Neuropteris flexuosa*, Sternb., so common with the upper coals, I have never seen in the flora of Coal No. 1. Of *Hymenophyllites* we have *H. furcatus*, Brong., *H. spinosus*, Goep., and several new species. Of the genus *Pecopteris* very few species are found here, as it is much more characteristic of the upper coal flora. Among the commonest is *Pecopteris plumosa*, Brong., one of the most beautiful ferns of the coal flora. As might have been anticipated from the abundance of Calamites in the flora of Coal No. 1, *Sphenophyllum*, *Asterophyllites*, and *Annularia* are found in abundance. *Sphenophyllum erosum* is common, but *Sph. Schlotheimii*, Brong., so far as my observation extends, belongs to the upper flora. The most common *Annularia* is a small one, which has been considered identical with *A. sphenophylloides*, Ung., but it is quite distinct from the variety or species described as *A. brevifolia* by Brong., and which does not occur below Coal No. 4. Perhaps the most peculiar and striking plants of the flora of Coal No. 1 are *Whittleseya elegans*, Newb.; *Antholithes priscus*, Newb.; *Neriopteris lanceolata*, Newb.; *Polysporia mirabilis*, Newb., and the species of *Alethopteris* and *Odontopteris* described in our first volume.

3d. The flora of the Middle and Upper Coal Measures. This begins with Coal No. 4, and is characterized by the great abundance of ferns, and especially of Pecopterids. Here we first find *Pecopteris arborescens*, Brong.; *P. cyathia*, Brong.; *P. arguta*, Brong.; *P. oreopteridius*, etc. *Dictyop-*

teris obliqua, Bunb.; *Annularia calamitoides*, Sch.; *A. sphenophylloides* var. *brevifolia*, Brong.; *Neuropteris flexuosa*, Brong.; *N. Cistii*, Brong.; *N. Grangeri*, Brong.; *Alethopteris nervosa*, Brong.; *A. aquilina*, Brong.; *A. Serlii*, Brong.; *Sph. Schlotheimi*, Brong., with many others not found, so far as my observations have extended, in the lower coal. Most of the species here enumerated run up through the series, and no subdivision of the flora seems to me possible above the line of Coal No. 4. For example, the roof shales of Coal No. 8 at Pomeroy are filled with the same species of plants found over Coal No. 4 in the valley of Yellow Creek, viz., *Neuropteris flexuosa*, *N. cordata*, *Cordaites borassifolia*, *Annularia calamitoides*, *Cyclopteris fimbriata*, *Pecopteris arborescens*, etc.

The upper flora of the Coal Measures is characterized by poverty in *Sigillaria* and *Lepidodendron*—genera which form the most striking features in the lower flora—and by the presence of *Psaronius*, which occurs locally in great abundance over Coal No. 8, but is unknown in the Lower Coal Measures.

The grouping of the coal plants at different horizons is generally a better guide than the presence or absence of individual species. This, however, could only be shown by long lists of names, and most of these would be repeated again and again. Even when, with considerable trouble, the coal plants of northern or southern Ohio had been stratified, it would be found that the grouping made would hold good for only that one locality. This will appear plainly from a comparison of the vertical distribution of the coal plants of Pennsylvania reported by Mr. Lesquereux with that which I have described as prevailing in Ohio. Many of the species which he finds there characteristic of the lowest workable coal, I find here, only at a higher level, and *vice versa*. By reference to the Illinois geological reports—which are enriched by copious descriptions and notes on the coal flora by Mr. Lesquereux—the same discrepancies will be observed; and we must, therefore, conclude that the flora of the Coal Measures, like the fauna, is distributed through the strata in such a way that no well-defined horizons are discernible in it.

The animal remains of the Coal Measure epoch consist for the most part of mollusks, for the reason that they inhabited the water, usually in large numbers, and their structures were mainly hard and imperishable; and thus generation after generation has been buried and preserved in the sedimentary deposits. The molluscous fauna of the Coal Measures has been carefully studied in several of our Western States, and though the collections made in Ohio are large, and they have been passed in review by one of the most learned and accurate of living palæontologists, comparatively little has been found that was new or of special interest.

In the report of Mr. Meek, which forms part of the volume on Palæontology that accompanies this, our Carboniferous mollusks are fully described, and, therefore, no further reference to them is required here.

Of articulates we have found very few. Several crustaceans are described in Mr. Meek's report, and I obtained from the shales over the lower coal in Summit county fragments of a single insect. This was a kind of cricket, of which a description, prepared by Mr. S. H. Scudder, will be found in Part II. of this volume.

By far the most interesting animal remains discovered in our Coal Measures are fishes and amphibians. Of these, the fishes were nearly all described in the volume already published. Since that appeared some interesting additions have been made to our Carboniferous fish fauna, of which the most important is a species of *Ctenodus*, a genus frequently met with in the Coal Measures of Europe, but not before found in the United States.

The amphibians of the Coal Measures are more fully represented in our collections than in all the material which has gathered elsewhere. Prof. Cope has already described twenty-six species of aquatic salamanders from the specimens obtained from the cannel underlying Coal No. 6 at Linton. These are figured and described in the Palæontological volume that accompanies this.

During the past summer I have procured several additional new species from this famous locality, and among others a well-marked *Keraterpeton*, a genus first described by Prof. Huxley from specimens obtained in the Coal Measures of County Kilkenny, Ireland. The species found here is distinct from that of Prof. Huxley, but it is closely allied to it, and is specially interesting as adding another to the list of vertebrate genera common to the Coal Measure fauna of America and Europe.

The large number of species of fishes and amphibians (about fifty) found in one single coal mine at Linton indicates that the vertebrate fauna of the Coal Measures was much richer than has heretofore been supposed. The cannel coal of this locality was undoubtedly deposited in a lagoon of open water in the marsh where Coal No. 6 was formed. How extensive this lagoon was, we have not as yet learned; but all the fossils found there have been taken from an area a few hundred feet in diameter. We have probably now obtained representatives of most of the fishes and salamanders that inhabited this body of water, but certainly not all, for every considerable collection made there has contained something new; and the fauna of the epoch in which this deposit was made must certainly have been very varied, since from this one spot have been taken the remains of fifty distinct species, less than a half dozen of which have been found elsewhere.

This coal mine at Linton may be regarded, therefore, as a kind of loophole through which we see, in all its details, the life of *one locality* in the great world of the Carboniferous age. Looking through that, we have before our eyes a little pool of water swarming with fishes of various kinds, some of them very large, clad in mail and provided with most formidable sets of trenchant teeth; others, small but exceedingly numerous, covered with enameled and highly ornamented scales and plates. These latter, as we learn by coprolitic masses, were the prey of the larger ones.

With the fishes were a large number of aquatic carnivorous salamanders, some of which must have been eight or ten feet in length, and as formidably armed as the larger fishes. Others were snake-like in form, yet several feet in length, bristling with spines, or protected by thick and bony scales. Others still were a few inches in length, very slender and delicate, and, as we know by their mutilated fragments, served as food for the more powerful.

A remarkable circumstance connected with the Linton deposit is this: that in working up some hundreds of tons of the cannel coal which contains the fishes and amphibians, we have obtained not a fragment of an insect, and only a few small and imperfect remains of crustaceans. Mollusks, too, are entirely absent, no shell of any kind being found there, except those of *Spirorbis*, which is thought to have been an annelid. These occur, however, in millions, and we may infer from the multitudes of these delicate organisms that the water they inhabited was quiet, warm, and almost stagnant. Whether salt or fresh, we do not know, but it seems to me most probable that it was fresh.

Very few remains of plants have been found in the Linton cannel, and these, if leaves, are skeletonized, showing their long maceration in water. In this, as in many other respects, the Linton deposit is strikingly different from that of Mazon Creek, Illinois, which has yielded a large number of insects, crustaceans, and plants, and very few fishes and amphibians.

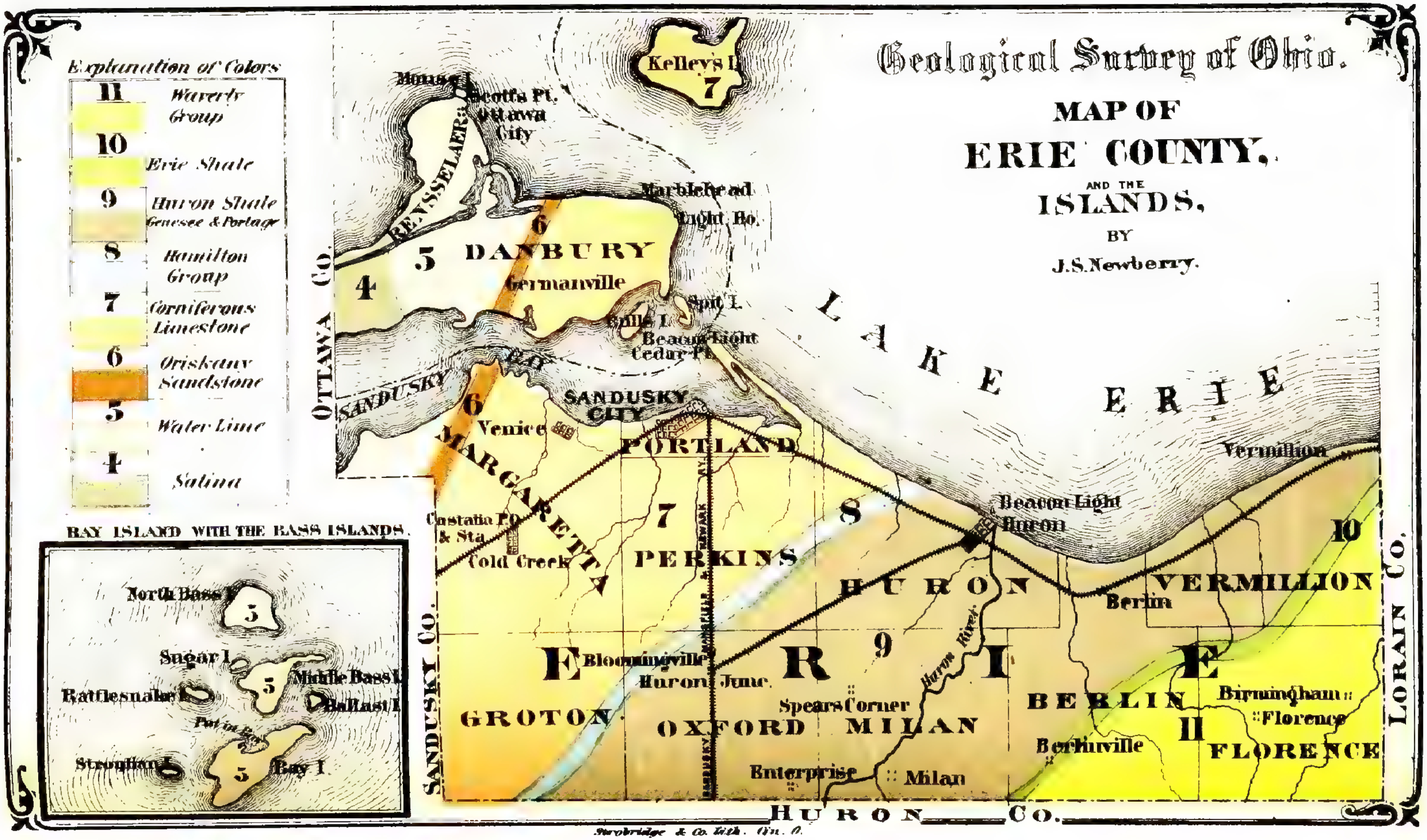
The entire distinctness of the fossils found in the two localities referred to—though they are of nearly the same geological age—further illustrates the richness of the fauna of the Coal Measure epoch, and teaches us that what we see of it, varied and interesting as it is, can give us but a very imperfect idea of the life of the Coal period.

GEOLOGICAL SURVEY OF OHIO.

VOL. II. PART I.

SECTION II.

LOCAL GEOLOGY.


Geological Survey of Ohio.
MAP OF
ERIE COUNTY,
AND THE
ISLANDS,
BY
J.S. Newberry.
Explanation of Colors
11 Waverly Group
10 Erie Shale
9 Huron Shale Genesee & Portage
8 Hamilton Group
7 Corniferous Limestone
6 Oriskany Sandstone
5 Water Lime
4 Salina
BAY ISLAND WITH THE BASS ISLANDS.
North Bass I.
Sugar I.
Middle Bass I.
Rattlesnake I.
Ballast I.
Put in Bay
Strontian I.
Bay I.
Kelley's I.
Mouse I.
Scotts Pt.
Ottawa City
RENSSELAER
Marblehead
Light Ho.
DANBURY
Germanville
Spit I.
Bulls I.
Beacon Light
Cedar Pt.
LAKE ERIE
OTTAWA CO.
SANDUSKY BAY
SANDUSKY CITY
Venice
PORTLAND
MARGARETTA
Castalia P.O. & Sta.
Cold Creek
PERKINS
Beacon Light
Huron
Vermillion
HURON
VERMILLION
Berlin
Huron River
ERIE
Bloomingville
Huron June.
Spears Corner
GROTON
OXFORD
MILAN
BERLIN
Birmingham
Florence
FLORENCE
Berlinville
Enterprise
Milan
SANDUSKY CO.
LORAIN CO.
HURON CO.
Strobridge & Co. Lith. Cin. O.

CHAPTER XXXII.

REPORT ON THE GEOLOGY OF ERIE COUNTY AND THE ISLANDS.

BY J. S. NEWBERRY.

SURFACE FEATURES AND DEPOSITS.

The most interesting features in the surface geology of Erie county are the splendid series of glacial markings inscribed on the Corniferous limestone in and about Sandusky City, the lake ridges which traverse the county from east to west, and the remarkable petrifying fountains, known as the Castalia Springs. The first two of these are but local exhibitions of phenomena which are wide-spread, and are the results of causes which, in their general action, are considered in a special chapter devoted to Surface Geology. The features to which I refer will, therefore, be only briefly described in this sketch, as the manner in which they have been produced will be better understood by referring to the fuller exposition of the subject given in the chapter cited.

In its topography, Erie county is without any strongly marked features. The surface, to the eye, seems nearly level, while, in fact, it forms a gentle slope from the south line of the county, where it has an elevation of 150 feet above the Lake to the lake level. This monotony of surface has been produced by the planing action of the great glacier that excavated the basin of Lake Erie; not only that basin which now holds the water, but the greater one of which the southern boundary is the watershed between the Lake and the Ohio. Erie county, therefore, lies near the bottom of this greater basin, and the great ice mass which filled it, moving from the north-east to the south-west, ground down the underlying rocks to a nearly uniform surface. The outlines of the lake shore have been apparently determined by the same great cause. The general bearing of the south shore of Lake Erie is essentially the same from near Buffalo to the mouth of the Huron river. There the coast line forms a large angle with its former course, and stretches, with only local variations, directly from Huron to the mouth of the Maumee. By a glance at this map, however, it will be seen that the west end of Lake Erie is blocked up with islands, and that a series of these islands stretches northward from Sandusky and forms a barrier which must have offered serious opposition to the westward movement of the glacier. The origin of the islands in Lake Erie is more fully discussed in the report on Ottawa county than it can be here, and it is there shown that they are the remnants, or rather most projecting portion of the barrier to which I have alluded, and that this barrier was formed by the arch of the strata, known as the Cincinnati axis, and described in detail in the first volume of the report. The effect of this ridge, thrown across the lake basin and struck obliquely by the moving ice mass, was to deflect that slightly to the south, and to cause it to cut the deep notch in the lake shore at the mouth of the Huron. The excavation of this point was also facilitated by the comparative softness of the Huron shale which underlies this portion of the county. Sandusky Bay is unquestionably one of the channels cut in the Cincinnati arch by the glacier moving westward, and it corresponds topographically with the channels between the islands from the north, all of which are shallow and are cut by the ice out of the solid rock. It is possible that the location of the Sandusky Bay channel was determined by the course of Sandusky river in former times. As is shown elsewhere in this report, we have abundant proof that Lake Erie was once a valley traversed by a river which now passes Detroit and flows over the falls at Niagara. At that time Sandusky river was a tributary, joining the main stream somewhere north and east of its present outlet, and it may have formed a valley in this part of its course, which was broadened and deepened by the subsequent glacier. The inscription made by the great Lake Erie glacier is very distinctly shown in many localities in Erie county, but especially on the Corniferous limestone in and about the city of Sandusky. Here the grooves and scratches which indicate the direction of motion in the ice mass are about S. 80° W., or nearly coincident with the major axis of the Lake. All the chief furrows correspond closely in bearing with those so conspicuous on the islands, and were evidently formed by the same ice mass. Another set of scratches are, however, seen upon the rock in some places. These have a north and south bearing, and were produced, as I have supposed, by the great glacier that excavated the basin of Lake Huron.

The Drift deposits which overlie the glaciated surface in most parts of the State have been removed from the greater part of Erie county. The bowlder clay is, however, found covering the rock surface in the southern part of the county. This is, as usual, a blue, or where exposed and its iron oxidized, reddish-yellow, unstratified clay, thickly set with angular fragments of shale taken from the lake basin. With these are more or fewer, generally small, bowlders, usually ground and striated, derived from the crystalline rocks north of the lakes. In this part of the county are also found beds of sand and the lake ridges which rest upon the bowlder clay. These latter deposits are evidently the effect of shore waves, and are in fact old beaches formed when the Lake stood much higher than it now does. A good illustration of the mode of deposition of such sand banks and ridges is seen on the lake shore between Cedar Point and Huron. Here the mouth of Sandusky Bay is partially closed by a ridge thrown up by the waves which will ultimately dike out the Lake from and reclaim a large area formerly covered by navigable water. The lake ridges which are found at different elevations, running parallel with the lake shore through many counties of northern Ohio, are popularly called "lake ridges," and no better proof of the truth of the theory of their origin implied in this name could be asked than the example I have cited. Between the ridges and sandhills which stretch east and west, north of Prout's Station, is a surface level to the eye formed by a fine black soil, which covers the limestone here presenting a remarkably level surface, and nowhere deeply buried. This district was originally prairie, with islands of timber, and has proved the most fertile and productive portion of the county. The origin of the peculiarities of this district—its monotony of surface; the absence of Drift deposits; its sheet of fine, largely organic soil, and its prairie character—though so striking, are, it seems to me, not difficult of explanation. We have here a broad surface of limestone planed down nearly as level as a house floor. This was doubtless once covered with Drift clay, but this has been removed by the waves of the Lake when they swept over it. Subsequently, when the water of the Lake had been withdrawn, this tract was left in a condition similar to that of the upper end of Sandusky Bay, or to that of the space behind the barrier east of the city, viz., covered with shallow, quiet water, which was gradually replaced by a fine sediment, mixed with the remains of the luxuriant vegetation that grew there. The result was a sheet of remarkably fine, rich soil, having all the characteristics of the prairie soils of the West, and, like them, covered with a growth of grass rather than trees. In future ages, when Lake Erie shall be further drained, what is now Sandusky Bay will undoubtedly present nearly the same appearance as the district under consideration. As the facts observable in this locality have a bearing on the theory of the origin of prairies, they are referred to in the notes on this subject, Vol. I., Pt. I., p. 26, of this report.

Castalia Springs.—The phenomena presented by Castalia Springs have excited considerable curiosity and interest, both on the part of residents of the county and of visitors from other States, and deserve a few words of description and explanation. As is known to most persons, at Castalia a volume of water which forms quite a river flows up from several deep orifices in the limestone rock, and supplies in its descent to the Lake the motive power for several mills. The water maintains nearly the same temperature winter and summer, and its flow is more uniform than that of surface streams in the vicinity, though sensibly affected by periods of unusual and wide-spread drouth. The water of the springs is highly charged with lime, rapidly incrusting any object covered by it, and it has deposited a sheet of travertine over an area of several square miles in the vicinity. The rock in which the subterranean channels are excavated, through which the waters of the springs flow, is the Waterlime, the uppermost member of the Silurian system. This is a magnesian limestone, in fact, a typical dolomite, containing about forty-two per cent. of carbonate of magnesia and fifty-five of carbonate of lime. This rock forms on the surface an unbroken sheet, reaching from Castalia to Logan county, the highest land in the State. The true theory of the formation of these springs is simply this: the Helderberg limestone, like many others, is soluble in atmospheric water containing carbonic acid It forms the slope of the watershed, and the drainage of the country south from Castalia, passing over and through it, has dissolved out a connecting system of channels which are really subterranean rivers. Castalia Springs are formed at the mouth of one of these. Similar springs and underground streams are met with in all limestone countries. The table-land of central Kentucky affords innumerable examples of them. This plateau is underlain by a thick mass of unusually soluble limestone. The surface water dissolves it away so easily that it enlarges every crack it penetrates, and has formed a connected system of underground channels by which all the drainage of the country is effected. The celebrated Mammoth Cave is only one of these channels. Along the margin of this plateau there are a great number of fountains like Castalia Springs, which mark the mouths of the subterranean streams that have been described. Such fountains are also common in other countries, and the classical Clitumnus bursts out at the foot of a limestone mountain, forming a fountain precisely like that of Castalia.

GEOLOGICAL STRUCTURE.

The section of the rocks underlying Erie county is, in descending order, as follows:

		Thickness.
1.	Berea grit	60 feet.
2.	Bedford shale	75 "
3.	Cleveland shale	50–60 "
4.	Erie shale	50 ? "
5.	Huron shale	300 "
6.	Hamilton limestone	20 "
7.	Corniferous limestone	100 ? "
8.	Oriskany sandstone	0–5 "
9.	Waterlime group	100 ? "
10.	Onondaga salt group	30–40 "

In the oil well bored at the mouth of the Vermilion river, the Niagara limestone, the Clinton group, and Medina sandstone were penetrated, but they nowhere come to the surface within the limits of the county. Of the foregoing strata, the first is the sandstone quarried at Amherst and Brownhelm, of which the outcrop crosses the east line of the county within less than a half mile of the lake shore; thence it sweeps round to the south and west, passing through Berlinville, and a little east of Norwalk, in Huron county. Within the area lying to the south and east of this line the Berea grit underlies most of the surface, but it is very generally covered and concealed by the Drift materials; and it is only where its more compact and massive portions have resisted the action of erosive agents, and these have been left in relief, that it projects above the surface. The hills in which the Amherst and Brownhelm quarries are located, and the elevation known as Berlin Heights, are all masses of this character. They were once bluffs upon the shore of the Lake, and every where show marks of the action of water and ice. Along the outcrop of the Berea grit its softer portions have undoubtedly been most extensively eroded, and are now deeply covered by Drift deposits, so that probably little of this portion of the area it occupies will furnish valuable quarries of building stone; but as the surface rises and the rocks dip toward the south and east it soon passes below the surface, and there is every probability that within the townships of Berlinville, Lawrence, and Vermilion, the Berea grit will hereafter be quarried in many localities precisely as it now is at Berea.

So far as we can judge from the exposures of this rock in Erie and Huron counties, it becomes more shaly toward the south, passing gradually into the soft ochery sandstone which represents it at Ashland, Mansfield, and further south.

Bedford Shale.—Below the Berea sandstone is a bed of shale forty to sixty feet in thickness, which is sometimes blue or banded in color, but more generally red. This red shale is conspicuously shown in the valley of the Vermilion, and is exposed at many places in this section of the State immediately underlying the Berea sandstone ; it may, therefore, serve as an important guide to those who are seeking for the excellent quarry stone furnished by that formation. Neither the Berea sandstone nor the red shale have in Erie county furnished any fossils ; but at Elyria, Lorain county, and at Berea and Bedford, Cuyahoga county, a large number of remains of mollusks and fishes have been taken from these strata.

Cleveland Shale.—Under the red shale in the banks of the Vermilion occurs a black, bituminous shale, here sixty or more feet in thickness. This is a constant member of the Waverly or Lower Carboniferous group, and forms the base of that series. It is unusually well exposed in the vicinity of Cleveland, and I have therefore called it, for convenience sake, "the Cleveland shale." In its lithological characters this shale is hardly to be distinguished from the great black shale (the Huron shale) which is a member of the Devonian system, and which here lies only a little below. Further east, however, they are separated by an interval of several hundred feet, and the fossils which they contain are widely different. In the Cleveland shale are bones, scales, and spines of fishes of small size and of Carboniferous types. In the Huron shale, on the contrary, we find the remains of fishes of enormous size, of most peculiar structure, and such as clearly belong to the Old Red Sandstone fauna so fully described by Hugh Miller.

Erie Shale.—The lake shore from the Pennsylvania line to Erie county is, for the most part, formed by a series of green and blue shales, which represent the Chemung and Portage rocks of New York, and belong to the Devonian formation. These shales thin out rapidly westward, and cease to be recognizable beyond the point under consideration. In the valley of the Cuyahoga they are exposed to the depth of one hundred and forty feet, and have there yielded the most characteristic fossils of the Chemung.

The upper layers of the Huron shale are interstratified with the lower ones of the Erie in the north-eastern portion of the State, as we learn by borings made at Cleveland and further east. Some traces of this interlocking may be seen at Monroeville, where the well sunk at the railroad station cuts some blue as well as black shales. South of this point, however, the Erie shale has not been recognized, and it probably reaches but a little way back from the lake shore.

Huron Shale.—This is a name we have given to the great mass of black shale designated by the first Geological Board as "the black slate," and of which the outcrop forms a belt which extends entirely across the State, from Erie to Scioto county. This is the shale which forms the banks of the Huron river at Monroeville and below. It is not here a homogeneous black shale, as there are some gray, argillaceous layers interstratified with the more carbonaceous portions. The greater part of it is, however, black, and highly bituminous, containing ten per cent. or more of combustible matter. From this bitumen, by slow spontaneous distillation, petroleum is evolved, and flows out in oil springs at a great number of localities. The process of distillation also gives rise to the gaseous hydro-carbons, and gas springs are even more abundant than oil springs over the outcrop of this formation.

The Huron shale in some places contains many concretions of impure limestone, of which hundreds may be seen at Monroeville, where they have washed out of the river banks. These concretions are sometimes almost absolutely spherical; and because of their geometric regularity they have been collected as objects of curiosity by the inhabitants of the vicinity—often serving as ornamental caps to gate-posts, etc. Some of these concretions contain the bones or teeth of huge fishes, first discovered in the same formation at Delaware by Mr. Hertzer, and, from its formidable character, called *Dinichthys* (terrible fish).

Two species of this genus have been found in Ohio—one at Delaware, near the base of the Huron shale, and named after its discoverer, *Dinichthys Hertzeri;* the other from the summit of the formation in Sheffield, Lorain county, and this I have named *Dinichthys Terrelli*, to commemorate the services rendered to science by Mr. Jay Terrell, to whose zeal and intelligence we owe all the best specimens yet obtained. Both these remarkable fishes will be found described in the palæontological portion of this report. Numerous fragments of the great bones of *Dinichthys* have been broken out of the concretions which have fallen from the shale banks of Huron river, but the specimens yet obtained from these are too imperfect to show to which species they belong. Little effort has been made to collect at this point, and it is probable that careful search would be rewarded by the discovery of some specimens of great interest.

As nearly as we can determine, the thickness of the Huron shale in this part of the State is about three hundred feet.

Hamilton Group.—At Prout's Station and Deep Cut, on the Sandusky, Mansfield and Newark Railroad, the base of the Huron shale is exposed, and beneath it are seen layers of light, cherty, and bluish, marly limestone, which are the representatives of the Hamilton group of New York. Here the formation has become insignificant in dimensions, compared with what it is further east; for it is not more than twenty feet in thickness, while in central New York the Hamilton group is twelve hundred feet thick. There is no mistaking the equivalence of these strata, however, for they are full of fossils. At Prout's Station the following species are found, viz.: *Spirifera mucronata*, *Cyrtia Hamiltonensis*, *Strophodonta demissa*, *Athyris spiriferoides*, *Heliophyllum Halli*, *Phacops bufo*, etc., etc., the most characteristic fossils of the Hamilton.

The Hamilton beds mentioned above are not always present; as at Belville, the Huron shale may be seen resting directly upon the Corniferons limestone, here presenting the lithological characters of the Sandusky quarry stone, and containing great numbers of *Strophodonta hemispherica* and other well-known Corniferous fossils.

From the softness of the Hamilton limestone in Erie county, as well as from its inconsiderable dimensions, it forms no well-marked line of outcrop, but it will be often detected in sections which include the base of the Huron shale and the top of the Corniferous limestone. It may be said to underlie a *very* narrow belt of territory, extending south-westerly from the lake shore, at a point half way between Sandusky and Huron, to the Lake Shore Railroad, midway between Monroeville and Bellevue.

The section exposed at Deep Cut is as follows:

1. Huron shale; base.
2. Hamilton limestone, ferruginous and cherty, with crinoids (*Ancyrocrinus*, etc.) and corals.. 10 feet.
3. Hamilton marl, with *Phacops bufo*, *Spirifera mucronata*, *Cyrtia Hamiltonensis*, *Athyris spiriferoides*, etc.; base not seen .... 20? "

The Corniferous limestone appears on lower ground near, but the connection is not seen.

Over the outcrop of the Hamilton cherty limestone a lake ridge is seen, with a nucleus of unworn blocks, chiefly of Hamilton limestone. The railroad has here an elevation of 135 feet above the Lake; the ridge is 145 to 150 feet. Broken ridges and knolls of sand, evidently one of the old lake beaches, form a distinct belt in this vicinity.

Corniferous Limestone.—The most interesting, and perhaps the most important, formation in Erie county is the Corniferous limestone. This is the rock underlying Sandusky City, that which forms Marblehead, Kelly's Island, Middle Island, etc.; the source from which the greater part of the lime used in northern Ohio is derived, and a rock scarcely less extensively employed as a building stone than the Berea grit. The upper portion of the Corniferous limestone is blue in color, and lies in thin strata. It is this subdivision of the formation that is opened in the quarries at Sandusky, and which furnishes the blue limestone known as the "Sandusky stone," and largely used for building, paving, and flagging at Sandusky and elsewhere. The lower portion is light-colored, and much more massive, and is that quarried at Kelly's Island and Marblehead. The fossils of the Corniferous limestone are exceedingly numerous and of great interest. Like most other limestones, this has been derived from the decomposition of organic structures, and in many places it is almost altogether made up of corals and shells. In chemical composition it is a magnesian limestone, containing twenty per cent. or more of magnesia. This peculiarity has been quoted as objectionable in its adaptation to the manufacture of lime; but, on the contrary, it is benefited by this ingredient, the magnesia making it slower in setting, "less hot," as the masons say, and therefore much more manageable.

The Corniferous limestone has been so fully described in the first volume of our report, both as regards its physical characters and fossils, that little need be here said of its general relations. It is proper, however, that I should here refer to the views advanced by Prof. Winchell in the reports on Delaware and Paulding counties, and which are not quite in accordance with those I have expressed in regard to the age of the upper, or Sandusky, member of the Corniferous limestone. It is claimed by Prof. Winchell that because it contains certain mollusks that are usually called Hamilton fossils, such as *Cyrtia Hamiltonensis*, *Spirifera mucronata*, and *Athyris spiriferoides*, it must necessarily be Hamilton; but with the exception of *Spirifera mucronata*, which I have never found in the formation except at its very summit, all the other Hamilton fossils found in the Sandusky limestone are such as are also found in the Corniferous of New York, and therefore they constitute no reliable evidence of the Hamilton age of the deposit. On the contrary, the Sandusky limestone contains quite a large number of fossils which are not only common in the lower, or Kelly's Island, subdivision of the Corniferous, but are regarded as characteristic fossils of the Corniferous in New York, and are not found in the Hamilton. We also have in the Sandusky limestone all the remarkable fossil fishes—alluded to further on, and more fully described in our palæontological reports—which form the most striking features of the fauna of the Lower Corniferous (Kelly's Island and Columbus) limestone. None of these have ever been met with in the Hamilton of New York. The Corniferous mollusks alluded to above as found in the Sandusky limestone are *Spirifera acuminata*, *S. gregaria*, *S. macra*, *Pentamerus aratus*, *Strophodonta hemispherica*, *Tentaculites scalaris*, etc. Of these, only the first has ever been found in the Hamilton, and this, perhaps, but in a single instance in New York, while it is locally nearly as abundant in the Sandusky as in the Kelley's Island limestone.

The insufficiency of the evidence upon which the conclusion is based that the Sandusky limestone belongs to the Hamilton group will be seen from the range of most of the fossils which form this evidence. For example, *Cyrtia Hamiltonensis* is found throughout the Corniferous, Hamilton, and Chemung. The same is true of *Atrypa aspera*. *Atrypa reticularis* ranges from the Clinton to the Chemung. *Athyris spiriferoides* is found throughout the Corniferous and Hamilton groups. I should also say that *Cyrtia Hamiltonensis* occurs in abundance at Sylvania, at the very base of the Corniferous group, and I have well-marked specimens from that locality obtained by Mr. Gilbert in limestone that was somewhat interstratified with the Oriskany.

This subject will be found discussed more at length in Vol. I., Part I., pp. 144–149, and the reader is also referred to the reports on Delaware and Paulding counties by Prof. N. H. Winchell, contained in this volume, and to that of Mr. S. K. Gilbert on Lucas county, Vol. I., Part I., p. 576.

The fossil fishes of the Corniferous limestone have attracted more or less attention from geologists for many years. They are now chiefly obtained from the quarries on Kelly's Island and Marblehead, in the Lower Corniferous limestone; in those of Sandusky and Delaware, from the upper member, or Sandusky limestone. My attention was first called to them by Dr. E. S. Lane, of Sandusky, as early as 1850. Since then a great number of fine specimens have been obtained from the Sandusky quarries by Dr. Lane, Dr. A. H. Agard, and Mr. L. P. Wheelock. These represent quite a number of genera and species, which are figured and described in the palæontological portions of this and the preceding volume. The following is a list of such fossil fishes as have been found at Sandusky and on the islands:

Macropetalichthys Sullivanti	Newb.
Onychodus sigmoides	"
Machæracanthus major	"
M. peracutus	"
M. sulcatus	"
Rhynchodus pangeus	"
R. secans	"
R. crassus	"
Asterosteus stenocephalus	"
Acanthaspis armatus	"
Acantholepis pustulosus	"

Of these, the first two are the most common and conspicuous, and will be recognized from a few words of popular description by all who have seen collections of fossils taken from the Sandusky limestone.

Of *Macropetalichthys* the only portion yet found is the cranium. This is composed of a number of geometrical plates of which the external surface is beautifully tubercled. It is known to most of the quarrymen, and by them it is generally regarded as the carapace of a turtle. It is, however, in fact, the cranium of a large fish, as any one will plainly see if they will take the trouble to compare with it the cranium of our common sturgeon. No teeth have been found connected with the cranial bones of *Macropetalichthys*, though many heads apparently complete have been discovered. I have, therefore, been led to conclude that, like the sturgeon, this fish was toothless.

Onychodus was an equally large fish, of which the cranial bones were much more numerous and easily separated, so that they are generally found detached and scattered through the rock. The jaws of this fish are not unfrequently met with. They are a foot or more in length, and are studded with teeth along the upper margin. The most singular feature in the structure of this fish is formed by a crest of seven large, curved, pointed teeth, which, attached to an arch of bone, were inserted between the extremities of the under jaw, apparently acting like the prow of a ram. These teeth are quite abundant in the Sandusky limestone, the smaller and more curved ones somewhat resembling the claw of some of the cat tribe, a resemblance which suggested the name I have given to the genus—claw-tooth.

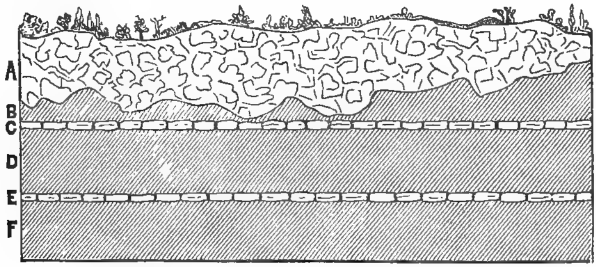
Oriskany Sandstone.—Beneath the Corniferous limestone, on the Peninsula, and near Castalia, a thin band of sandstone is visible. This holds the position of the Oriskany sandstone in New York, and though it has here yielded no Oriskany fossils, they are said to have been obtained from it in Indiana; and there is little doubt, therefore, that it should be regarded as the equivalent of the Oriskany sandstone.

Waterlime.—The upper portion of the Silurian system is, in Ohio, represented by the Waterlime and Salina formations. Of these, the Waterlime is the uppermost and by far the most conspicuous. It underlies a larger portion of Ohio than any other formation except the Coal Measures. It composes all of Catawba Island, Put-in-Bay, and the other islands of that group. Erie county just reaches the edge of the Waterlime area, and, as has been mentioned, it is in this rock that the subterranean channel is excavated through which flows the stream of water that forms Castalia Spring.

The Waterlime group is probably about one hundred feet in thickness. The upper portion is a nearly pure dolomite, the lower an argillaceous limestone, some of which is well adapted to the manufacture of hydraulic lime.

Salina Group.—The Waterlime is immediately underlain by a series of calcareous shales and beds of gypsum, which apparently represent the Onondaga Salt group of New York. The gypsum quarries worked by Mr. George A. Marsh on Sandusky Bay lie within the limits of Ottawa county, but the same formation extends under Sandusky, where it has been reached in boring wells for oil, at too great a depth, however, to be profitably worked. These beds of gypsum also form the bottom of the Lake off the south point of Put-in-Bay Island, so that they apparently underlie a large area in this vicinity. They deserve to be carefully sought for, as they may be found in localities where they will be readily accessible. From the continuity of the surface clays, this exploration, however, can only be effected by boring. The gypsum of Sandusky is of excellent quality, and the quantity is apparently inexhaustible. About ten thousand tons per annum are produced at the quarries of Mr. Marsh.*

* The gypsum occurs at Mr. Marsh's quarries in horizontal strata, of which the upper is covered by Drift clay, has been very much eroded, and its normal thickness is not determinable. This is underlain by a stratum of limestone one foot in thickness, beneath which is another stratum of snowy gypsum six feet in thickness. Below this is another limestone band one foot in thickness, and a third stratum of snowy gypsum, which has been excavated to the depth of about six feet and has not been passed through. The subjoined wood-cut will give a better idea of the deposit than any verbal description:



A. Drift clay, 5–12 feet. D. Snowy gypsum, 6 feet.
B. Snowy gypsum, 0–5 feet. E. Limestone, 1 foot.
C. Limestone, 1 foot. F. Snowy gypsum, 6 feet.

The bands of limestone interstratified with the beds of gypsum in the above section afford conclusive evidence that the gypsum was not produced by the action of acidulated waters on limestone. This theory of the genesis of gypsum has been advocated by high authority, but all the great deposits which I have seen were certainly not formed in this way, but rather by precipitation from basins of water charged with salt, sulphate of lime, etc.

ECONOMIC GEOLOGY.

The mineral staples of Erie county consist of—

1st. *Building Stone.*—No portion of the State is more abundantly supplied with excellent building materials than that immediately about Sandusky. The Amherst sandstone, which is known, and I can almost say used, all over the United States, reaches into Erie county, and, though not yet quarried there to any considerable extent, may perhaps become hereafter an important contributor to the wealth of the inhabitants.

The Sandusky limestone is also highly prized as a building material, and its capability of supplying suitable stone for large and handsome structures is illustrated in the splendid high school building and various other edifices at Sandusky, as well as churches, stores, and residences at Toledo, Cleveland, etc.

The quarries of the Corniferous at Marblehead and Kelly's Island are in Ottawa county, but the strata worked there underlie all of Erie county, and may be reached at various points with little trouble. The same beds of the Corniferous furnish quick-lime not inferior in quality to any manufactured in the State, so that lime may be specified as one of the important mineral staples of the county.

For certain purposes a carbonate of lime is required purer than that furnished by the Corniferous limestone. This may be supplied in abundance by the travertine from Castalia Springs, of which I give two analyses made by my assistant in the School of Mines, Mr. G. L. Baxter:

	1.	2.
Silica	0.075	.110
Sulphate of baryta	.356	......
Alumina and iron	.362	.102
Carbonate of lime	97.726	92.410
" magnesia	1.481	2.853
Water and loss	....	4.525
Total	100.00	100.00

2d. *Oil Shales.*—The carbonaceous matter contained in the Huron shale is equivalent in heating power to that of a thick seam of coal, but up to the present time we have not discovered any mode of making that source of power available except by distilling oil or gas from it. Both these useful substances are constantly being evolved from this great carbonaceous mass by spontaneous distillation, and it is possible that they may be hereafter, when the supply of petroleum from wells has failed, artificially generated from this source so cheaply as to pay a profit to the manufacturer. It is also worth remembering that further east along the Lake shore, as at Erie, Pennsylvania, and Fredonia, New York, the spontaneous flow of carbureted hydrogen gas from the Huron shale has been extensively utilized. Fredonia was for many years exclusively, and still is partially, lighted by natural gas, and at Erie wells sunk for the purpose are supplying combustible gas which is being successfully applied to the heating and lighting of residences and manufacturing establishments.

The gypsum and hydraulic lime of the Waterlime and Salina groups should, perhaps, be enumerated among the mineral resources of Erie county, as, though not found upon the surface, they lie not far below. The quantity and accessibility of these materials are, however, yet so much in doubt that no one would be justified in anticipating a great increase in the wealth of the county from this source.

In concluding this report, it affords me pleasure to acknowledge my obligations to Dr. A. H. Agard, Mr. L. P. Wheelock, and Hon. D. C. Richmond, for valuable assistance rendered in my explorations of the county.

GEOLOGY OF THE ISLANDS IN LAKE ERIE.

Although forming part of two counties, the islands in Lake Erie constitute a group which it has been more convenient to study together, as, topographically, they are dependent on a common cause, and, geologically, are so closely connected as to be best considered in one view.

The number of islands in the west end of Lake Erie is considerable, and they are scattered over an extensive area. All the larger ones, however, are so closely approximated as to be visible from a single standpoint. The largest of all these islands is Point Pelé, of which the area is about 11,000 acres; the next largest, Kelly's Island, contains about 3,000 acres; Put-in-Bay Island, 1,500 acres. North and Middle Bass Islands, Sugar Island, Middle Island, Rattlesnake Island, Ballast Island, Gibraltar, Green Island, and Starve Island, are all much smaller. Middle Island and Point Pelé Island lie north of the Canadian line. All these islands are formed out of the solid limestone rock, apparently by glacial action, and are separated by channels of no great depth, of which the rock bottoms (when they are not covered with Drift clay), like the islands themselves, every where bear the inscription of the ice masses which once moved over them.

A deep channel connects Lake Huron with Lake Erie, now for the most part concealed by Drift clays with which it is filled. Just what the outlines and depth of this channel are, has not yet been correctly ascertained; but the borings made for oil at Enniskillen and Bothwell, in Canada West, show that the clay which occupies it has in some places a depth of two hundred feet. Borings made at Detroit show that a mass of Drift material underlies the city to the depth of more than one hundred feet below the surface of Detroit River. This deep channel apparently connects with the basin of Lake Erie north of the islands that have been mentioned, and south of it all the western portion of the Lake is comparatively shallow. Here and there masses of limestone project above the surface, and form, beside the group of islands already mentioned, the East, West, and Middle Sisters, the Hen and Chickens, etc. The surfaces of all these islands are plowed and furrowed, and afford, perhaps, the most conspicuous examples of glacial markings to be found in the country.

Most of these glacial furrows have a bearing nearly coincident with the longer axis of Lake Erie, showing that the ice masses by which they were formed moved in that line. The evidence is no less conclusive that the motion was from the east end of the Lake toward the west. This is shown by the general contour of the islands, their eastern sides being more sloped and cut away than the western, and not unfrequently masses of rock will be found broken and unworn on the western sides, showing that they were in the lee of the moving mass of ice. The direction of the movement is, however, still more distinctly shown on those portions of the glaciated surface which contain masses of flint. These have resisted the ice action to a greater degree than the surrounding limestone, though they are found more or less worn or broken on their eastern sides, while a longer or shorter trail of limestone shows the protecting power of the flint. Beautiful examples of this kind are reported by Mr. Gilbert on West Sister Island, and a photograph of a block taken from that island will be copied to illustrate the chapter on the Drift which forms part of this volume. The margins of most of the islands have been more or less cut away by the action of the waves, so that the glacial markings are destroyed or removed; but in a few instances—as on the north side of Kelly's Island and the south of Put-in-Bay—the sides of the rocky masses have been protected from wave action, and still exhibit their original form and character. Here we find evidence that the ice not only passed over every portion of the islands, but molded itself to their sides in such a way as to scar and furrow them quite as distinctly as the level surfaces. In one instance, a perpendicular wall, composed of layers of unequal hardness, has been fluted or beaded like a cornice, and even cut under, so as to present an overhanging shelf planed on its under as well as on its upper side. Such examples afford positive proof that the cutting away of the limestone was effected by glacial and not by iceberg action; and it is impossible that any one should study the surfaces of these islands without becoming a convert to the glacial theory, for every phase of the excavations effected in those rocks over which glaciers have moved is repeated here in all the most striking details.

The reason why the western portion of Lake Erie is so much more shallow than the eastern, and why that portion is studded with islands, is simply this: by a reference to the geological map of Ohio it will be seen that the line of the Cincinnati axis of upheaval passes through the western end of the Lake, and along this axis the rocks are raised up in a great fold, and the solid masses of the Devonian and Upper Silurian limestone come to the surface. East of this arch the surface is underlain for a long distance by soft shales (Huron and Erie) of Devonian age. These have yielded readily to the erosive power of the glacier, and have been cut away to form the principal portion of the lake basin. When the moving ice mass reached the line of the Cincinnati arch it encountered a formidable barrier in the strata of limestone of which that arch is mainly composed. Hence this portion of the lake basin was less deeply excavated, and the most prominent or the most resistant masses of limestone have been left in relief, and now project above the surface of the Lake. It is probable, also, that the channels between the islands are in part due to surface erosion, for we have evidence that all the region about the islands was for a long period entirely above drainage. This is proven not only by the deeply excavated channels of all the streams which flow into the Lake, as Grand River, the Cuyahoga, Black River, the Huron, Portage, Maumee, and so on. All these streams now enter the Lake from one hundred to two hundred feet above their ancient beds, and when they flowed in their now deeply buried rocky channels Lake Erie had no existence as a lake, but was a valley traversed by Detroit River, which flowed north of Point Pelé Island at least two hundred feet below the present lake level, and received the streams I have mentioned as its tributaries. We have other evidence that the country about the islands was once all dry land in the caves upon those islands, which were ancient subterranean water-courses, and are excavated considerably below the lake surface.

SOIL AND VEGETATION.

In most parts of the islands the rocks of which they are composed are covered with a greater or less thickness of Drift clay. This, when exposed to the air, is brown, or chocolate color, from the oxidation of its contained iron, and, like much of the bowlder clay on the main land, is filled with minute fragments of the rocks which have been excavated to form the lake basin, mainly Huron and Erie shale. With these are pebbles—rarely bowlders—of crystalline rock, evidently brought from the north. The clay also contains great numbers of fossils plainly derived from the Hamilton rocks. The most abundant of these is the *Spirifera mucronata*, generally worn and rounded, as though transported some distance from its place of origin. In a few localities, as in the westerly side of Put-in-Bay Island, there are heavy masses of gravel and bowlders, mostly of remote origin, and which, perhaps, deserve to be considered as moraines.

The soil of the islands is partly derived from the disintegration of the underlying rocks, and partly from the Drift clay. It is, therefore, highly charged with lime, and has proved to be so well adapted to the culture of the grape that nearly all the cultivated portions are laid out in vineyards. The success of the grape culture on the islands has also been dependent in part upon the equable climate which they enjoy, and which they owe to the broad expanse of water surrounding them. The summer is longer upon the islands than upon the main land, and frosts are much less likely, in spring and fall, to injure blossoms or prevent the ripening of fruit. The mildness of the climate is also shown by the presence and luxurious growth of many plants which belong to the flora of the southern portions of the State.

In the condition of nature, the islands were covered with a dense forest and undergrowth, from which had accumulated an unusual thickness of humus, and this has given them their extraordinary fertility. Another peculiarity of the islands, depending probably both on the peculiarities of the climate and the calcareous quality of the soil, is the vast numbers of land-shells found upon them. Several species of *Helix*, which are somewhat rare on the main land (*H. solitaria* and *H. multilineata*), occur here in such abundance that the soil in some localities is whitened by and largely composed of their shells.

When first visited by the whites, the margins and many of the more rocky portions of the islands were covered with a dense growth of red cedar. This has been now entirely cut away, largely by plunderers, and nought but the stumps remain to witness to the unusual size of the trees which formerly flourished there. The primeval forest was, however, composed, for the most part, of white oak, and this, when cut away (if the area is not immediately placed under cultivation), is followed by a dense growth of sumach, which attains here greater dimensions than I have elsewhere seen; and it is probable that, from the value of their bark in tanning and their luxuriant growth, these trees might prove a crop scarcely less remunerative than any now raised on the islands. The lower and more level parts of the surface formerly sustained a very heavy growth of maples and hickory, and here, as elsewhere, the first was thickly interwoven by vines of the wild grape, which, by their size and luxuriance, were prophetic of the success that has followed the introduction of cultivated varieties.

KELLY'S ISLAND.

Geological Structure.—Kelly's Island and Middle Island are composed entirely of Corniferous limestone, as they lie in the line of the belt of outcrop of this formation which passes northward through Columbus, Delaware, and Sandusky. Only the lower, or Columbus, division of the Corniferous limestone is shown on these islands—the upper, or Sandusky, limestone having been entirely removed.

On Kelly's Island the limestone has been extensively quarried for many years; and these quarries have been the chief sources of the supply of lime to all the cities on the eastern shore of the Lake. Hardly any lime is manufactured here, but the stone is exported and burned in the immediate proximity of the markets, and where fuel is more abundant. The quarries of Messrs. Kelly, Huntington, Carpenter, and G. W. Calkins are quite largely worked, and have formed the basis of the principal business on the island. The greater part of the stone produced is used for lime and flux in the furnaces of northern Ohio. It is usually sold by the cord, and varies in price from three to five dollars per cord.

The most elevated portion of the island is on the northern side, where a local summit rises to sixty feet above the Lake. Here is a magnificent display of glacial markings, such as deserve especial notice, from the fact that they are inscribed on the vertical as well as on the horizontal surfaces.

Still more interesting glacial grooves have recently been uncovered at the quarry of Mr. Calkins. Mr. J. W. Dunn, foreman of the quarries, has had them photographed, so that though the originals will be soon destroyed, the copies will remain.

The limestone on Kelly's Island furnishes a large number of the characteristic fossils of the Corniferous group, of which examples may be found in most of the collections in the country. Many remarkably fine specimens obtained in the quarries of Mr. Norman Kelly have been carefully preserved by him; and we owe to his intelligence and courtesy a number of those of which figures adorn the plates of the palæontological portion of this report.

Middle Island, as has been mentioned, lies within Canadian territory. It is of limited area (seventy acres), and rises but little above the surface of the Lake. It is, however, a locality of much interest to the geologist, as, in addition to the fine exhibition which it affords of glacial marking, it is, perhaps, the richest in fossils of all the group of islands. The Corniferous limestone here resembles, in its lithological characters and the abundance of its fossils, the exposure at the falls of the Ohio; and here, as there, we seem to be standing on an ancient coral reef. The corals of Middle Island include a large number of species, many of which were of gigantic dimensions. Some of these grew in dome-shaped masses, like the *Astreas* and *Meandrinas* of our present tropical seas. I have seen on Middle Island specimens of *Cyathophyllum rugosum*, *Eridophyllum*, and *Strombodes* ten and even twelve feet in diameter.

All the islands of Lake Erie west of the two I have mentioned are composed of the Waterlime group, and on Put-in-Bay, North and Middle Bass, Rattlesnake, and Green Islands, we have some of the best exposures of this formation to be found in the State. The group of islands which cluster around Put-in-Bay are separated by narrow channels, and seem originally to have formed a single mass. The limestone of which they are composed exhibits evidences of having been lifted and shattered, and the relief of these masses is, probably, in part, due to upheaval. As has been before stated, these islands lie in the track of the Cincinnati arch, and it would seem that there had been some disturbance long subsequent to the original upheaval. The evidences of this disturbance are seen in the irregularity of the bedding of the limestone, and in belts along which it appears to have been completely shattered, and subsequently re-cemented; as in these belts large fragments are not unfrequently seen standing at right angles to their former position, which is distinctly marked by their stratification. It would also seem that along these lines of fracture several thermal springs once arose to the surface, for we here find the interstices of the brecciated rock not unfrequently filled with masses of calc spar, sulphate of baryta, sulphate of strontia, and native sulphur.

We nowhere get upon the island a complete section of the Waterlime group, as its upper portion and junction with the Oriskany and Corniferous are buried in the channel between Kelly's Island and Put-in-Bay. At the southern point of Put-in-Bay Island, however, we have the base of the Waterlime and an exposure of the upper part of the Salina. The section at this point is as follows:

1.	Gray brecciated limestone, massive, and without fossils.......	30 feet.
2.	Cream-colored, thin-bedded limestone	3 to 7 "
3.	Gray brecciated limestone, similar to No. 1, containing immense numbers of *Leperditia alta*....................................	8 "
4.	Thin-bedded, dove-colored, or gray, laminated, earthy limestone, with fossils; used for waterlime..........................	12 "
5.	Blue, earthy, massive limestone, weathering chocolate, without fossils, at lake level	10 "

In the foregoing section the last number belongs to the Salina group, and its surface marks the junction between the Salina and the Waterlime.

Just off South Point the anchors of vessels frequently drag up masses of gypsum, which shows that the Lake bottom is composed of that material. On the Peninsula, eight miles distant, the gypsum comes to the surface, and is extensively worked. Here it is overlain by blue, earthy limestone, similar in character to the limestone exposed on Put-in-Bay Island.

At the northern end of the island last mentioned, the dip being in this direction, higher beds of the Waterlime group are exposed. These are similar in character to those of South Point, viz., massive and brecciated layers, intersected by thin sheets of laminated limestone. These latter, at Peach Point, have furnished large numbers of fossils which serve to identify accurately the formation with the Waterlime of New York. These are, *Eurypterus remipes*, *Spirifer plicatus*, and *Leperditia alta.*

The rock composing Rattlesnake Island, Middle Bass, Sugar Island, etc., is precisely similar to that which forms the mass of Put-in-Bay Island; and, therefore, the geology of those islands requires no detailed description. I should mention, however, that on North Bass there were obtained from a well sunk for water some unusually fine masses of crystallized celestine; and on Rattlesnake Island I procured a large quantity of fluor spar in brown crystals. Green Island also deserves special notice, as it has furnished nearly all the fine specimens of crystallized celestine which have been obtained in this country—much finer, indeed, than are known to exist any where else in the world. The celestine here occurs in masses of many tons weight, filling pockets and fissures in the limestone. This island is a light-house station, and belongs to the United States Government. If possessed by private parties, it is quite possible that the strontian might be profitably worked, to meet the demand for the nitrate of strontia, which forms the red fire of theaters and of pyrotechnical displays. The splendid crystals of celestine obtained from Green or Strontian Island are found studding the walls of cavities. They are sometimes met with as large as one's hand, and almost perfectly transparent throughout.

The cavernous character of the Waterlime group has been referred to in another part of this report. Of this we have striking examples in the group of islands now under consideration, and in the neighboring peninsula and highlands. The surface of Put-in-Bay Island shows a great number of depressions, or "sink-holes," which are nothing else than caves of which the rooofs have fallen in; and it seems probable that nearly the whole mass of the island is honey-combed by subterranean galleries. Several of these have been entered, and two of them constitute the chief curiosities of the island for the numerous visitors who make this a place of summer resort. One of these, "Perry's Cave," as it is called, has special geological interest. It is plainly a subterranean channel of drainage, like most caves in these limestone rocks, which are generally filled with the water of the Lake. The water which stands in this cave is known to have the same level as that of the lake surface without, and it rises and falls with all the temporary oscillations of level which the Lake undergoes. The lower portion of the cave is now completely submerged, and how deeply it sinks, or whither it leads, is not known. The part which is above the water-line was formerly hung with stalactites, and the floor covered with stalagmites, many of which still remain. These, as is well known, are formed by the dripping from the roof of water holding lime in solution, and the precipitation of this lime both on roof and floor. This precipitation could, of course, only take place in air, and would be impossible in a gallery filled with water. But during the last summer the interesting discovery has been made by Capt. John Brown (who resides on the island, and has given much attention to its geology) that the floor of the cave was studded with stalagmites far below the present level of the Lake. This shows very palpably (what is, however, taught by the very existence of the cave) that the lake level was once much lower than at present, and that all that part of the cave which is now under water was once filled with air, through which the water dripped from roof to floor, precipitating its lime, as is now done in the upper portions of the cave.

The limestone of which Put-in-Bay and the adjacent islands are formed, as proved by our numerous analyses, is nearly a typical dolomite—that is, it contains more than 40 per cent. of magnesia. This composition of the stone has been cited as proof that it was unfit for the manufacture of lime; but, as a matter of fact, the lime which is most esteemed in the southern part of Ohio, and in many other portions of the country, has nearly the same composition as that obtained from the Put-in-Bay Island stone. For example, the lime most esteemed in Cincinnati, derived from the Niagara group, and obtained at Springfield, Yellow Springs, and Cedarville, has almost the composition of the Put-in-Bay waterlime, as will be seen by the table of analysis given below. The lime preferred above all others in the city of New York is that manufactured from the Sing Sing marble, which is a typical dolomite, containing—

Carbonate of lime	53.24
Carbonate of magnesia	45.89
Silica and alumina	.87
	100.00

ANALYSES OF THE MASSIVE BEDS OF THE WATERLIME GROUP, PUT-IN-BAY ISLAND, MADE BY PROF. E. W. ROOT.

	1.	2.	3.	4.
Carbonate of lime	42.03	55.40	54.23	63.37
Carbonate of magnesia	41.64	42.37	44.98	32.57
Alumina and oxide of iron	0.40	0.30	0.56	0.40
Insoluble residue	0.30	0.29	0.74	0.33
Loss by ignition	1.81	1.15	0.35	0.68
	98.18	99.51	100.86	97.36

Analyses of Hydraulic Layers of Waterlime from South Point, Put-in-Bay, by Dr. H. Endemann.

	1.	2.	3.	4.
Carbonate of lime	51.43	49.11	51.28	42.95
Carbonate of magnesia	40.24	36.87	39.65	39.79
Silica	3.85	10.05	7.80	13.30
Alumina and iron	3.85	3.65	2.75	3.55
	99.37	99.68	101.48	99.59

As is usually the case in the State of New York, the Waterlime group on Put-in-Bay Island contains certain layers which make good hydraulic cement. These are the flaggy layers which form No. 4 of the section given on a preceding page. No satisfactory test has ever been made of the quality of this stone, but some of the layers are known to possess hydraulic properties. It is probable that, with some care in the selection of the material, good cement could be produced in any desired quantity, and at little expense, at South Point.

In my examination of the geology of the islands I have been greatly aided by the cordial and efficient co-operation of my friend Capt. John Brown, of Put-in-Bay, and I take this occasion to return to him my sincere thanks for numberless favors of various kinds. I also desire to acknowledge my obligations to Mr. Norman Kelly and Mr. John W. Dunn, of Kelly's Island; to the first, for numerous fine specimens taken from his extensive quarries; to the second, for the intelligent appreciation and preservation of the magnificent glacial furrows uncovered at the quarries of G. W. Calkins & Co., and also for a series of photographs illustrating them.

CHAPTER XXXIII.

REPORT ON THE GEOLOGY OF LORAIN COUNTY.

BY J. S. NEWBERRY.

SURFACE FEATURES.

The topography of Lorain county is, as a general rule, simple, and for the most part even monotonous. The surface slopes gently from the southern townships—where, in Huntington and Rochester, it has an elevation of from 300 to 400 feet above the Lake—to the lake shore. To this rule there are, however, some exceptions, such as that of the gorge of Black river at and below Elyria, where some wild and beautiful scenery is to be found. The underlying rocks are rarely exposed to view, as they are generally covered with a thick sheet of superficial materials, which forms a smooth and unbroken surface. The lake front in Avon and Sheffield is a precipitous cliff, which, at Avon Point, has a height of 75 feet, here forming a bold and picturesque headland. This feature is dependent upon an arch of the strata which brings up some of the lower and harder rocks, and these have offered greater resistance to the waves than the softer overlying beds which come down to the lake level both east and west.

At the mouth of Black river, and thence west to the county line, the shore of the Lake is low. At Amherst are bold ledges of Berea grit, which project above the surface and overlook all the low country between them and the Lake. These ledges evidently once formed the lake shore, when the water stood 140 feet higher than it does now, and at that time they were shore cliffs similar to those now seen at Avon Point, although composed of very different material.

The soil of Lorain county, particularly the southern part, is generally clay derived from the underlying bowlder clay, one of the Drift deposits. This has given a peculiar character to the vegetation, and to the system of agriculture which followed the removal of the primeval forest. The forest growth on this surface was mainly elm, linden, ash, and hickory, and when brought under cultivation the soil was found better adapted to grass than grain. Hence the farmers generally became dairymen, and have devoted their attention to the raising of stock and the making of butter and cheese. As an effect of these causes, Wellington is now one of the most important cheese markets of the Western Reserve.

In the central part of the county a belt of sandy soil reaches across from east to west. The sand of this region is intimately connected with the lake ridges, and is the product of the action of the shore waves when the lake level reached to the altitude of this belt. Near the lake shore the soil is clay again, but here mostly derived from the decomposition of the underlying rocks, the Drift clays having been generally washed away. Good examples of this kind of soil are seen in the northern part of Avon and Sheffield; and there, as in the adjoining township of Dover, Cuyahoga county, it has been found well adapted to the cultivation of the grape, and the surface is already largely occupied with vineyards. The timber of the center and northern part of the county, where the soil is light, is mainly oak, hickory, and chestnut. The original forest growth in all parts of Lorain county was dense and strong, the accumulation of vegetable mold beneath it deep, and the fertility of the resulting soil is marked and universal.

Lake Ridges.—The most interesting feature in the surface geology of Lorain county is formed by the lake ridges which traverse it from east to west. These have been frequently alluded to in the reports on the other counties which border the present lake shore, particularly in that on Cuyahoga county (Vol. I., Part I., p. 178); and the proof is there given that they were thrown up by the action of the waves of the Lake, and mark the place of old shore lines at successive periods of rest in the descent of the lake level. The lake ridges are, perhaps, nowhere better shown than in Lorain county. The impression has generally prevailed that there were but three of these ridges—those known as the north, middle, and south ridges. It will be seen, however, by reference to the map which accompanies Chapter XXX., prepared at my request by Prof. A. A. Wright, of Oberlin, that while there are three principal ridges, having the altitude respectively of 100 to 118 feet, 150 to 160 feet, and 200 to 220 feet, there are also a number of local or intermediate ridges, which frequently are continuous for several miles. For example, in Amherst, the lowest, called Whittlesey's ridge, is a little less than 100 feet above the Lake, and within two miles of the lake shore. The next, or north ridge, is nearly continuous from Cleveland to Brownhelm, and extends much farther both east and west. This has generally an altitude of from 100 to 110 feet. 3d. Middle ridge, extending diagonally northwest and south-east through the center of the township, having an altitude of about 150 feet. 4th. South ridge, continuous through the southern part of the township, and having an altitude of 200 feet. Near Elyria this south ridge divides into two parallel ridges, which turn up the valley of Black River and reappear in Carlisle, Eaton, and Ridgeville, there known as Chestnut Ridge and Butternut Ridge. Thence they continue easterly, with some interruptions and interlocking, till they reach Brooklyn, Cuyahoga county, and curve southward into the valley of the Cuyahoga. In Ridgeville, which has taken its name from the ridges, four distinct ridges have been identified, while another, the most continuous of all, passes further north through Avon.

The want of uniformity in the elevation of the surface in different parts of these ridges is not greater than we should expect to find in the circumstances. No one who will examine the composition of the ridges, and trace their courses on the map, will doubt that they are contour lines inscribed upon the topography by the action of shore waves. But on all sea beaches we find that the materials thrown up by the shore waves, or blown up by the wind, rise to somewhat different heights in different localities, according to the exposure and to the abundance and fineness of the material. Where this is sand, it is not generally thrown up to any great height by the waves, but it is often caught by the sea or lake winds, and heaped up much beyond the reach of wave action. Hence the ridges were doubtless higher in some places than others when first formed, and this inequality may have been exaggerated by the surface erosion to which they have been exposed during the ages which have since elapsed. By surface erosion they have also been frequently cut through, and perhaps locally quite removed; and to this cause we must attribute many of the gaps and interruptions which break their continuity.

The ridges parallel with the south shore of Lake Erie are sometimes continuous with and run into terraces; that is, the waves cut steps, or notches, into the shore where it was abrupt and hard—washed up material and formed ridges along the same line where it was low and soft.

In the same way we now see a cliff forming at Avon Point, and a ridge being raised between the mouth of Huron River and Cedar Point, Erie county. In some places, also, a terrace left by the old shore waves is composed of unstratified Drift clay. In such localities the declivity has been mistaken for a ridge, and from the nature of the materials composing it some erroneous ideas have been conceived in regard to the origin of the lake ridges. Precisely such terraces as I have referred to may, however, be seen now forming near Cleveland, and at other points where the immediate shore of the Lake is composed of Drift clay.

Drift Deposits.—As has been mentioned, most of the surface of Lorain county is immediately underlain by beds of clay, which form part of the series of Drift deposits that cover so much of Ohio and the adjoining States. Beneath these the surface of the underlying rocks—wherever hard enough to retain such markings—is found planed, grooved, and striated, evidently by ice which formed part of a great glacier that filled the lake basin and flowed over it, reaching as far as the Ohio. This glacier was for ages moving from the north southward, and as it rested with immense weight on the rocky sub-strata of the country, by the aid of sand and gravel which accumulated beneath it, it ground down the rocks over which it moved to nearly a plane surface, and grooved and scratched them just as glaciers now do the rocks which they traverse. The materials excavated and ground up by the ice-sheet were pushed along by it in its motion and thrust out at its margin, where they remained to form a "moraine," or were washed away by the water formed by the melting ice. Hence it is apparent that no considerable accumulation of matter of any kind could take place under the glacier. But we find the glaciated surface often deeply buried under beds of clay, sand, and gravel, which must have been deposited there after the retreat of the glacier. These sheets of superficial material are called the "Drift," from the fact that they have been generally transported long distances from their place of origin. In the northern part of Ohio the Drift deposits are usually clay—stratified or unstratified—with more or less sand and gravel, and at the surface large transported bowlders. Of this series the lowest is unstratified clay, thickly set with fragments of shale, and with some small, usually striated, bowlders of crystalline rock, brought from the region north of the lakes. This deposit is called the bowlder clay, and is the direct product of the grinding action of the glaciers upon the shales, limestones, etc., which have been excavated in the formation of the lake basin. As the glacier melted away and retreated northward, this bowlder clay was left in a somewhat irregular sheet along its margin, and we still find it covering the rock surfaces over most of Lorain county, where a basin of water took the place of the ice. From this were deposited sheets of fine clay, frequently beautifully stratified, and without pebbles or bowlders. Hence we often find the lower bowlder clay overlaid by laminated clay, but the two varieties blend together and have been included in the general term "Erie Clay." The bowlder clay is also frequently called *hard-pan*. It is blue in color, and exceedingly compact and tough. Sometimes it is yellow or reddish, from the oxidation of the iron it contains; and this is the prevailing color of the stratified clay.

The sand and gravel which sometimes overlie the clays were deposited long after the bowlder clay, when water filled the lake basin, and they are largely due to the action of shore waves and of the streams which drained the high lands back from the Lake, and brought down sand and gravel from their sources.

The bowlders which are scattered abundantly over the county must have been transported from the Canadian highlands by icebergs, as I have shown elsewhere (Vol. I., Part I., p. 183).

GEOLOGICAL STRUCTURE.

The rocks which immediately underlie the surface in Lorain county are, with the exception of a single exposure on the lake shore, portions of the great Carboniferous system, and belong to the Lower Carboniferous, or Waverly group. They include all the members of the Waverly group, and nearly the entire thickness of the formation. The succession of rocks in the county is as follows, beginning with the highest and descending to the surface of the Lake:

1.	Cuyahoga shale,	average thickness,	150 feet	....	Waverly.
2.	Berea grit,	" "	60 "	....	
3.	Bedford shale,	" "	70 "	....	
4.	Cleveland shale,	" "	50 "	....	
5.	Erie shale,	" "	100 "	....	Devonian.
6.	Huron shale, exposed	"	50 "	....	

The lower two elements in the above section represent the summit of the Devonian system; the others are all Waverly. The rocks enumerated form sheets which have a general dip in the State toward the south and east, but within the limits of Lorain county this dip is reversed or replaced by several local folds. It is not easy to say precisely what the north and south dip of the rocks is, as the exposures are only superficial in the southern part of the county. Taking the Berea grit, however, as a guide, we find it in Brownhelm, within a quarter of a mile of the Lake, where its base has an altitude of less than 100 feet above the Lake. In Amherst it lies 140 feet above the Lake, while in the valley of Black River, at Elyria, it is but 65 feet. Toward the eastern margin of the county it rises again, reaching an altitude of 140 feet. This latter arch is strongly marked on the lake shore, where the strata are seen rising westward from Rocky River to Avon Point and dipping again to the west, half way between Avon Point and Black River.

Cuyahoga Shale.—All the southern half of the county is underlain by the Cuyahoga shale, the uppermost member of the Waverly group. This formation consists of blue or gray argillaceous shale—frequently called soapstone—with thin bands or flags of fine-grained sandstone. The maximum thickness of the Cuyahoga shale is something like 250 feet; but as the upper portion has been removed from Lorain county, its thickness here may be estimated at 150 feet. This formation supplies comparatively little that is of scientific interest or economical value. It rarely furnishes any good building stone, and is generally destitute of fossils. Its upper beds, however, yielded in Medina a very large number of beautifully marked mollusks and crinoids, many of which are described and figured in our report. Fossils are also found in the bed of Black River, within the limits of this county.

Berea Grit.—The Cuyahoga shale is underlain by the Berea sandstone, the most distinctly marked and economically important element in the geology of the county. As it extends through a large part of Northern Ohio, and has been fully described in other portions of our report, no detailed notice of it will be required here. It contributes largely to the wealth and business of all the country it traverses, but its best and most valuable development occurs in Lorain county. Though varying considerably in thickness and character in different localities, the Berea grit is generally a rather fine-grained and homogeneous sandstone, lying in courses from a few inches to several feet in thickness, and varying in color from a light drab to a light blue or dove color. Its thickness ranges from fifty to seventy feet, and it forms a continuous line of outcrop, except where covered by superficial deposits. It enters the county from the east in the township of Avon, and its lower surface is exposed at the village of French Creek; thence it passes south-westerly to Elyria, where it forms the falls; thence sweeping around through Amherst to its most north-westerly outcrop in Brownhelm. As it lies so nearly horizontal, and has a thickness so considerable, the Berea grit is the surface rock over a very extensive area of the northern and central portions of the county, but it is generally overlain and concealed by the Drift clay, even where it approaches very near the surface. As the Berea grit supplies perhaps the best building stone in the State, and one that is exported to New York and Boston on the one hand and Chicago on the other, it has such value that its distribution, quality, and accessibility deserve to be carefully studied over all the region where it can be reached. I shall, therefore, refer to it again when I come to speak of the economic geology of the county. The exposures of the Berea grit which have hitherto attracted the most attention are those of the Amherst and Brownhelm ledges. These, as has been before stated, were undoubtedly once the shore cliffs of Lake Erie, when its waters stood much higher than now. They owe their prominence and relief, however, mainly o the fact that the rock which composes them is more massive than that which connects and surrounds them. Hence, in the erosion to which this region has been exposed, these harder and more massive portions have best resisted the denuding action, while the softer rocks have been more deeply cut away. The light and uniform buff of the Amherst stone is undoubtedly due to the fact that these elevated cliffs, being freely drained, have been traversed by atmospheric waters, so that the iron the rock contains has been thoroughly oxidized. In localitie where the stone is beneath the water level, or is covered with a considerable thickness of clay, it will be found to have a light blue color, as at Berea. This is well illustrated by the recent workings of the Amherst quarries, in which a stratum of very fine-grained, homogeneous blue stone has been found beneath the lighter beds, and where the rock was imperfectly drained. This variety is called *Blue Amherst*, and is very handsome and highly esteemed.

No fossils have been found in the Berea grit of Lorain county, so far as I am informed. It has, however, yielded many interesting fossil fishes at Chagrin Falls (*Palæoniscus Brainerdi*), and some fish spines (*Ctenacanthus formosus*), and a large *Lingula* at Berea, so that something of the kind may be looked for in the quarries of Lorain county.

Bedford Shale.—Below the Berea grit comes in the Bedford shale, and this is exposed in all places where the sandstone is cut through. In Lorain county the upper part of the Bedford shale is generally red, and this will serve as a convenient guide in future explorations made in search of the Berea grit, it being understood that the only red shale in the county lies immediately beneath the sandstone. This red shale is well shown at the village of French Creek, in the gorge of Black River, at Elyria, in the railroad cut between Elyria and Amherst, in the quarries at Amherst, and in the cliffs bordering the Vermilion in Brownhelm. The best exposures of the entire thickness of the Bedford shale are on Black River, below Elyria, since the cliffs are chiefly composed of it for two or three miles. Here it is seen that the upper portion is deep red, the lower, bluish red and gray. It will be also noticed here that the upper surface of the shale is very irregular, showing that the currents of water which transported the sand—now the Berea sandstone—cut away the shale, then a red clay, in deep and broad channels. As these were filled with sand, the under surface of the sandstone is very uneven and its thickness variable. Several thin bands of impure limestone occur in the Bedford shale in the banks of Black River, and these contain a few fossils, the most abundant being a lammellibranch mollusk, called *Macrodon Hamiltoniæ*, and a small *Lingula* not yet described. In one of these limestone bands I also found a triangular fragment, six inches long by four inches wide and one and a half inches thick, of the bone of some gigantic fish, probably allied to *Dinichthys*. This is the only trace of this fish yet found, and it indicates that the Bedford shale may upon proper search furnish some much more interesting material than any yet obtained from it. At Berea a considerable number of fish teeth have been obtained from the calcareous bands in the Bedford shale, so that though at first thought utterly barren, it may prove quite rich in new species of fossils.

Cleveland Shale.—This is a black bituminous shale, fifty or sixty feet in thickness, which is well exposed beneath the Bedford shale in the valleys of Black and Vermilion rivers. It contains over ten per cent. of carbonaceous matter, and this gives it a black color, by which it may be at once recognized when freshly broken. Where long exposed, its carbon is burned out by oxidation, and it becomes gray. Hence its outcrops, taking the color of the other gray shales in the series, may not be identified without some excavation. The only fossils found in the Cleveland shale of Lorain county up to the present time are minute, rhomboidal, enameled fish-scales. These belong to a ganoid fish, probably a species of *Palæoniscus*, but no entire individuals have yet been obtained. The Cleveland shale has no economic importance, except that it is clearly the source of the petroleum found at Grafton and Liverpool.

Erie Shale.—This is the summit of the Devonian system, as now classified. It is a mass of gray, argillaceous shale, with thin flags of sandstone and lenticular iron ore. It is not easy to say with accuracy what its thickness is in Lorain county, but it is somewhere from 100 to 150 feet in the central and eastern portions, while in the valley of the Vermilion it has almost disappeared. In this county it is the wedge-shaped edge of a formation that thickens rapidly eastward, forms the lake shore most of the way from the mouth of Black River to the State line, and attains a thickness of fully 2,000 feet in the State of New York. In most places it is very barren of fossils, and has yielded none in Lorain county; nor does it furnish any material which can be made to contribute to the wealth or comfort of the inhabitants. The Erie shale is well exposed on the lake shore at Avon Point, and less perfectly in the bed and banks of French Creek and Black River near their mouths.

The Huron Shale.—This is a formation which attains a thickness of 300 feet or more, and is exposed in a continuous belt reaching from the Lake through the central part of the State to the Ohio. In Huron county it forms the banks of Huron River, and its entire thickness is exposed. In Lorain county it is only seen on the lake shore between Avon Point and the mouth of Black River, and at the mouth of the Vermilion. In the former locality it is brought up in a fold of the strata to which allusion has already been made. About fifty feet of the extreme summit of the formation are here exposed, consisting of bands of black bituminous shale, interstratified with gray shale and thin sheets of micaceous, pearly sandstone. In the valley of the Huron, as generally farther south, it is a nearly homogeneous black shale. Although showing such limited exposures in the limits of Lorain county, the Huron shale has furnished some of the most interesting and extraordinary fossils that have ever been discovered. These are chiefly the remains of gigantic fishes, similar in character to some of those described by Hugh Miller, but very much larger. Most of the specimens obtained are referable to a single species of the genus *Dinichthys*, which will be found fully described in the palæontological portion of this report. The remains of *Dinichthys* were first found by the Rev. H. Hertzer in calcareous concretions at the base of the Huron shale, near Delaware, Ohio, and the species to which they belong—named in honor of the discoverer—is figured and described in Vol. I., Part II., p. 316, plates 30 and 31. Subsequently Mr. J. Terrell, of Sheffield, and Prof. G. N. Allen, of Oberlin, found on the lake beach, west of Avon Point, rolled fragments of large bones, which I recognized as portions of the great dorsal shield of *Dinichthys*. The finding of these specimens prompted a search for the bones in place in the cliff of Huron shale from which they had evidently been washed out. This search was rewarded with very interesting results. Prof. Allen obtained by excavating the rock a complete dorsal shield some sixteen inches in diameter; and later, in company with Mr. G. K. Gilbert, a supra-scapular and a large pre-maxillary tooth. But the most interesting specimens found in this locality have rewarded the laborious and intelligent search of Mr. J. Terrell, the proprietor of the Lake Breeze House, situated in the immediate vicinity of the outcrop of the fish-bearing stratum. His first important discoveries were those of an entire dorsal plate and the posterior half of a cranium, both of which are figured on plates 32 and 33 of our first volume. Unfortunately, these speciments were destroyed in the burning of Ely's block in Elyria. Their loss has, however, been more than made good by Mr. Terrell, who has since discovered nearly the entire bony structure of an individual of gigantic dimensions, of which a more detailed description will be found in Part II. of this volume. This proves to be a distinct species from that found at Delaware at the base of the formation. The latter has a row of conical teeth on the edge of the maxillary, and a corresponding row with which these interlocked in the middle of the mandible, while in the Sheffield species, to which I have given the name of *Dinichthys Terrelli*, the maxillaries terminate below in a sharp, knife-like edge, which plays upon a similar edge on the mandible, and the whole dentition constitutes a cutting or slicing apparatus of great power. So far as at present known, all the bones of *Dinichthys* found at Sheffield belong to this species, while all those found at Delaware appertain to *D. Hertzeri*. A fine spine of *Ctenacanthus* (*Ct. vetustus*) was also found at Sheffield by Mr. J. W. Hulbert, of Elyria; and this is described in Vol. I., Part II., p. 326, pl. 35, fig. 3. Mr. Terrell obtained, in addition to the fossils mentioned, several bones of small and, as yet, undescribed fishes, some cones, apparently belonging to *Lepidodendron*, and an undescribed species of *Goniatites*, all from the Huron shale at Sheffield. Broad, flag-like impressions of plants are very common in the formation here as well as elsewhere. These are undoubtedly the remains of seaweeds, and it is probable that the carbonaceous matter the shale contains was derived from this source.

The succession of the rocks exposed in the central and northern portions of the county will be seen at a glance by reference to the section given below, which begins at the surface of the Berea grit, 15 feet below the Lake Shore Railroad at Elyria, and reaches to the lake level at the mouth of Black River.

SECTION OF THE ROCKS IN THE VALLEY OF BLACK RIVER.

1.	Berea grit, thickness	40 to 70 feet.	
2.	Red shale, "	30 to 60 "	Bedford shale.
3.	Gray shale, "	10 "	
4.	Gray limestone, thickness	5 to 8 inches.	
5.	Calcareous shale, "	1 foot.	
6.	Black bituminous shale, thickness	27 feet.	Cleveland shale.
7.	Gray shale, thickness	7 "	
8.	Black shale, like No. 6, thickness	50 "	
9.	Gray shale, to Lake, "	40 "	Erie shale.

A well bored for oil in the valley of Black River, at Elyria, and begun a few feet below the base of the Berea grit, is said, by a near resident and stockholder, to have been carried to the depth of 1,000 feet, "600 feet of which was in shale, the remainder in limestone and sandstone." If this boring can be relied upon, the interval between the Berea grit and the Corniferous limestone is here only about 600 feet, while at Peninsula, in the valley of the Cuyahoga, wells beginning at the same horizon were bored to the depth of 1,000, and in one case 1,400 feet, and, as reported, "all in shale;" and at Cleveland a well, begun more than 200 feet below the Berea grit, was sunk 1,000 feet in gray and black shales without reaching the limestone.

There is probably some inaccuracy in the statement quoted above, as two wells were bored for oil by Mr. D. M. Fisher, near the mouth of Black River, and in these 700 feet of shale were passed through before the limestone was reached.* These wells were begun nearly 100 feet lower, geologically, than that at Elyria; so that the interval between the Berea grit and the Corniferous limestone, under the central portion of Lorain county, cannot be less than 800 feet.

All these borings indicate that the Erie shale, and probably the Huron, have thinned very much in the interval of thirty miles between the valleys of the Cuyahoga and Black River. Going west, this thinning still continues; in the valley of the Vermilion the Erie shale having pretty much disappeared, the Cleveland shale apparently resting directly upon the Huron. A well bored at the mouth of the Vermilion shows the thickness of the shales which separate the Berea grit from the Sandusky limestone to be less than 400 feet, and gives a thickness to the Huron shale of about 300 feet. The borings made in the eastern counties indicate that it has in some places a thickness nearly twice as great.

ECONOMIC GEOLOGY.

As has been stated, much the most important element in the mineral resources of Lorain county is the Berea grit, which already makes a gross annual contribution of more than a half million dollars to the wealth of the county; and there is every reason to believe that this treasury is not only inexhaustible, but that it is destined to be far more largely drawn upon in future years than it has yet been. The variety of stone furnished by this formation greatly enhances its value, as it serves many useful purposes. It supplies, perhaps, the most highly esteemed and popular building stone known in the State, which is now not only extensively used throughout northern Ohio, but is exported to St. Louis and Chicago on the west, Canada on the north, and Boston and New York in the east. It is every where highly appreciated for its beauty, durability, and the ease and certainty with which it is worked. In its different varieties the Berea grit is applicable to all kinds of grinding, and grindstones made from it are not only sold in all the principal markets of our own country, but are exported to nearly all parts of the civilized world. Although passing through a large number of the coun-

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* About 130 feet below the bottom of the shale, or 830 feet from the surface, in both wells, fissures, oil, gas, and salt water were reached. The oil was heavy—30° Beaume—and the quantity was small. It was probably derived from the Niagara below.

ties of the State, and extensively quarried in many localities, the Berea grit seems to reach its maximum of excellence in Lorain county. Here it has been chiefly quarried at Amherst, and the "Amherst stone" is now as widely known and has a reputation as firmly established as any other building material in use. The Amherst quarries are located in a series of ledges which, as I have stated, were once the shore cliffs of Lake Erie. The base of the stratum here lies about 140 feet above the Lake, with which the quarries are connected by railroad. The Lake Shore Railroad also passes them, and supplies means of transportation by which a large part of their product is removed. The Berea grit at Amherst, as elsewhere, varies considerably in character, and especially in solidity, within limited distances, and the ledges in which the quarries are situated apparently represent the more massive and solid portions of the stratum which have best resisted erosion, and hence have been left in relief. Their elevation has also caused them to be thoroughly drained, and the iron contained in the stone generally oxidized so that it has a warmer tint than where, as at Berea, it lies below drainage. The Amherst stone is commended by the following qualities which it possesses in an unusual degree:

1st. Durability. It is chemically nearly pure silica, and is scarcely more affected by weathering than the best granite; it is also very refractory, and will endure exposure to fire by which granite or limestone would be entirely destroyed.

2d. Strength. This varies from 6,000 to 10,000 pounds to the square inch; from two to four times that of the best brick, and at least sufficient to endure any weight likely to be imposed upon it by modern architecture.

3d. Color. This is generally light drab, warm, cheerful, uniform, and unchangeable. The variety known as "blue Amherst," recently obtained from the base of the formation, is a delicate and attractive blue.

4th. Texture. This is fine and homogeneous, without flaws, iron, or clay balls. While containing the quarry water, it works, as the stonecutters say, "like cheese," but hardens on exposure, and retains every inscription with the greatest fidelity.

These qualities are rarely found in as great perfection combined in one stone, and are such as fully warrant the high reputation it enjoys. The other uses of the Amherst stone are scarcely less important than those to which I have referred. It is now furnishing several varieties of grindstones which have no superior in the world. They are wrought of all sizes, and are adapted both for dry and wet grinding. Among other grindstones made at Amherst, the "American Wickersley" stone is specially esteemed for grinding saw-plates, edge-tools, etc.

The ledges which supply the stone at Amherst extend into Brownhelm, there exhibiting the same features, and are largely worked in part by the same proprietors. The following firms and individuals are engaged in the quarrying of stone and the manufacture of grindstones at Amherst and Brownhelm: The Clough Stone Company; Worthington & Sons; The Wilson & Hughes Stone Company; G. Barber; J. McDermott & Co.; W. James; Peck Brothers; J. S. Butler & Co.; The Cleveland Stone Company.

The product of the quarries for 1870—for which I have the fullest returns—was as follows:

Block stone, cubic feet		509,434
Sawed stone, square "		41,818
Grindstones,	tons	13,700
Railroad ballast,	"	12,000
Sand,	"	500
Perch stone,	"	9,000

The price of block stone was from 40 to 50 cents per cubic foot; of grindstones, $12 to $15 per ton. The value of the production of the Amherst quarries in 1870 was estimated at about half a million of dollars, and it has been steadily increasing since. The number of men employed was 620.

Elyria Quarries.—The exposures of the Berea grit at Elyria are ample, and they show the formation to be as thick and massive here as at any other point in the county. It may also be said that the stone is more accessible here than at any other locality, as it forms the bed and bank of Black river both above and below the falls. As a general rule, it is coarser and less homogeneous here than at Amherst. Very excellent stone has been obtained, however, from the quarries on the land of Albert Ely, Esq., on the west side of the river; and the new quarries recently opened by Mr. H. E. Mussey, on the west bank of the West Fork, above the falls, reveal courses of very excellent stone of both drab and gray tints. These quarries are most conveniently situated along the track of the extension of the Tuscarawas Valley Railroad, and seem capable of supplying an inexhaustible quantity conveniently placed for shipment by the railroads or the Lake. Between the forks of Black River, and in the suburbs of the town, Mr. Elmer Adams has a quarry which has been in operation for some years. The stone it furnishes is of a blueish or gray color, massive and homogeneous, and closely resembles in color and texture much of the Berea stone. On the lands of Heman Ely, Esq., on the east side of the West Fork, and opposite the quarries of Mr. Mussey, the Berea grit is very accessible, and quarries might be opened here at small cost which would probably afford stone of the same quality with that on the west side of the stream. West and north-west of the village, over a considerable area bordering both the Lake Shore and Black River Railroads, the Berea grit comes near to the surface, and is covered only with Drift clay. In this vicinity there would seem to be quite a large amount of quarry land where the stone is readily accessible and favorably located for shipment.

No effort has yet been made to manufacture grindstones from the Berea grit at Elyria, and the impression has prevailed that the stone was too coarse for any but heavy grinding. To this purpose some of it is certainly well adapted, and there is every reason to believe that search for a finer and better grindstone grit will be rewarded with success. It should be remembered that the character of the Berea grit varies very much, both as regards solidity and fineness, in its different layers and in different localities, and the true value of the deposit in this vicinity can only be accurately determined by more thorough exploration than has yet been made. It may be confidently expected, however, that the quarries at Elyria will hereafter become an important source of wealth to the community, and that this will be one of the principal points of shipment of stone to supply the great lake market.

In Ridgeville the Berea grit comes to or near the surface in many localities. Its quality can hardly be said to have been tested, as but little quarrying has been done here. Some of the stone seems, however, to be good, and the chances of opening valuable quarries in this township are such as to warrant more attention than they have yet received.

The Berea grit has also been quarried at the village of French Creek by Mr. Ebenezer Wilson, in Pittsfield by Mr. McRoberts, in Lagrange by Mr. Nelson Rose, and it is much more extensively worked in Columbia, where the stone is of excellent quality and has an established reputation. From these facts it will be seen that the Berea grit is accessible in nearly all parts of the county, thus insuring to the inhabitants throughout all time an abundance of building stone of the best quality at their very doors—a blessing far more rare than generally supposed—and affording an unfailing source of revenue.

Petroleum.—This should also be enumerated among the mineral resources of Lorain county, although very little is produced there at the present time. In Grafton, oil springs were discovered by the first settlers, and petroleum taken from springs in the adjoining township (Liverpool) was sold throughout the country as a medicine long before wells were bored on Oil

Creek. Very naturally, when the oil excitement began, the oil springs of Grafton attracted attention. They are quite copious, and, in some instances, the soil about them is completely saturated with tar and asphalt, produced by the evaporation of the oil. A series of pits which may be seen about the oil springs at Grafton furnish evidence that here, as at Mecca and Oil Creek, oil was collected by the ancient inhabitants of the country. In 1861 several wells were bored for oil in Grafton, and at one time speculation ran high there. The oil proved, however, to be limited in quantity, and, being very thick, was not well adapted to distillation (the only use then made of petroleum); and, as a consequence, the enterprise was not successful. Since then this variety of oil has come into general use as a lubricator, and is very much more valuable than the lighter kinds. The character and promise of this oil district is very similar to that of Mecca, Trumbull county. The oil is undoubtedly derived from the Cleveland shale, and has risen into and saturated the Berea grit; but inasmuch as the quantity coming from this bituminous mass, which is of only moderate thickness, is not large, and there is no impervious cover over the reservoirs furnished by the sandstone, the oil has evaporated, or flowed away, as fast as formed, and no such accumulations have taken place as in the capacious, deeply buried, and closed reservoirs of Oil Creek. The oil of Grafton is dark in color, has a specific gravity of 22° to 25° Beaume, is an excellent lubricator, and would be worth in market about a dollar a gallon. The details of the efforts made to obtain oil at Grafton are as follows: Four wells have been sunk there. The Rising well, on lot 58, was bored to the depth of 150 feet. This well yielded 30 barrels of lubricating oil within three months' time, the oil flowing from a seam 85 feet below the surface. Erastus Jones' well, one and a half miles north of the center, was sunk to the depth of 600 feet, but drew its oil from a point 100 feet below the surface. The total yield of this well was about 30 barrels of oil. The Crittenden well is the only one of the series now worked. It is pumped by a wind-mill, the yield being about 40 barrels in six months. It is possible that well-directed efforts would greatly increase the yield of oil at Grafton, at such a cost of time and money as would be well repaid.

During the prevalence of the oil excitement several wells were bored in the valley of Black River, at and below Elyria. In these some oil was obtained, but not in "paying quantity." There is still a conviction lingering in the minds of some of those who were interested in this enterprise, that further trials would be more successful. To this faith, however, I am unable to give much encouragement. To me it seems more probable that if additional wells were bored in the valley of Black

River, their history would be similar to that of all those which have been bored here and in the valleys of the Cuyahoga, Rocky River, and Vermilion—that is, that oil would be obtained from them, but only in small quantity. The reasons for this opinion have been given in full in Vol. I., Part I., page 160, of this report, and I will only very briefly state them here. While the geological formation is essentially the same in the valleys of Oil Creek, the Cuyahoga, and Black River, it is also true that the strata are thinner, finer, and less disturbed in Ohio than in Pennsylvania. Hence the supply of oil is less. There are no beds of sandstone above the oil-producing rock to act as reservoirs, but, instead, a compact mass of fine impervious shale. In these circumstances, the quantity of oil to be obtained might be expected to be small, and, as a matter of fact, all the oil wells bored in Cuyahoga and Lorain have been failures.

Gas Springs.—Like all the country lying over and near the outcrops of the bituminous Cleveland and Huron shales, Lorain county abounds in gas springs. Nearly every township has its "burning spring," and some of them are of considerable magnitude. Of these I will enumerate a few. In Avon township a "gas spring" may be seen in the Lake opposite the Sherman farm, half a mile west of the center road. Here a steady flow of gas comes to the surface over an area of about one square rod. In fair weather this keeps the water in agitation, as though it were boiling, and it is said never to freeze in this spot in winter. The flow of gas is here constant, and so copious that, if it could be utilized, it would be of great value. Another similar spring has been noticed half a mile from the land, opposite the farm of Mr. Henry Titus. In Brownhelm a group of gas springs may be seen near the east bank of the Vermilion River, just above the mouth of Chance Creek. In Columbia township a voluminous "gas spring," and perhaps the most remarkable in the county, is situated in the Hickox mill-pond, near Olmsted Station. The gas here sometimes throws up the water to the height of five or six feet, and makes a noise which can be heard at the distance of several rods. In Grafton there is a gas well on the farm of Mr. Truman Bogg, a half mile east of the center. The oil wells all yield more or less gas, and numerous gas springs are known in the township. In LaGrange there is a gas spring on the farm of George Foster, one mile south of the center. In Penfield Mr. Henry C. Luther, who lives two miles north-west of the center, has a well from which the flow of gas is used to light his house. The supply is much greater than is required for this purpose, and could probably be made to do the cooking as well. The gas from this well has been used since 1869, with no apparent diminution in quantity. In Russia township numerous gas springs are known, and Lot Parsons, Esq., living two miles north of the first church, has a well that supplies gas by which his house is lighted. The above cases are cited from a large number noticed in the progress of the Survey, for the purpose of calling attention to the fact that in many parts of the county combustible gases are escaping from the ground, and that these are capable of being utilized for both lighting and heating. It is now well known that at several points along the shore of Lake Erie wells have been bored for the purpose of obtaining supplies of gas, and that a large number of such efforts have been successful. The pecuniary value of such a flow of gas, if it could be made to do the heating, lighting, and cooking of a family, would be very great, while the convenience, cleanliness, and comfort of its use would make it an almost priceless luxury.

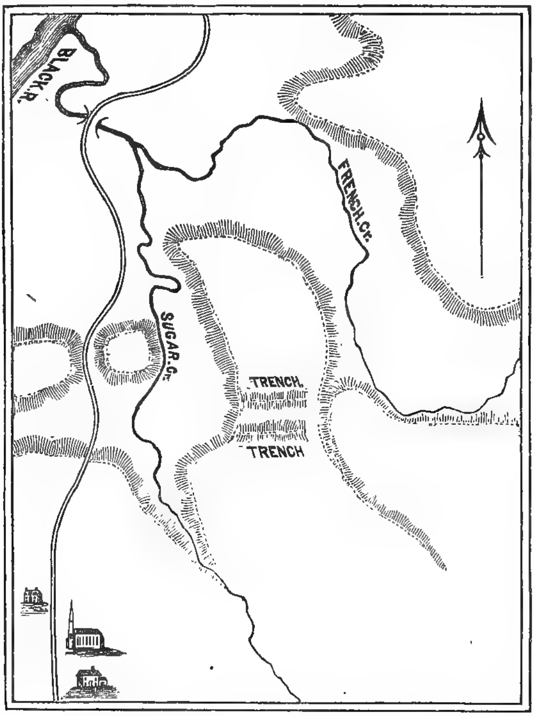
Peat and Marl.—No peat is now produced in Lorain county, but it exists in considerable abundance in several localities. In Brighton and Camden are extensive marshes, which were doubtless once lakes, but which are now filled with peat. In the Great Bear Swamp, in Camden, a pole may be thrust down twenty feet through peat. In Brighton, on land owned by Mr. Driver, is one of these lakes, but partially grown up, and which shows a water surface of about four acres. This lake is said to be 100 feet deep. It is surrounded by a broad margin of peat, and was evidently once much larger than now. Whether the peat of Lorain county can yet be successfully substituted for coal and wood as a fuel, is an unsolved problem; but there is little doubt that, where remote from railroads, when the supply of wood shall have been exhausted, these peat bogs will be utilized and be shown to have great value. It is worth remembering that the remains of the elephant and mastodon are usually found in peat bogs similar to those referred to. In any excavations hereafter made, for drainage or other purposes, in these marshes, this fact should be borne in mind.

Shell marl has been found in various parts of the county, but as yet has been scarcely applied to the use for which it has considerable value—the fertilization of farming land. The peat beds referred to above, and which have taken the place of water in little lakes, are frequently underlain by shell marl. All such deposits can be conveniently explored by a screw or pod augur, with a handle ten feet in length.

Iron Ore.—Patches of bog ore are found in many parts of the county, but as they probably have no economic value, they do not require particular notice. A blast furnace was built in 1861 in the village of Charleston, and is now owned by Mr. S. O. Edison, of Cleveland. Formerly some bog ore and "beach ore" (the latter washed out of the shales) were used in connection with specular ore from Lake Superior, but lately the use of the native ores has been discontinued.

ANCIENT EARTH-WORKS.

Mounds and embankments made by the ancient inhabitants of the country are found in several places in Lorain county, two of which will be briefly noticed here. The best-preserved "fortifications" in the county are on the land of R. Burrell, Esq., in the angle formed by the union of French and Sugar Creeks, in Sheffield township. The valleys of these two streams are quite deeply excavated, and inclose a narrow triangle of



high land at their junction, which is bounded by cliffs of shale 45 feet in height and almost perpendicular. Across the base of this triangle, at the distances respectively of 350 and 278 feet from the apex, are two deep, parallel trenches, each 135 feet long, reaching across from bluff to bluff. Mr. Burrell states that when the land was first cleared, in 1816, these trenches were eight feet deep. They have been plowed over from year to year since, but are quite plainly discernible. The purpose of these trenches was evidently to defend from attack a village or citadel situated on the level surface of the height. The plateau was evidently inhabited for many years, perhaps centuries, as the soil which covers it is a "made soil," abounding in bones of animals, stone implements, and arrow-heads. Probably the efficiency of the trenches was increased by palisades or some other defense of wood, all trace of which has disappeared by decay.

An ancient fortification erected by the Mound Builders is discernible on land owned by Mr. Jacob Delker, on a bench of the west bluff of the Vermilion River, where it makes a bend after entering the township from Henrietta, not far below the bridge. The descent upon this projection of land is quite rapid. About midway of the descent a trench was dug, and breastworks were thrown up. They now stand out distinctly, but have been cut through in the middle to permit the passage of wagons. The trench has been mostly filled in by the washing down of the gravelly bluff above. A young peach orchard is on this old fortification.

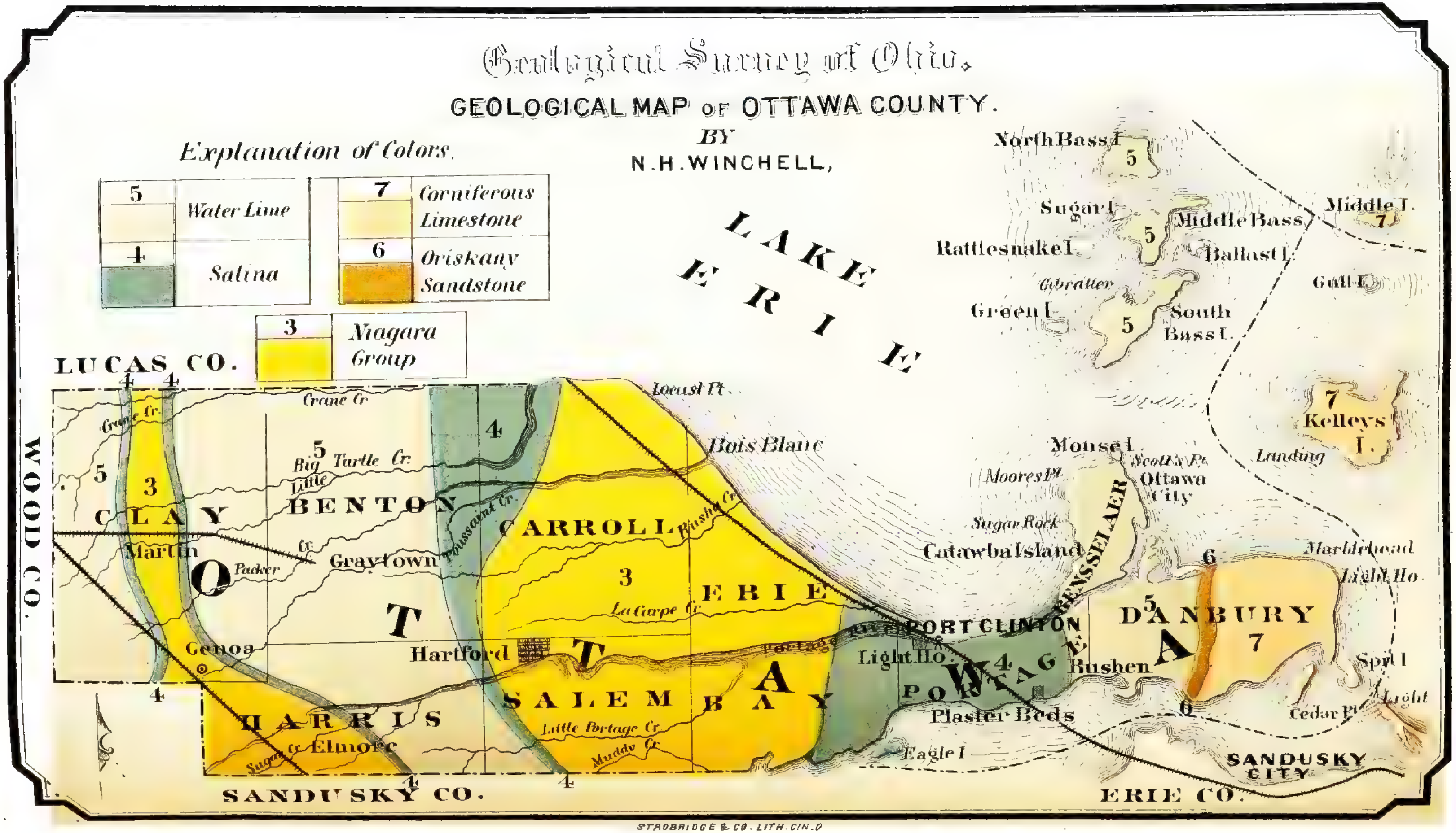
About seven acres are included in a large fort on Mr. Jacob Ennis's land, on the east bank of the Vermilion River, three miles above its mouth. The Mound Builders must have considered this an important station, as shown by these extensive intrenchments, now somewhat obscured in outline on one side by reason of many years' plowing. The soil of this fort contains quantities of fragments of bone and pottery and chippings of flint.

PROF. J. S. NEWBERRY, *Chief Geologist:*

DEAR SIR—I have the honor to transmit herewith Reports on the Geology of Ottawa, Crawford, Morrow, Delaware, Van Wert, Union, Paulding, Hardin, Hancock, Putnam, Allen, Auglaize, Henry, and Defiance counties.

Yours, very respectfully,

N. H. WINCHELL.


Geological Survey of Ohio.
GEOLOGICAL MAP OF OTTAWA COUNTY.
BY
N.H.WINCHELL,
Explanation of Colors.
5 Water Lime
4 Salina
7 Corniferous Limestone
6 Oriskany Sandstone
3 Niagara Group
LAKE ERIE
LUCAS CO.
WOOD CO.
SANDUSKY CO.
ERIE CO.
OTTAWA
CLAY
BENTON
CARROLL
ERIE
SALEM
HARRIS
PORTAGE
DANBURY
BAY
Genoa
Martin
Graytown
Hartford
Elmore
Port Clinton
Light Ho.
Plaster Beds
Bushen
Sandusky City
Catawba Island
Sugar Rock
Moores Pt.
Mouse I.
Scott's Pt.
Ottawa City
Rensselaer
Marblehead
Light Ho.
Cedar Pt.
Light
Eagle I.
Locust Pt.
Bois Blanc
Landing
Kelleys I.
North Bass I.
Sugar I.
Middle Bass
Ballast I.
Rattlesnake I.
Gibralter
Green I.
South Bass I.
Middle I.
Gull I.
Crane Cr.
Big Turtle Cr.
Little
Toussaint Cr.
Packer Cr.
Rusha Cr.
La Carpe Cr.
Portage
Little Portage Cr.
Muddy Cr.
Sugar Cr.
STROBRIDGE & CO. LITH. CIN. O

CHAPTER XXXIV.

REPORT ON THE GEOLOGY OF OTTAWA COUNTY.

BY N. H. WINCHELL.

That portion of Ottawa county known as "the Peninsula," including the townships of Danbury and Rensselaer, is not included in this report. The remainder of the county is very densely wooded, and but few outcrops of rock are known. With the assistance, however, of the county surveyor, Mr. Ernest Frank, and under his guidance, all those outcrops were visited.

POSITION AND AREA.

Ottawa is one of the most northern tier of counties, and borders on the west end of Lake Erie; the peninsula included between Sandusky Bay and Lake Erie, belonging to this county, being its most eastern extension. North of its western end is Lucas county. It is bounded west by Wood county and south by Sandusky county. It contains an area of about eight townships, of thirty-six square miles each.

NATURAL DRAINAGE.

The Portage is the principal river of the county, and is navigable for tugs and schooners as far as Oak Harbor. It intersects the county in a direction a little north of east, and enters Lake Erie at Port Clinton. The entire drainage of the county is in the same direction; the other streams, such as the Little Portage, which enters the Portage from the south, in the township of Bay, Toussaint Creek, and Turtle Creek, having, like the Portage, a very gentle descent, with slack-water several miles above their mouths. The Portage itself is a mere creek in the summer season above the slack-water, and some of the other streams become quite dry.

SURFACE FEATURES.

The surface of the county is quite flat, and elevated but little above Lake Erie. With the exception of the drainage valleys, which are excavated in the Drift to the depth of fifteen to twenty-five feet, the limestone ridges and knolls constitute the only diversity of surface. These ridges produce gentle upward undulations of the surface, extending sometimes two or three miles, usually exposing the rock, and rising from five to fifteen feet above the general level. In traveling over the country they are hardly perceptible to the eye, and are first revealed by the occurrence of stones and small bowlders on the surface of the Drift. Such limestone ridges are most frequent in the township of Clay, and the rock is exposed on sections 4, 9, 16, 28, 27, and 34. The rock is also exposed in a similar way in Benton township, sections 14, 23, and 26; also in Harris township, section 14. In the bed of the Portage the rock may be seen through most of the township of Harris. In addition to their flood-plains, the streams have one general terrace, or bench. The former consists of such deposits as the freshet stage of the stream is not able to carry away. In it are imbedded vegetable remains—leaves, branches, and trunks of trees. The mass of the deposit is, however, a loose but homogeneous marly sand. It is also liable to contain stones of considerable size, the result of stranded ice in spring time. Its height along the Portage is, in Ottawa county, seldom over six feet above the summer stage of the water, dependent somewhat on the obstructions to the current. The latter, or the first terrace above the flood-plain, is simply the result of the erosion of the stream, and shows the original condition of the Drift deposit. Its height, owing to the evenness of the original surface, is not apt to vary much, and is seldom over twenty-five feet. The changes of the stream from one side to the other of its flood-plain sometimes cause the union of these two terraces in one; in such cases the entire bluff may be thirty feet. Such banks may be seen in the township of Harris, sections 8 and 9, and at numerous other points.

Character of Soil and Timber.—The soil is clay, with very few superficial stones or bowlders; at greater depths it contains some gravel and bowlders—the residue untransportable by water—which may be seen in the beds of the streams, and which are met in wells. There are also superficial deposits of sand, not only along the immediate beach of Lake Erie, but at points several miles from the Lake. They are far more infrequent, however, than in Wood and Sandusky counties. This cold and tough character of the soil, together with the difficulties of local drainage arising from its general flatness, has impeded the settlement of the county. By the aid, however, of the recent general drainage law, the whole county is being rapidly subjected to an excellent system of artificial drainage, and the soil is not only sooner relieved of the surplus of standing water in the spring of the year, but it is brought into an arable condition as early as the farmer requires. Elm, cottonwood, sycamore, oak, ash, beech, hickory, and maple, with some black walnut, are the principal forest trees. The whole county was originally densely wooded.

GEOLOGICAL STRUCTURE.

Owing to the uniform spreading of Drift deposits, the boundaries of the different formations can be certainly located in but few places. There are sufficient outcrops of rock to determine the sequence of the formations, and furnish a basis for a geological map, but the location of their boundaries throughout the most of the county is somewhat conjectural.

The Niagara limestone occupies a narrow belt of country north and south through the western part of the county, widening toward the east in the township of Harris, its eastern boundary crossing the Portage about a mile east of Elmore, and leaving the county in section 22 (Harris). Its western boundary runs nearly north and south within about two miles of the western county line, bending to the east at Genoa so as almost to join the eastern boundary line. It leaves the county S. W. ¼, section 4 (Clay). The Niagara also forms an anticlinal axis by outcropping in the south-eastern part of the township of Benton. It probably occupies most of the area in the townships of Carroll, Salem, Erie, and Bay, although no outcrops have been seen in that part of the county. The principal exposures of the Niagara are at Genoa, in Clay township. In addition to the natural ridges from which the Drift deposits have been denuded so as to show the rock over considerable areas, it has been opened in several quarries. William Habbeler has opened the Niagara to the depth of about six feet. An opening, known as Woodbury's quarry, half a mile north of the village, also shows six feet of the Niagara limestone. Besides these, the quarries of Mr. Frank Holt, one mile north of Genoa, those in the Jackson Ridge, N. W. ¼, section 28, and of Charles Sawyer & Co., S. E. ¼, section 16, Clay township, are in the Niagara. Those of Messrs. Newman and Ford, and of Wyman and Gregg, less than a quarter of a mile east of the village, are in the Waterlime which overlies the Niagara. These quarries are all for the purpose of the manufacture of quicklime, the stone not being adapted to any other use. The Niagara here has that phase which, by the geologists of Canada, has been named the Guelph, and is believed to constitute its highest member. Observations made in counties further south go to show that this lithological aspect of the Niagara is not horizontally continuous, but is liable to occur at other altitudes in the formation. The rock here is loosetextured, often carious, yet when compact is crystalline. It is in thin beds of about three inches, more or less lenticular, making it easy to quarry and to get into fragments of suitable size. Yet it also sometimes has a brecciated or concretionary structure, when large pieces of irregular shape, often cavernous and easily broken, are taken out. It has a light buff color, and is sometimes white. When freshly quarried it may be spotted and variously marked with purple, especially when taken from the deeper parts of the quarry. The rough and vesicular condition may be seen in Woodbury's quarry, also in Mr. Holt's; the more even-bedded in William Habbeler's. Fossils collected at Genoa have been forwarded to the Palæontologist of the Survey, and the reader is referred to his report for names and descriptions.

The Salina shale immediately overlies the Niagara in Ottawa county. Along the north shore of Sandusky Bay, in the township of Portage, it is an earthy, dove-colored limestone, in beds of two to four inches, which, exposed to the weather, becomes quite blue; and being permeated with gypsum in small, detached masses, it often crumbles. Some of the beds are more enduring, and are, in that case, more brown than blue, weathering a chocolate. The bedding is quite loose, as if some profound disturbance had shattered the layers. At the Plaster Beds, owned by Mr. George A. Marsh, of Sandusky, the Salina is exposed to the depth of thirty feet in quarries which have been opened for gypsum.* Although the geological relation of the rock containing the gypsum cannot be ascertained by examining outcrops within Ottawa county, it is believed to hold a place within the Salina, since neither the Niagara nor the Waterlime is known to afford this mineral in workable quantities in other parts of the country; yet the lithological features of the rock containing it are very similar to those of the Waterlime seen in Wyandot and Allen counties. Although it here has a thickness of at least thirty feet, at Genoa it is reduced to less than a foot, and is seen in the form of a green shale, which also, on weathering, turns blue and falls to pieces. It is best seen at the bottom of the quarry of Messrs. Newman and Ford, but is penetrated also in Wyman and Gregg's.

Over the Salina shale the *Waterlime* is found. This has three distinct lithological characters within the limits of the county. It most frequently occurs—

1st. As a coarse brecciated, gray, or drab-gray, limestone, with rough, cavernous surfaces, indistinct bedding, or massive, with no fossils. It

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*About 10,000 tons of gypsum are taken per annum from these quarries. It is of excellent quality, and is widely sold throughout the western States.

has this character at some points in the western part of the county, but its typical exposure is in the the upper and central portions of the bluffs about the south end of Put-in-Bay Island, and in the island of Gibraltar which incloses Put-in Bay Harbor.

2d Massive or even-bedded, coarse-grained, harsh, dirty buff limestone, non-fossiliferous, magnesian and soft, very much like some parts of the Lower Corniferous; beds fifteen to thirty inches, sometimes with curly bituminous films; useful for general building, and for all walls and abutments. This character of the Waterlime is believed to be confined, in Ottawa county, to its lowest fifteen feet, although it probably occupies less than that thickness. It has not been met with in actual outcrop within the county, but it is in outcrop along the Portage, in Wood county, in such proximity to the Niagara that its place in the formation may be pretty nearly determined. It would probably be found within a belt of three miles wide bordering on either side the Niagara anticlinals.

3d. The Waterlime may appear as it does in the upper part of the quarries of Messrs. Newman and Ford, and of Wyman and Gregg, at Genoa. It is there in beds of about three inches—though they are very often seen at other places less than an inch—and of a drab color. The texture is close, and the grain is fine. The bedding is subject to sudden changes of dip, showing such local flexures as to render it quite impossible to depend on the dip seen for a guide in searching for higher or lower members. It has been seen to vary within the distance of ten rods so much as to change a westerly dip of twenty degrees to an easterly dip of the same amount. Its bedding is uniformly separated by bituminous films or colored sedimentation, which often give the surfaces of the beds a blue cast when exposed to the weather, although the films themselves are at first nearly black. The surfaces of the beds are also usually marked with a stylolitic or wavy contour. This condition of the Waterlime is often fossiliferous.

Phase No 1 is met with only in Ottawa, Wood, and some parts of Sandusky counties. It wholly disappears from the formation in counties further south. Phase No. 2, while it occupies the base, or a position near the base, of the formation in Ottawa and Wood counties, also is met with near the top, in close proximity to the Oriskany sandstone, in Sandusky and Seneca counties. They seem to be gradually replaced by phase No. 3, which, with a considerable addition of bituminous matter, is the only form of the Waterlime seen in counties further south (Wyandot and Allen). No. 1 is believed to change its place stratigraphically in the formation, or at least not to be confined to any definite limits. Its position at Put-in-Bay Island, in the upper part of the Waterlime, corresponds, in general, with that in the island of Mackinac, although it shows at the latter place a greater thickness, and is not separated by a belt of regularly laminated beds into two portions. Yet this tendency to the rough and brecciated condition has been seen even in the very bottom of the formation. In the quarry of Messrs. Newman and Ford, at Genoa, there are irregular masses of porous and brecciated rock, which, by cementing and breaking up the bedding, give the formation a massive structure. In the bed of the Portage, in section 9 (Harris), there are singular, dome-shaped masses of rough and vesicular, or brecciated, Waterlime, standing out six to eighteen inches above the glaciated surface, on which the even beds (phase No. 3), which are thin, seem to have been deposited unconformably, or are arranged concentrically about the mass.

The following downward section covers all the quarries at Genoa:

SECTION AT GENOA.

No. 1.	Thin beds, 1 to 3 inches, drab	1 foot.
No. 2.	Brecciated and carious, with cavities and fossils	6 to 12 feet.
No. 3.	Green shale, weathering blue	1 foot.
No. 4.	Niagara (Guelph), beds 3 to 6 inches	16 feet.

The quarries of Messrs. Newman and Ford, and of Wyman and Gregg, at Genoa, are in the base of the Waterlime. Other quarries at the same place are situated in the top of the Niagara.

The Waterlime underlies a strip about two miles wide north and south along the western end of the county, and a large area in the center. It also crosses "the Peninsula" through the townships of Rensselaer and Danbury.

The Drift in Ottawa county has not been so carefully observed as in adjoining counties, yet it is believed not to be an exception to the general view which has been taken of the Drift deposits in the Fourth District. The banks of the Portage consist, wherever seen, of unmodified Drift. The upper six to eight feet are of a light brown color, and the first two or three very rarely contain stones or gravel. It is, perhaps, to some extent made up of a re-deposit of the finest parts of the hardpan, incident to the sifting agency of the waves and currents of Lake Erie when it stood at a higher level; but it is generally too gravelly to admit of that origin, and its finest parts, if deposited in that way, can not be separated or distinguished from those parts of the unmodified Drift which are also very fine, and which graduate insensibly into it. In general, also, such re-deposits by the action of Lake Erie consist of sand with no stratification, while this fine clay is seen sometimes, as at Toledo, to be handsomely arranged in horizontal and oblique laminations, with alternations of very fine sandy layers.

Below the brown hard-pan there is an unknown thickness of blue hard-pan. This also contains gravel stones of all sizes, and often large bowlders. In the township of Benton, along the northern division of the Lake Shore and Michigan Southern Railroad, a number of wells, sunk for supplying steam saw-mills with water, have penetrated this blue hard-pan a few feet. It sometimes shows an indistinct stratification, and in one or two wells near Genoa beds of gravel and sand were met in this deposit, or immediately below it. In a moist state, as thrown out of the well, it has a tough plasticity, and is known as "*blue clay.*" The average thickness of this deposit in the county would probably not fall short of forty feet. Below this, and lying on the rock, there is apt to be a stratum of water-worn gravel and sand, which lies in a very compacted state, often cemented along its upper surface into a rock-like layer, which offers great resistance to the drill. It is sometimes mistaken for the rock-bed. Below the cemented layer the sand and gravel, when present, is from six inches to ten feet, and usually supplies water. It is plain that the water in such wells, confined before by the impervious hard-pan above, will rise immediately with great force to a height equal to that of its head or source, or until it encounters a way of lateral escape through beds of sand or gravel in the hard-pan. The slope of the surface being very gradual toward Lake Erie, such artesian wells rise but few feet above the ground. They are found at Oak Harbor, in Salem township, at a depth of about fifty feet, the water rising but a few inches above the surface. Nearer Lake Erie, along the Toussaint Creek, the water rises in such wells about seven feet above the ground. In connection with the Drift phenomena, the occurrence of stones and bowlders of all kinds in the vicinity of the limestone ridges must be mentioned. They are due to the removal of the finer parts of the Drift by the waves and currents of Lake Erie, and are left on the bare rock, and in a belt surrounding it, because they could not be so removed. Their place was originally in the glacial hard-pan.*

Wells and Springs.—The artesian wells of Ernest Frank, Esq., and of Mr. George Momany, of Oak Harbor, have a distinct sulphurous taste. A well of Mr. Messersmith, in section 22, Benton township, is very strongly sulphureted, and the water is used only because of the difficulty of obtaining other water. This water issues from the rock, and as such water is known to rise from the Niagara limestone at various points in other counties, it is the best evidence we have, in the absence of natural outcrops, of the presence of that formation. There are other wells in

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* See page 17 and page 60.

the same part of the county which, without penetrating the rock, have similar mineral water. They, however, derive it from the gravelly sheet which lies on the rock, the water of which must be considerably affected by streams from the rock. Such springs and wells as depend on the gravel or sand within the hard-pan could not be influenced by the underlying rock. Hence they are not known to show only those mineral characters that they can obtain in the Drift. They are sometimes chalybeate, but usually show no impurities whatever.

The well of Mr. George Momany seems to be influenced by the fluctuations of the level of Lake Erie. A westerly wind for a few days depresses the west end of the Lake, and the rise of water in the well is less. When a wind from the east or north-east prevails, it overflows at greater height. This was noticed by Mr. Momany by reason of the well ceasing to flow at certain times, owing to the outflow being within an inch of the greatest rise. It seems, therefore, that the height to which water will rise in artesian wells depends not altogether on the level of their supply, but also on the facility of escape below. This point is supposed to be about seven feet above Lake Erie, and the actual set-back of dead-water from that obstruction could not be much above the level of that lake. This seems to be an illustration of that principle of hydrostatics, but little known, that an obstruction in a current, as in a river, not only causes a certain amount of "dead-water" near it, but also retards, by a kind of reaction, the water higher up the stream, when the rapidity of the current is not perceptibly changed to the eye.

MATERIAL RESOURCES.

Besides the deep and fertile soil that every where covers the county, and furnishes the chief means of material wealth, Ottawa county is generously supplied with other natural resources, the immediate product of the underlying rock. The quarries in the Lower Corniferous limestone in the eastern part of the county, known as the "Marblehead Quarries," are highly prized for the fine blocks of a variegated stone, suitable for the largest structures, which they produce, and which are extensively used not only in many places in the State of Ohio, but in neighboring States. They will be more fully noticed in the report on that part of the county.

The shipments of gypsum from the Plaster Bed quarries of George A. Marsh, in the township of Portage, amount to six or eight thousand tons per annum, bringing three dollars per ton. The gypsum is of unusual purity and whiteness, with occasional delicate cloudings. The principal markets for agricultural purposes are in Ohio, Kentucky, Indiana, and

Michigan. It is found in the principal cities from Buffalo to Memphis, and from Pittsburgh to Chicago.

The facilities for lime-burning in the western part of the county can not be surpassed. The stone, itself of the best quality, occurs in the most favorable situations, both for purposes of quarrying and for cheapness of shipment. These circumstances have made Genoa the greatest lime-shipping point on the Lake Shore and Michigan Southern Railroad, the aggregate being, for the year 1870, nearly twelve thousand tons. The lime, especially that which is burnt from the Niagara formation, is a pure white, yet that from the Waterlime can not, by the eye alone, be distinguished from it. The two are sold in the market indiscriminately, bringing the same price. It is believed, however, that the Niagara will differ from the Waterlime in being more cheaply and quickly burned, will weigh less, bulk for bulk, will be a little whiter, will slack quicker and with greater evolution of heat, and will set sooner. The Waterlime is more dense, has a slight hydraulic quality—at least in many places—will not crack after once setting in the wall, and for plasterers' use will be preferable in applying hard-finish, since it will afford ample time for polishing and rubbing down.

The only brick-yard within the county, so far as known, is that owned by Henry Moser, at Elmore.

CHAPTER XXXV.

REPORT ON THE GEOLOGY OF CRAWFORD COUNTY.

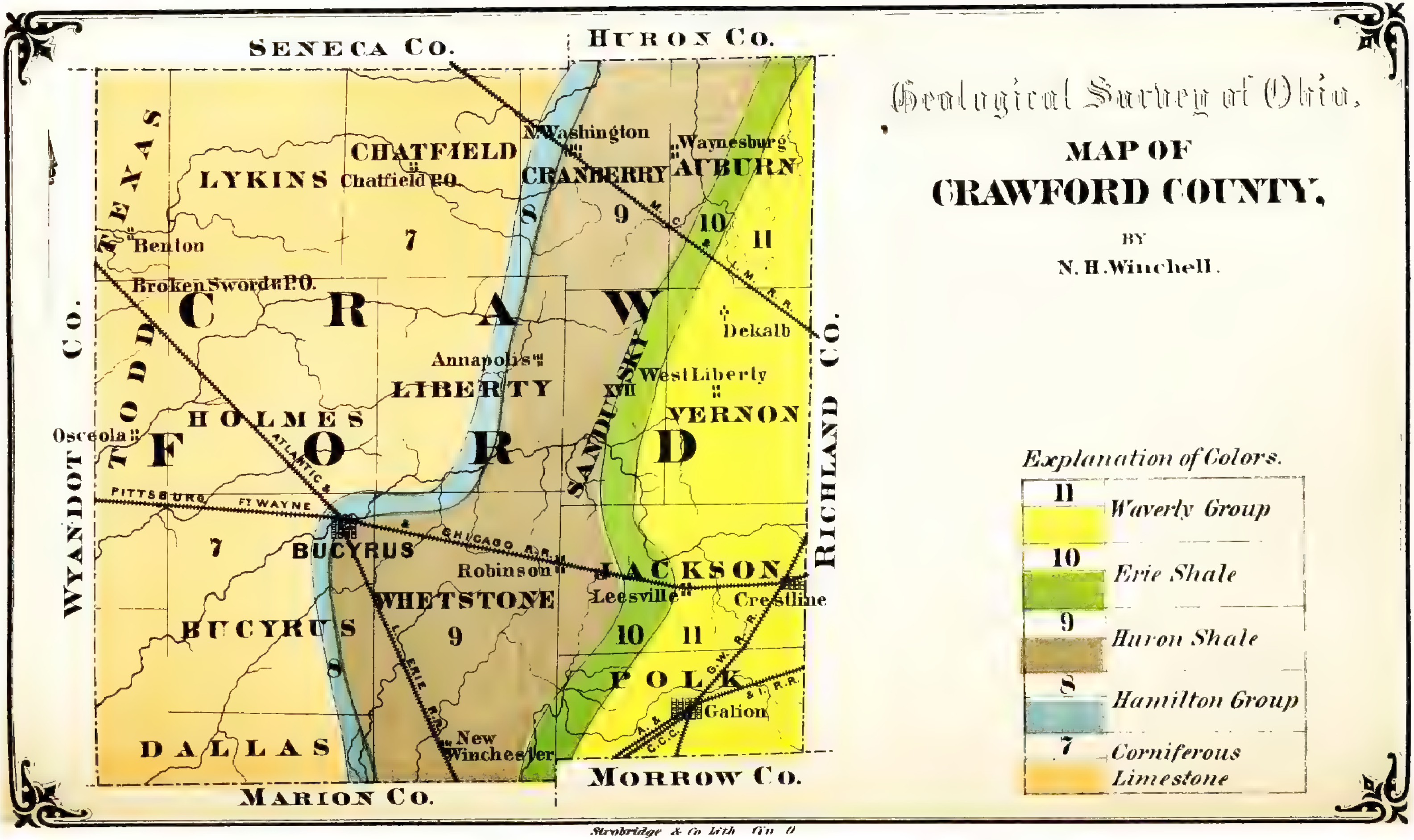
BY N. H. WINCHELL.

SITUATION AND AREA.

Crawford county lies north from the center of the State, and about midway between that point and Lake Erie. It is bounded north by Seneca and Huron, east by Richland, south by Morrow and Marion, and west by Wyandot, and has an area of about eleven congressional towns, situated so as to give it nearly the form of a square. Its total area is 252,156 acres, of which 138,368 are arable, 37,074 meadow and pasture lands, and 76,714 uncultivated or woodland. The average value, exclusive of buildings, is $29.78 per acre.

NATURAL DRAINAGE.

It lies on the summit of the great watershed, embracing the headwaters of some of the principal rivers of the State, that leave it in opposite directions. In the north-eastern corner of the county are a few small tributaries that join the Huron River in a northerly direction. Those of the Scioto and Olentangy have a general south-westerly direction until they are well off the watershed and on the southern slope. The upper waters of the Sandusky River, including its tributaries, the Sycamore Creek, Cass Run, and Broken Sword Creek, have a noticeable flow south-westwardly and westerly along the direction of the general watershed until they are outside of the limits of the county, when they reach the greater valley of the Sandusky; then they turn nearly at right angles north-westerly and unite with that river. The streams are generally small, yet large enough to afford, in favorable situations, ample water-power for flouring and manufactures. The flatness of the county generally, except in the eastern tier of towns, is unfavorable for the production of water-powers. The rivers rarely strike the bed-rock, and hence rarely have waterfalls or rapids that can be so utilized.


Geological Survey of Ohio,
MAP OF
CRAWFORD COUNTY.
BY
N. H. Winchell.
Explanation of Colors.
11 Waverly Group
10 Erie Shale
9 Huron Shale
8 Hamilton Group
7 Corniferous Limestone
SENECA CO.
HURON CO.
RICHLAND CO.
MORROW CO.
MARION CO.
WYANDOT CO.
CRAWFORD
TEXAS
LYKINS
CHATFIELD
CRANBERRY
AUBURN
TODD
HOLMES
LIBERTY
VERNON
BUCYRUS
WHETSTONE
JACKSON
POLK
DALLAS
SANDUSKY
XVII
Chatfield P.O.
Benton
Broken Sword P.O.
N. Washington
Waynesburg
Dekalb
West Liberty
Annapolis
Osceola
BUCYRUS
Robinson
Leesville
Crestline
Galion
New Winchester
PITTSBURG, FT. WAYNE
ATLANTIC &
CHICAGO R.R.
L. ERIE R.R.
M. C. L. M. R.R.
Strobridge & Co Lith Cin O

SURFACE FEATURES.

A general division of the county may be made into three nearly equal belts running north and south. The most easterly of these belts may be described as rolling and stony, with frequent gravel beds and bowlders; yet in the eastern portion of the townships of Vernon and Jackson the surface is decidedly flat, even in this belt. The streams throughout this belt have greatly increased the original unevenness of the Drift surface, and in some cases their channels are dug, not only through the Drift, but also into the rock, to the depth of forty or sixty feet. At the quarry of Mr. James Morrow, section 1 (Jackson), the banks of the Sandusky have a height of 68 feet 6 inches, abruptly rising from the water, with a further ascent of 10 feet within a few rods. Thirty-five feet of this excavation is in the Berea grit of the Waverly sandstone. Under this stone is a shale, probably belonging to the Bedford of Dr. Newberry, which is not bituminous.

The second, or middle, belt affords a strong contrast to the last, being usually quite flat. It is very distinctly marked off by a series of knobs or gravelly hills pertaining to the Drift. East of this rolling upland the surface is apt to continue more or less broken, producing the features already described, while toward the west the surface becomes very soon a monotonous flat, with a tough and heavy clay soil. This distinction is very marked in the central and southern portions of the county. In the northern its uniformity is disturbed by the influence of a series of ridges which intersect it; and the whole northern portion of the second belt, as in the vicinity of New Washington and Annapolis, is undulating, with a gravelly clay soil. This middle belt is underlain by the black slate and the shale beds above and below it. The streams in this middle belt, though deeply cut in the Drift, very rarely expose the underlying rock.

The third belt lies along the west side of the county, and is about coextensive with the area underlain by the upper member of the Corniferous limestone. The surface here varies from flat to undulating. In the southern part of the county it is flat and marshy. Extensive prairies prevail in Dallas township. But the northern portion of this belt is more broken, and characterized by broad surface swells, or ridges, which cross the belt obliquely.

The features of these three belts seem to be coincident with, and doubtless are dependent on, the nature of the underlying rock. They are all confined to the surface deposits. If these deposits were brought about by a uniform force, acting equally on all parts of the county, such as submergence beneath the ocean, the character of the underlying rock would produce no effect on the distribution and character of the Drift, especially in a county so level as Crawford county is. That force, whatever it was, must hence have been something that came some way into contact with the rock, in order to receive different impressions from it.

As has already been remarked, the uniformity of the characters of these belts is interrupted by a series of ridges, equally pertaining to the Drift, which cross them in a direction north-east and south-west. A very prominent ridge of Drift materials enters the county from Wyandot county,* in section 1, Todd township, and runs along the north side of the Broken Sword Creek, serving in Crawford county, as in Wyandot, as a barrier to the westward flow of that stream to the valley of the Sandusky, driving it far to the south-west before it is able to pass it. The handsome farm and residence of Mr. J. A. Klink, section 6, Liberty township, are located upon it. This ridge of Drift can be traced, with some interruptions, through north-western Ohio a distance of over a hundred miles, when it leaves the State and enters Indiana. It has been named the Wabash Ridge, from the Wabash River, which it diverts from its course through a distance of more than forty miles. In Crawford county the Drift accumulations belonging to this ridge are not always heaped up in one ridge, but are spread out into a succession of ridges having the same direction and made up of similar materials. This is particularly noticeable north from Bucyrus, in the township of Chatfield. This series of parallel ridges crosses the northern portion of Todd and Holmes townships. In Cranberry township, as it enters upon the rolling tract due to the underlying Waverly sandstone, it becomes confused, and cannot certainly be identified. It lies on the north side of the watershed of the State, and pertains to the Lake Erie valley, yet it serves to turn the Scioto diagonally across the watershed, and causes it to turn southward instead of northward. In the same way it diverts the Wabash from the Lake Erie valley, and compels its waters to reach the ocean through the Mississippi valley instead of the St. Lawrence.

Soil and Timber.—The soil of Crawford county varies, of course, according to the prevalence of one or the other of the foregoing varieties of surface. In the eastern belt it is gravelly, with some patches of tough clay. In the central belt it is generally clayey, and needs artificial drainage. In the western belt it is a clayey soil, but shows more gravel than in the central. The soil of the ridges above described is sufficiently gravelly, and the surface is sufficiently sloping, to admit of perfect natural drainage. The prairie patches, situated in different parts of the county, are

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* See Geology of Wyandot County.

sometimes untillable by reason of poor drainage. The soil is here made up largely of organic matters in process of decay. The county originally was mostly covered with a deciduous forest. The prairies, even, in Dallas and Whetstone townships, have some small oaks and hickories scattered through them on knolls of coarser Drift that rise above the common flat.

The following varieties of timber were observed in traveling over the county. This list can not be regarded as complete, but embraces the most prominent varieties:

Oak—Quercus alba (White Oak)	L.
" palustris (Pin Oak)	DuRoi.
" bicolor (Swamp White Oak)	Willd.
" Castanea (Chestnut Oak)	Willd.
" prinoides (Chinquapin)	Willd.
" rubra (Red Oak)	L.
Beech—Fagus ferruginea	Ait.
Sugar Maple—Acer saccharinum	Wang.
Cottonwood—Populus monilifera	Ait.
Elm—Ulmus Americana	Willd.
Black Cherry—Prunus serotina	Ehr.
Butternut—Juglans cinerea	L.
Black Walnut—Juglans nigra	L.
Shagbark Hickory—Carya alba	Nutl.
Tulip Tree—Liriodendron tulipifera	L.
Pepperidge—Nyssa multiflora	Wang.
Buckeye—Æsculus glabra	Willd.
White Ash—Fraxinus Americana	L.
Swamp Maple—Acer rubrum	L.
Sassafras—Sassafras officinale	Nees.
Basswood—Tilia Americana	L.
Sycamore—Platanus occidentalis	L.
Ironwood—Ostrya Virginica	Willd.
Blue Beech—Carpinus Americana	Michx.
Honey Locust—Gleditschia triacanthos	L.
Aspen—Populus tremuloides	Michx.
Willow—Salix nigra (tree a foot in diameter; wet places; leaf small, lance-linear)	Marsh.
Chestnut—Castanea vesca (in Auburn township, Sec. 10, and sparingly at Leesville and Galion)	L.
Thorn—Crataegus coccinea	L.

GEOLOGICAL STRUCTURE.

The strike of the formations is north and south across the county, the dip being toward the east. The rocks of the county pertain to the

Devonian and Carboniferous ages, and may be enumerated as follows, in descending order:

	Approximate thickness.
Cuyahoga shale and sandstone	50 feet.
Berea grit	35 "
Bedford shale	20 "
Cleveland shale	50 "
Erie shale	30 "
Huron shale	200 "
Olentangy shale	30 "
Upper Corniferous (Tully and Hamilton limestones)	35 "
Lower Corniferous (Corniferous and Onondaga limestones)	75 "
Total approximate thickness	525 "

Of these the first five belong to the Carboniferous, the remainder to the Devonian.*

The Cuyahoga Shale and Sandstone.—This shale further north, and especially at Cleveland, has a very great development, reaching there the thickness of one hundred and fifty feet. In Crawford county it has not been certainly identified in outcrop, but most probably underlies the flat land in the eastern part of Vernon, Jackson, and Polk townships. It is met with in Morrow county, where the arenaceous character becomes so strong that it is often quarried for building. Further south it is probably the equivalent of the "Logan sandstone," one of the members of the Waverly group.

The Berea Grit.—This is the most important member of the Waverly group. Its line of outcrop is marked by a series of quarries which crosses the eastern tier of townships, the most important of which are located in Jackson and Polk townships. Beginning in Auburn township, the most northerly outcrop of the Berea within Crawford county is in S. W. ¼, section 28, where it is found along a little creek on Samuel Hilborn's land, and at the highway bridge. It also occurs near DeKalb, in Vernon township, on Mr. James Coruther's land. Slight exposures occur also S. W. ¼, section 19, along a little creek on land of Barnet Cole and Adam Freeze. It may also be seen on the land of James Campbell and Jacob Myers. In section 36 (Sandusky), it is exposed in a ravine on the farms of David Wirtz and Fred. Beech. In Jackson township, N. E. ¼, section 1, is James Morrow's quarry.

SECTION AT JAMES MORROW'S QUARRY, SECTION 1, JACKSON TOWNSHIP.

		Ft.	In.
No. 1.	Thin-bedded sandstone	8	0
No. 2.	Heavy-bedded sandstone	27	0
No. 3.	Shale (Bedford and Cleveland), not well seen	33	6
	Total thickness	68	6

* Dr. Newberry.

This quarry is one of the oldest in the county. The quarries at Leesville are about a mile north of the railroad station, and in the bluffs of the Sandusky. Those of Mr. John Bippus have been constantly worked for thirty or forty years. Others at Leesville are owned by John Haller and John Newman. Mr. J. W. Shumaker has also recently opened a quarry on his land.

Mr. Bippus's quarry, near the highway bridge at Leesville, is on the same horizon as that of Mr. James Morrow. The exposure is somewhat less, and as follows, in descending order:

SECTION AT JOHN BIPPUS'S QUARRY, LEESVILLE.

No. 1.	Thin beds, or flags, 1 to 3 inches	10 feet.
" 2.	Heavy-bedded sandstone	16 "
	Slight dip east.	

Mr. Haller's has about twelve feet exposed. The upper six feet are in beds of six to eight inches. The rest is like the upper part of Bippus's, and on the same horizon.

Mr. Newman's quarry is in stone about the same as Bippus's, without exposing the heavy beds.

In Polk township (S. E. ¼ section 2) Mr. Thomas Park's quarry is located just at the point where the river, the two railroads, and the highway all cross each other. The exposed section here is as follows:

SECTION AT THOMAS PARK'S QUARRY, IN POLK TOWNSHIP.

No. 1.	Hard-pan Drift	12 to 15 feet.
" 2.	Thin, loose beds of sandstone	15 "
" 3.	Thick beds of sandstone	12 "
" 4.	Blue shale, seen	10 inches.

The quarry of Mr. Asa Hosford is situated N. W. ¼ section 1, in Polk township, and shows about twenty-five feet of sandstone on the same horizon as Mr. Park's. Below the sandstone Mr. Park encounters, according to his description, a loose, sandy bed, of a few feet in thickness and blue color, before reaching the Bedford shale.

None of the quarries in the Berea in Crawford county show a conglomeratic or even a coarse-grained composition. The stone is rather a homogeneous and moderately fine-grained sandstone. Its thickness seems to be no more than thirty-five or forty feet. It graduates upward into a shaly and thin-bedded sandstone, that probably belongs to the *Cuyahoga* division of the Waverly.

The Bedford Shale.—At Elyria, and further east, as in Cuyahoga county, the Berea grit is underlain by a copper-colored and bluish shale, the colors of which vary in their positions. At Elyria the copper-colored or red shale lies first under the sandstone, which seems to be considerably tilted from the horizontal position by upward protrusions of the shale. The same phenomenon may be seen at Leesville, although there the horizontality of the sandstone is not disturbed, and the color is gray, or light blue, weathering to an ashen blue. This shale may be seen a few rods above Mr. Bippus's quarry, on the left bank of the Sandusky, exposing about fourteen feet. The shale appears to protrude upward. The exact manner of superposition of the sandstone cannot be seen, but, judging from the horizontality of the sandstone beds, where they reappear a few rods higher up the river, and also on the other bank, nearly opposite, the shale looks like an isolated or lenticular mass—at least, that its upper side is unconformable with the sandstone beds.

The thickness of this shale cannot be stated. Its identity with the Bedford is also somewhat doubtful, although its horizon is exactly that of the Bedford. This fact, taken in connection with the occurrence of red shale below the stone at Mr. Morrow's quarry, section 1, Jackson, is strong presumptive evidence of the continuance of the Bedford as far at least as Crawford county. It is not known to afford any fossils in Crawford county. It is also slightly exposed in the creek, N. E. ¼ section 2, in Polk township, near the highway bridge.

The Cleveland Shale.—The identification of this member of the Waverly group is not so satisfactory as desirable. Yet there are two exposures of a black, or purplish-black, shale in the county, that cannot, apparently, be referred to the great black slate of the Devonian. At Mr. James Morrow's quarry the sandstone is underlain by thirty-three and one-half feet of shale. Near the bottom of the sandstone this shale is red. In the bed of the river, thirty feet lower, it is a bluish black. It is supposed that about twenty feet of this belongs to the Bedford, and the remainder to the Cleveland, although the junction of the two has not been seen.

Similar shale is exposed on the farm of Mrs. Steinbach, S. E. ¼ section 12, Jackson, in the bank of the Sandusky. When it is wet it is black, but when dry it becomes slate-colored. It crumbles under the weather into pieces *no larger* than an inch across, and usually less than half an inch, and a quarter of an inch or less in thickness. It shows here a very slight dip east, and is exposed to the amount of twenty feet. This must be slightly below the horizon, exposed in the river at Mr. Morrow's, and will give as the observed thickness of the Cleveland in the county about thirty-three feet. Careful search for fossils in the outcrop on Mrs. Steinbach's farm afforded none.

The Erie Shale.—Below the Cleveland shale there is a considerable thickness of gray shale, reaching four or five hundred feet in Cuyahoga county. It has been named the Erie shale by Dr. Newberry. Although this shale has not been observed in outcrop at but one place in the county, it is believed to occupy a belt of flat land intervening between the outcropping edge of the Cleveland shale and that of the black slate. It was struck in a well at twenty-eight feet, by Mr John Shumaker, N. E. ¼ section 26, Polk. Pieces thrown out of this well have a somewhat firm and rock-like aspect. It glitters in the sun as if with minute scales of mica, and is specked as if with coal.

The Huron Shale.—This conspicuous formation occupies a belt about six or eight miles wide, running north and south across the center of the county. The city of Bucyrus is just within its western edge. It underlies portions of Chatfield and Cranberry, and all of Liberty and Whetstone townships. Although it may be called a conspicuous geological horizon, yet not an exposure of it is known to occur in Crawford county. It is met with sometimes within the area mentioned, in drilling wells, and its presence is then evinced by the offensive odor of the water obtained, or by the escape of inflammable gas. In general, wherever the Huron shale underlies the Drift, there is a belt of sulphur springs and gas wells. Such sulphur springs occur at Annapolis and in the vicinity of New Washington. At the latter place wells dug to the rock emitted a gas, which accidentally took fire and caused considerable alarm by the violence of the flame. They were immediately filled by the owners. On Joseph Kniseley's land, section 26, Sandusky township, is an unusual assemblage of natural gas springs. The gas accompanies the rising water, and is sufficient to serve for illumination, for which it was used for some years. A funnel placed over one of these springs so as to confine the gas, supported a flame continuously for two years.

Olentangy Shale.—Below the Huron shale, which is black, tough, and bituminous, is a thickness of about thirty feet of a bluish and more sectile shale, containing less bituminous matter. It sometimes is interstratified through its whole perpendicular extent with bituminous beds, like those of the Huron shale. It has afforded no fossils, but holds occasional thin beds of impure blue limestone. It lies on the top of the blue limestone quarried in the western part of the county. It is not visible in Crawford county, but is favorably exposed in Marion and Delaware counties along the Olentangy Creek.* On the geological map of the county it is named "Hamilton group" by Dr. Newberry.

Corniferous Limestone.—This name has been applied to the limestones intervening between the foregoing shales and the Oriskany sandstone

* See Geology of Delaware County.

that forms the base of the Devonian. It is distinctly divisible, on palæontological and lithological differences, into two parts, the upper part embracing the "blue limestone," which shows some relations to the Hamilton, and the lower part embracing the lighter-colored and dolomitic limestones of the Upper Helderberg of the Mississippi basin. They are both well represented and favorably exposed in the western part of Crawford county. The former is about thirty-five feet thick, and is extensively wrought at Delaware and Sandusky. The latter is quarried at Marblehead, on the peninsula north of Sandusky, and at Columbus, in Franklin county, and is about seventy-five feet thick.*

In Crawford county the exposures of the limestones are mostly confined to the Broken Sword Creek. Beginning in section 18, Holmes township, the Upper Corniferous appears first on the land of S. F. Sawyer, where it has been worked a little. It makes a floor-like bed to the creek, rising but few inches above the water along the banks. Beds are three to five inches thick, containing *Strophomena rhomboidalis*, Wahlenb., and numerous crinoidal stems. Mr. C. K. Stephens's quarry is on the next "eighty," toward the south. About four feet of hard, blue limestone can here be made out, although much of the quarry is subject to inundation by the creek, showing a decided dip to the north-east. The stone is in beds of about four inches, varying below that thickness, making a good flagstone. Some of it is harsh on weathering, although plainly argillaceous and sometimes with vermicular or fucoidal markings. It is also liable to be shaly, or slaty, irregularly. Lenticular flakes cleave off. It has distinct purely calcareous bands of sedimentation. It contains *Cyrtia Hamiltonensis* and a species of *Tentaculites*. It also holds casts of large coiled cephalopods. Its general facies is that of a firm limestone, nearly free from magnesia, but containing irony, bituminous, and argillaceous impurities. The next quarry in descending the stream is that of Christian Reiff, in beds of the Upper Corniferous, stone undistinguishable from the foregoing. The quarry of Mr. Perry Wilson is opposite that of Nicholas Poole, on the S. E. ¼ section 24. The stone here is the same essentially as that at Stephens's, but is undoubtedly in a lower horizon, exposed six or eight feet. The Bucyrus corporation owns a quarry here in the same beds of the Upper Corniferous.

The Upper Corniferous also occurs on Mr. Edward Cooper's land, N. W. ¼ section 33, in Liberty township. It is but little opened and cannot be seen *in situ*, although there is no doubt of its being so. The pieces that have been taken out are thin and fossiliferous, *Spirifer mucronatus* being

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* See Geology of Delaware County.

the most noticeable fossil. Although the stone, so far as explored, here appears rather slaty, it would probably become thicker and very useful for common building on reaching the undisturbed bedding. The situation of this outcrop demonstrates either a wide detour westward of the boundary line separating the geographical areas of the Corniferous and overlying shale, or an isolated area of Corniferous surrounded by the shale, since it is sufficiently certain that the black slate underlies the city of Bucyrus. On the other hand, the Bucyrus area of black slate may be an outlier only, surrounded on all sides by the underlying limestone. Besides the places above mentioned, there are many indications of the occurrence of the Upper Corniferous in the bank of the Sandusky, on the S. E. ¼ section 24, in Dallas township, on the land of Mr. McNeal. A little below Mr. McNeal's, in the same section, flat stone, answering to the Upper Corniferous, was taken out of the bed of the Sandusky in small quantities, about twelve years since, on land now owned by Mr. James Echart.

The Lower Corniferous is also exposed in the Broken Sword Creek, and at Benton, in the Sycamore Creek. At the latter place it is worked a little by Mr. Benjamin Kuntzman and Mr. Martin Stoertzer. It may be seen more or less in the bed of the creek between Benton and the county line. Throughout this distance the exposures are so meager, owing to the prevalence of the Drift, that the rock cannot be seen except where the water actually runs, and no reliable section can be obtained. It is a coarse-grained, dirty, fossiliferous, and magnesian limestone, with considerable bituminous matter, in beds varying from six to twenty inches in thickness, suitable for abutments and heavy walls. Near Occola the Lower Corniferous is considerably exposed, and is quarried for general building stone and for quicklime. The following quarries are in the Lower Corniferous at this place, viz., those of John Schnavely, David Schnavely, widow Schnavely, Luther M. Myers, Dennis Coder, Gotleib Doerer, and Joseph B. Christie. Of these, John Schnavely's and Mrs. Schnavely's are in the upper portion of the Lower Corniferous, the principal fossils of which are brachiopods. The stone is light-colored and crystalline, appearing somewhat saccharoidal, in beds of about three inches. The lime made is nearly white, but slightly creamy. The quarries of Messrs. Myers, Coder, Doerer, and Christie are in lower beds. The stone of these quarries, when fossiliferous, is characterized by a profusion of corals, with very few brachiopods. It is bituminous and also magnesian, harsh to the touch, appearing often much like a sandstone. It is a much darker colored stone than that of Schnavely's quarry, but the lime made from it is equally white. Large portions of the stone are perfectly free from bituminous impurities. Such are especially the compact coral masses, which make a purely white lime. The genera *Stromatopora*, *Coenostroma*, and *Cyathophyllum* are most common. *Cystiphyllum* can also be distinguished in the rock, as well as *Favosites*. There is also a coralline form which shows no evident structure, but seems to consist of a series of concentric waves on a rock surface, spreading over a diameter of a foot or two. At Mr. Myers's quarry these corals are especially displayed, making the stone very irregular both as to color and bedding. Although the thickness of the beds is usually from two to four inches, they are quite loose and often lenticular. Thick films and scales of black bituminous matter spread through it, giving rise to various local designations for the different portions of the quarry. In some places the bituminous matter is evenly disseminated through the beds, making the whole appear darker, even to a brown; in others it is gathered into scales, films, and pockets, which, combined with the occurrence of the different corals, produces a very uneven and unattractive stone.

The Drift.—This deposit in Crawford county received special attention during the progress of the Survey. I presents the usual characters of a glacier deposit. Its most common aspect is that of a gravelly clay, elsewhere designated hard-pan. This clay not only embraces gravel stones, but also bowlders of all sizes, and has an average thickness of thirty to fifty feet. Along streams, and in all valleys of erosion even where no streams now exist, the bowlders belonging in this hard-pan are made to appear superficial by the removal by running water of the clayey ingredients. Occasional exposures of the Drift in fresh sections reveal not only a confused mingling of clay, stones, and bowlders, but also in some places an oblique stratification and perfect assortment of gravel and sand. Such stratified beds pertain, for the most part, to the upper portion of the Drift, and specially prevail in the eastern or sandstone district. They give rise to springs of ferriferous water, and furnish that of a great many wells. In counties bordering the lake shore this hard-pan is frequently overlain by a fine clay arranged in horizontal laminations, but that form of the Drift is not met with in Crawford county. At the bottom of the hard-pan, and separating it from the bed-rock, there is very often a water-bearing layer of gravel and sand.

As has already been remarked under the head of *Surface Features*, the Drift of Crawford county lies in ridges crossing the northern and central portions of the county. These are believed to be due to the temporary halting of the margin of the ice-field when it occupied successively those positions. These ridges are all situated so near each other, and sometimes become so involved with each other, that they seem to pertain to one system, or to one greater moraine ridge. Indeed, they are not generally separable, but are heaped together in one ridge, that which lies along the north-west side of the Broken Sword Creek.

The color of the Drift is blue, except where it is oxidized or stained by iron. The blue color may be seen in railroad cuts, as on sections 4 and 3, Vernon and near New Washington, but generally it is replaced by a yellowish-brown, or rarely by a reddish or irony-brown, as in the north-eastern part of Auburn township, to the depth of about fifteen feet, depending on its porosity or facility for absorbing water and air. No glacial marks have been seen in the county.

At Leesville, in the southern part of section 7, Jackson, is a long and prominent ridge of gravel, popularly denominated a "hog's-back." The gravel ridge has been in use for fourteen years, during which time thousands of car loads have been taken away for the Pittsburgh, Fort Wayne and Chicago Railroad, but the part which still remains rises forty feet above the surrounding level. A former spur from this, known as the "Cleveland Hill," rose twenty feet higher, but it has been entirely removed. This gravel ridge is a little over half a mile long, and runs nearly north and south, or a trifle east of south. The "Cleveland Hill" tended more easterly along the southern extremity. The main ridge lies on the observed line of superposition of the Berea grit over the Bedford shale. The soft shale is in outcrop along the banks of the Sandusky River, on section 12, within a quarter of a mile of the ridge, and the sandstone is extensively wrought about half a mile east of the ridge. This ridge is not bordered on both sides by low, swampy belts, as several others have been observed to be, at least it is not on the eastern side. On the west side there is more low ground, but the Sandusky River and a ravine tributary to it have somewhat broken up its original surroundings in that respect. The country about is flat, or nearly so, and the drift is made up of the common hard-pan clay. The gravel of the ridge embraces a great many bowlders about the size of eighteen inches in diameter, some also much larger. This conjunction of a gravel ridge pertaining to the Drift with the line of outcrop of two formations, the one hard and the other soft, is not an uncommon occurrence in north-western Ohio. They are mentioned under the head of *Drift* in the reports on Auglaize, Hardin, Allen, Morrow, and Delaware counties, and seem to the writer to bear an intimate relation to the cause of that deposit. They indicate that whatever that cause was, it was susceptible of being influenced by the character of the underlying rock.

The skeleton of a mastodon was exhumed near Bucyrus many years ago. It was nearly perfect, and was imbedded in the muck and marl of a swamp. It is described in the report for 1839 of the former Geological Board. What remains of it is now in possession of the Ohio Agricultural and Mechanical College.

Wells and Springs.—The following list of wells will give some idea both of the thickness of the Drift deposit and of the quality of water found in different parts of the county:

WELLS AND SPRINGS.

Owner's name.	Location.	Feet above the rock.	Feet in the rock.	Total depth.	Through what.	Remarks.
Luther M. Myers ...	N.W. ¼ sec. 25, Todd	22	......	22	Gravel, sand, and blue clay	Good water. Well situated 13 rods N.W. of the creek.
Luther M. Myers ...	"	6	4	10	All coarse gravel	Good water. Well in creek bottoms.
George Heiby	Sec. 14, Liberty	40	......	40	Clay, then hard-pan	Good water.
Alcorn House	Bucyrus	28	......	28	To the rock.....	Sulphurous water.
Rudolph Heiply	N. Washington	18	......	18	Brown loam and sand......	Good water.
Paul Miller............	"	34	......	34	....	"
Catholic Church.....	"	65	......	65	Blue clay	"
Jacob Stoutenour ...	"	15	......	15	....	"
Jacob Stoutenour ...	"	14½	......	14½	....	"
* John A. Sheetz.....	W. ½ sec. 14, Cranberry	30	......	30	....	Gas; filled again.
* Abram Guiss........	"	30	......	30	Clay............ ..	Gas and water; filled again.
Jacob Hofsaetz........	Waynesburg ...	21	......	21	Brown and blue clay......	Good water in gravel.
Wensel Mor..........	"	18	......	18	....	Good water.
William Lahman ...	"	32	......	32	....	"
Jacob Bender.........	N. E. ¼ sec. 5, Vernon..........	13	......	13	Clay and gravel	"
Louis Weller	W. Liberty	16	......	16	....	"
John Warner	"	15	......	15	....	Artesian.
Public pump	"	22	......	22	....	Slightly sulphurous.
J. A. Klink............	Sec. 6, Liberty	40	......	40	....	Slightly irony; on the ridge.
A. V. Moffit..........	Sec. 31, Chatfield	26	......	26	Clay, sand, and gravel...	In gravel.
Philip Moffit	"	26	......	26	....	Slightly irony.
George Haupt........	Sec. 19, Chatfield	37	......	37	....	
Jacob Miller..........	N. Washington	40	......	40	....	
T.H.B Clutter, M.D	Leesville.........	10	9	19	Stony clay	
John Hahn............	"	17	......	17	"	Slightly sulphurous.

* These gas wells burned with violence, throwing a flame ten or fifteen feet above the surface of the ground.

WELLS AND SPRINGS.

Owner's name.	Location.	Feet above the rock.	Feet in the rock.	Total depth.	Through what.	Remarks.
J. H. Brokan	Leesville	6	17	23	......	Slightly sulphurous.
B. Heckard	"	14	......	14	......	Sulphurous.
Samuel Stuck	Sec. 30, Bucyrus	47	......	47	Clay and gravel	Good water.
Franklin Stuck	"	38	......	38	Clay and sand	Not good for cooking; makes food bitter; cannot be used for coffee or tea.
Widow Bishop	N. E. ¼ sec. 26, Dallas	15	......	15	......	Good water.
J. Hainla	N. Winchester	43	......	43	Clay and sand	"
J. Hainla	"	19	......	19	......	Bitter water, like Stuck's.
Jno. J. Shumaker	N. E. ¼ sec. 26, Polk	28	14	42	......	Slightly sulphurous.

MATERIAL RESOURCES.

The chief natural resources of the county are those derived directly from the soil. Agriculture is the principal occupation of the people, and will always remain so. Crawford county lies mostly on the northern side of the watershed. and hence its surface, soil, and features partake of those characteristics so conspicuous in the lake counties, and so well known for their uniform fertility and strength. The following summary of the agricultural statistics of the county is gleaned from the reports of the State Board of Agriculture for 1869 and 1870. These may be considered direct products of the soil:

	Acres sown.	Bush produced.	Bush. per acre.
Wheat	21,742	254,945	11.6
Rye	181	1,744	9.8
Buckwheat	175	2,480	14
Corn	24,811	1,004,675	40.5
Barley	627	10,708	17.2
Oats	14,679	477,409	32.4
Potatoes	1,247	76,947	61.7
Sweet potatoes	15	804	53.6

	Acres.	Tons of hay.	Bush. of seed.
Meadow	15,383	19,673	......
* Clover	9,593	12,687	16 997
Flax	528	......	4,300
Pasturage	32,875	......	......
Uncultivated land	53,215	......	......
Orchards	4,159	......	......

* 284 acres of clover were plowed under.

	Bushels.	Gallons of sirup or wine.	Pounds.
Maple sugar	....	812	3,424
Grapes	....	259	8,699
Apples	229,012	....	....
Peaches	1,225	....	....
Pears	397	....	....
Tobacco	....	....	110
Sorghum	....	7,372	29

There are various other indirect products of the soil, such as farm stock and products of the dairy. These need not be here enumerated. In 1870 the taxable lands of the county were ascertained to be 252,156 acres. Of this sum 138,368 acres were arable, 37,074 acres were meadow or pasture lands, and 76,714 acres were uncultivated or wood land. The average product of wheat per acre for the whole State of Ohio for 1870 was 11.4 bushels, or two-tenths of a bushel less than the average for Crawford county. The average of the same for rye was 9.4 bushels, or two tenths of a bushel less than the average for Crawford county. The average product of buckwheat in 1870 in the State was 11.8 bushels per acre, or 2.2 bushels less than the same average in Crawford county. The average product of corn per acre for the State in 1870 was 37.5 bushels. The same average for Crawfoad county was 40.5 bushels, or three bushels per acre more than the average product of the State. The average product per acre of barley in the State in 1870 was 19 bushels, or one bushel and eight-tenths more than the same average for Crawford county. The average product of oats per acre in the State was 27 bushels, or 5.4 bushels less than the same average in Crawford county. The same average for potatoes was 69 6 bushels, or 7.9 bushels more than in Crawford county. The average product of sweet potatoes for the State was 112.4 bushels per acre, which was 58.8 bushels more than the same average for Crawford county. Thus in every respect Crawford county exceeds the average product of the State in the important farm products, except in barley and potatoes.

Averages for 1868 and 1869.

	Wheat.	Rye.	Buck-wheat.	Oats.	Barley.	Corn.	Pota-toes.	Sweet pota-toes.
State average—								
1868	11.3	9.3	10.9	23.9	20.3	34.3	72.2	70.3
1869	11.4	11.3	7.5	29.1	25.4	26.8	85.4	66.1
County av'age—								
1868	13.8	11.6	10.1	21.4	19.8	33.2	71.9	56.7
1869	19.1	13.6	8.3	31.6	17.2	20.8	81.9	103.3

Crawford county is also well supplied with building stone and with limestone for quicklime. The quarries in the townships of Holmes and Todd not only furnish stone for building throughout a wide circuit of country, but also produce a large quantity of quicklime, which is shipped from Nevada, in Wyandot county, by the Pittsburgh, Fort Wayne and Chicago Railroad.

The following proximate statements of the annual product of these quarries in quicklime were obtained from the owners in 1871:

	Bushels.
J. B. Christie	20,000
Dennis Coder	4,000
Luther M. Myers	15,750
Mary Schnavely	4,000
Schnavely Brothers	6,000
John Schnavely	20,000
Nicholas Poole	10,000
Perry Wilson	20,000

The retail price on the ground is 20 cents per bushel. It is delivered in quantity (wholesale) at Nevada for 18 cents. If the aggregate production sells for 18 cents, the revenue amounts to about $18,000 per year. All the kilns used at Occola are of the old style, requiring to be emptied entirely before second use. By this method there is a loss of wood and of labor. The following tabular view shows the amount of wood required per hundred bushels at some of the quarries, and the weight of the lime per bushel, as nearly as can be ascertained:

Name.	Formation.	Hours of burning.	Cords per 100 bushels.	Pays for wood.	Weight per bu.
Perry Wilson	Upper Corniferous	60	Nearly 3	1.75	*65
John Schnavely	Lower Corniferous	60	" 3	1.75	65
Luther M. Myers	Lower Corniferous	60	" 2½	1.75	......

In the south-eastern part of the county the quarries in the Berea grit have been wrought for about forty years, and have become celebrated throughout a wide extent of country for the excellence of the building stone which they afford. Stone from Berea is, on close comparison, seen to be of a coarser grain and less firm than that taken from beds of the same horizon in the central counties of the State. The limestone sold at the quarries in the western part of the county brings about a dollar

* Reaches 70 pounds when about half slacked.

per perch, or five dollars per cord. The sandstone taken out in the eastern part of the county brings a better price. The best sells for $2 per perch. Other grades bring $1 50 and $1. A cheaper quality is sold for fifty cents per load. Flagging sells from six to twenty cents per square foot; a thin kind of walling stone for fifty cents per load.

For brick and common red pottery the Drift clays are considerably used. These clays afford in all places a very fine material for these uses. There is probably not a square mile within the county where such clay could not be obtained. In the progress of the survey of the county the following establishments of this kind were noted. This list may not be complete:

Brick and Pottery Works.

A. Gronerberger, Bucyrus—Brick. Situated in the creek bottoms. The material here used is a clay-loam, and contains no gravel. The brick, which are of a dark red color, show no evidence of lime when broken.

William Sitter, New Washington—Brick.
Joseph Schell, " —Pottery.
Jacob Green, section 34 (?), Chatfield—Brick.
——— Retan, section 1 (?), Liberty—Tile.
Matthias Haiser, Crestline—Brick.
John Willerton, " —Tile and brick.
Daniel Baslinger, Bucyrus—Brick.
Bryant & Smith, " "
William Fail, Galion—Brick.
Leopold Wiltendollar, Galion—Brick.
John Cronowelt, " "
" section 18, Whetstone—Tile.

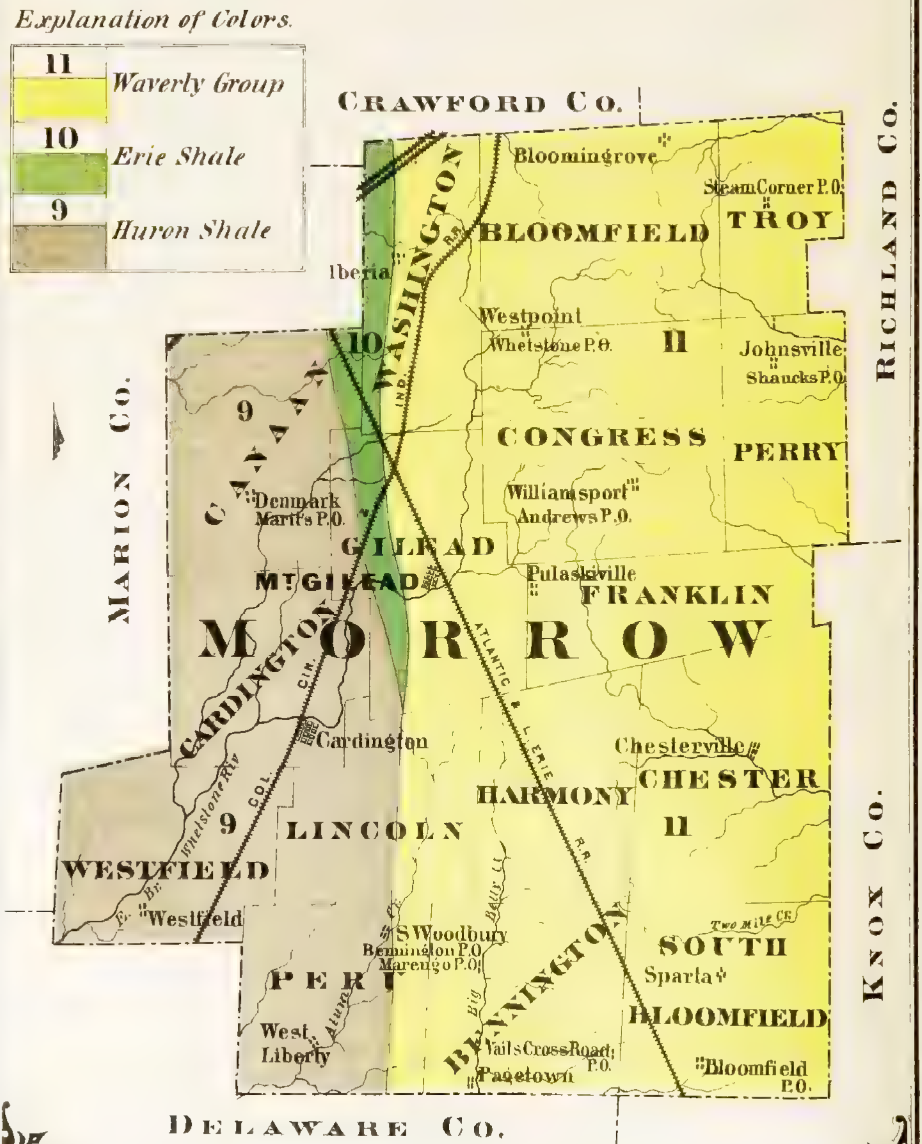
The eastern portion of the county, especially the rolling strip of land that characterizes the line of junction between the Berea grit and the Bedford shale, is well supplied with gravel and sand. These knolls are largely made up of stratified gravel and sand mingled with northern bowlders. One of the oldest gravel pits in the county is that near the depot at Leesville. From it thousands of car-loads have been taken for use on the Pittsburgh, Fort Wayne and Chicago Railroad. It affords also a great many northern bowlders of all sizes, averaging about eighteen inches in diameter. This gravel ridge has already been referred to under the head of *Drift*. Several deposits of gravel and sand were also noted in the flat and more clayey portions of the county; but here they are much more rare, and also more valuable. One occurs on Mr. Nathan Cooper's land, in the bank of the Sandusky River, S. W. ¼ section 32, Liberty.

Geological Survey of Ohio.

MAP OF MORROW COUNTY,

BY

N. H. Winchell.



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CHAPTER XXXVI.

REPORT ON THE GEOLOGY OF MORROW COUNTY.

BY N. H. WINCHELL.

SITUATION AND AREA.

Morrow county is situated very near, but a little north, of the center of the State, and was among the first settled, the first inhabitants coming largely from the New England States, and from New York and Pennsylvania. It is bounded on the north by Crawford and Richland counties, east by Richland and Knox, south by Knox and Delaware, and west by Delaware and Marion. Its form is nearly that of a rectangle, lying north and south. Its western boundary is broken by its wanting a town in the north-west corner, and by its inclosing Westfield in the south-west corner. Its area, given by the State Board of Equalization in 1870, is 253,149 acres, of which 83,698 acres are arable, 91,045 acres are meadow and pasture land, and 78,406 acres are uncultivated or wood land. The average value, exclusive of buildings, is $30.40 per acre.

NATURAL DRAINAGE.

The most of the drainage of the county is into the Scioto river. Its eastern portions are drained into the Muskingum; yet the Sandusky, which flows into Lake Erie, has some of its sources in the township of North Bloomfield, in the northern portion of the county. The streams are not large, but are ample for most purposes in an agricultural community. Many flouring mills exist in the county, the motive power being hydraulic.

SURFACE FEATURES.

The undulations in the rocky structure are usually very gentle, even imperceptible, through the Drift sheet. Hence the general surface was originally nearly flat. The unevenness that now prevails in some parts of the county is mainly due to subsequent causes, and can be referred to the known effect of atmospheric forces. The eastern half of the county is decidedly rolling, and even hilly; the western half is more level. The Drift was at first deposited with unequal thickness, whatever may have been the condition of the pre-existing surfaces. In the valleys of those streams that flow toward the east, in the eastern part of the county, there are unmistakable evidences of a previous erosion of the rock surface, but in the western part of the county no such indications have been seen. Besides occasional irregularities in the surface of the bedded rocks, the manner of the deposition of the Drift was such as to leave very noticeable differences in its condition and thickness in different parts of the county. In the sandstone region, and especially where the Berea grit forms a line of junction with the underlying shale, the Drift is coarse and stony, and the surface is broken. Frequent springs of ferriferous water issue from the hillsides, which seem to be very gravelly. The channels of the streams are deeply cut into the bed rock—plainly beyond the power of the present volume of water—and the valleys are marked by large bowlders. Such bowlders are found in the valleys in all parts of the county, but are much more noticeable in the sandstone district. Near South Woodbury, in the creek bottoms (lot 10), is a bowlder of fine-grained syenite, the extreme dimensions of which are nine feet by seven and a half feet, showing four and a half feet above the ground. In this bowlder hornblende predominates, and the feldspar is flesh-colored, quartz being scarce, giving a rather dark color to the whole. In the western part of the county, however, where the surface is underlain by shale or by the black slate, the Drift is more evenly spread, and the country is flat. The streams have (in very much the same manner, though not to the same extent) cut their channels into the bed rock, but they are fewer in number, and have a less average descent to the mile. The water of wells and natural springs is apt to be sulphurous, and bubbles and jets of gas are very often met with. In some marshy places an inflammable gas rises spontaneously, though this is not known to be the same as that which rises from the shale below the Drift. The surface is clayey, and the soil needs artificial drainage.

The following observations for altitude, by aneroid barometer, are referred to the level of Lake Erie through Mt. Gilead Station, the height of which is given at 466 feet by the Cleveland, Columbus, and Cincinnati Railroad

	Above Lake Erie.	Above the Ocean.
Mt. Gilead Station	466 feet.	1031 feet.
Sill of National House, Mt. Gilead	516 "	1081 "
Creek at the mill, Mt. Gilead	391 "	956 "
Creek at south bridge, Mt. Gilead	356 ? "	921 ? "
Summit of ridge 1½ miles north of Franklin Center, section 7, Franklin	625 "	1190 "
Summit of ridge, Franklin Center	599 "	1164 "
Chesterville, Main street	320 "	885 "
Chesterville, bed of creek	286 "	851 "
Bloomfield Cemetery, N. W. ¼ section 17	576 "	1141 "

Thus, in the eastern part of the county, where the sandstone beds lie nearly horizontal wherever exposed, there are short undulations in the natural surface of over three hundred feet, and that, too, without any exposure of the rock. It is altogether improbable that the Drift has that thickness. It is more reasonable to suppose that the rocks themselves suffered erosion, and embraced valleys running according to the direction of drainage before the deposit of the Drift.

Soil and Timber.—The soil of the county presents great diversity. The flat portions of the county have a heavy clay soil. The sandstone district, and the belt of rolling land that marks the junction of the Berea grit with the Bedford shale, have a lighter and more porous soil. Stones and gravel are almost never seen in the western part of the county, but in the eastern the plow turns them up constantly. The timber varies noticeably with the change in the soil. Probably one-half of the native forest trees in the county are beech, while another quarter is made up of sugar maple, ash, and oak. The chestnut is confined to the rolling and gravelly portions of the county. In the survey of the county the following species of timber were noted:

Quercus alba (White Oak)	L.
“ imbricaria (Shingle Oak)	Michx.
“ palustris (Pin Oak)	Du Roi.
“ tinctoria (Black Oak)	Bart.
“ rubra (Red Oak)	L.
“ castanea (Chestnut Oak)	Willd.
“ bicolor (Swamp White Oak)	Willd.
Acer saccharinum (Sugar Maple)	Wang.
Acer rubrum (Swamp Maple)	L.
Castanea vesca (Chestnut). Only in the eastern part of the county	L.
Ulmus Americana (American Elm)	Willd.
Fraxinus Americana (White Ash)	L.
Platanus occidentalis (Sycamore)	L.
Fraxinus quadrangulata (Blue Ash)	Michx.
Gleditschia triacanthos (Honey Locust)	L.
Nyssa multiflora (Gum)	Wang.
Juglans nigra (Black Walnut)	L.
Prunus serotina (Black Cherry)	Ehr.
Liriodendron tulipifera (Tulip Tree)	L.
Ostrya Virginica (Ironwood)	Willd.
Carya alba (Shagbark Hickory)	Nutl.
Carpinus Americana (Water Beech, eight inches diameter)	Michx.
Tilia Americana (Basswood)	L.
Ulmus fulva (Slippery, or Red Elm)	Michx.
Juglans cinerea (Butternut)	L.
Salix nigra (Black Willow)	Marsh.

Carya porcina (Pig Hickory)	Nutl.
Amelanchier Canadensis (June Berry)	Torr and Gray.
Æsculus glabra (Buckeye)	Willd.
Asimina triloba (Pawpaw)	Dunal.
Lindera Benzoin (Spice Bush)	Meisner.
Populus grandidentata (Large-toothed Aspen)	Michx.
Celtis occidentalis (Hackberry, or Sugarberry.) This is a large tree in Morrow and Delaware counties, of two feet in diameter	L.

GEOLOGICAL STRUCTURE.

The geological series of the county embraces that much disputed horizon that lies near the junction of the Devonian with the Carboniferous. The names given to these members in the northern portion of the State by the Chief Geologist of the present Survey are as follows, in descending order. The names are not known to be applicable in the central and southern portions of the State, but are supposed to be:

Cuyahoga shale and sandstone,	approximate	thickness...	150 feet.	
Berea grit	"	"	... 60 "	
Bedford shale (red and blue)...	"	"	... 75 "	
Cleveland shale (black)	"	"	... 55 "	
Erie shale and sandstone (gray)	"	"	... 400 "	to 500 feet.
Huron shale (black)	"	"	... 300 "	

Of these Dr. Newberry includes the last two in the Devonian, and the remainder in the Lower Carboniferous. In the southern part of the State the series seems to be different, and names that have a general parallelism with the foregoing have been applied by Prof. E. B. Andrews, as follows:

Logan sandstone	133½ feet.
Alternations of fine sandstone and conglomerate	85 "
Coarse Waverly sandstone and conglomerate	400 "
Waverly black slate	16 "
Waverly shale and sandstone	130 "
Huron shale or black slate	320 "

In the southern part of the State Prof. Andrews extends the Waverly group, and so the Lower Carboniferous, down to the Huron shale, embracing the interval, which is probably the equivalent of the Erie shale in the northern part of the State, consistent with the limits set by the early geological surveys in the West, which referred the Waverly, however, entirely to the Devonian. It has been shown, however, by Prof. A.

Winchell, of the Michigan Geological Survey, that the Upper Waverly belongs to the Carboniferous, thus dividing between the Devonian and Carboniferous ages the series usually embraced under the single designation of Waverly. For the upper or fossiliferous portion of the old Waverly the term Marshall group has been used by the Michigan Survey, and that name, intended to cover the base of the Carboniferous, antedates all other names. It is a question whether the term Waverly should be perpetuated by applying it to a part only of the series to which it was at first given.

To what extent these subdivisions exist in Morrow county it is not possible to determine from the exposures that occur. It is only known that there is (1st) in the eastern part of the county a fine-grained, shaly sandstone, which is probably some part of the Cuyahoga shale and sandstone, although having more the lithological characters of the Logan sandstone, its equivalent in the southern part of the State. (2d) Succeeding this shaly sandstone is a valuable series of even-bedded sandstones, useful for building and extensively quarried, the equivalent of the Berea grit.* (3d) Below this is a blackish slate, although its exact junction with the overlying Berea grit has not been observed. It may be separated from the Berea grit by a thin stratum of shale representing the Bedford shale. The thickness of this black shale has not been made out. It is succeeded by (4th) a considerable thickness of bluish or gray shale, seldom seen exposed. This is followed (5th) by the Huron shale, or black slate, which occurs in the western part of the county.

Cuyahoga Shale and Sandstone.—The quarry of W. T. Appleman, on the north side of the creek, in section 7, Troy township, is in the sandstones of the Upper Waverly (Marshall). The surface of the country here is generally very broken, the streams having cut deep channels through the Drift and into the rock. These sandstone beds here lie horizontal. They are from one to four inches in thickness. But few feet can be actually seen, but the bluffs and ridges show every indication of being composed of beds of the same formation *in situ* to the thickness of nearly a hundred feet This stone is without the gritty texture of the Berea beds. It is more shaly, and has shining specks. Sometimes the heaviest beds show parting planes, by which they separate into thin layers, giving the whole very much the appearance of a true shale. The surfaces of the beds sometimes show fossils, the most conspicuous and common of which is *Productus arcuatus*, Hall. One or two specimens of *Productus Shumardianus*, Hall (?), were also observed. South-west from Mr. Appleman's is

* Graduating below into thin-bedded shaly sandstone.

Mr. Jacob Aman's quarry (about N. W. ¼ section 18). It occurs along a little ravine running north, and shows the following section:

SECTION AT JACOB AMAN'S QUARRY.

No. 1.	Rusty, irregular, shattered sandstone; micaceous, with intercalated beds of shale; beds 1 to 6 inches	7 feet.
" 2.	Micaceous shale, with intercalated beds of sandstone (some of which are fossiliferous). This shale is argillaceous, and when dried has a glittering and soapy luster, appearing talcose	8 "
	Total	15 "

Jacob Mandeville's quarry is situated N. E. ¼ section 13, in North Bloomfield, and consists, so far as exposed, of a hard, ringing, blue limestone, which seems silicious. The most of a thickness of eighteen inches is devoted to this limestone. Generally a coating of sandstone incloses the limestone, filling out the angles in the bedding, and making the limestone really lie in lenticular pieces, with rounded edges. Beds of sandstone are known to underlie this limestone, but the overlying rock is unknown. No fossils have been seen. The beds are horizontal.

The quarry of Mrs. Elizabeth Treisch is on the N. W. ¼ section 19, Troy, and occupies the banks of a precipitous ravine. The section exposed is as follows, in horizontal beds:

SECTION ON SECTION 19, TROY, MORROW COUNTY.

No. 1.	Thin beds of sandstone, with some shale, seen	11 feet.
" 2.	Interval, unseen	5 "
" 3.	Thin-bedded sandstone	1 ft. 6 in.
" 4.	Fissile blue shale	1 "
" 5.	Thin beds of sandstone, seen	2 "
	Total	20 ft. 6in.

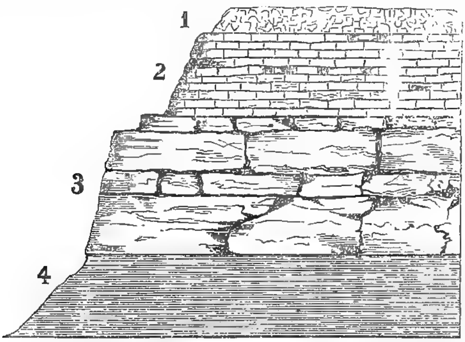
Daniel Stull owns a quarry in the same beds, adjoining Mrs. Treisch's. Along the creek, in section 36, North Bloomfield, Mr. John Snyder and Mr. Daniel Sorrick have taken out a little stone for common use. It lies in thin beds, and is poorly exposed.

On lot 8, William Struble's land, a mile and a half north-east of Chesterville, about ten feet of sandstone beds are exposed in the banks of a ravine. These beds are similar to those of widow Treisch's quarry, section 10, Troy, and are rarely over three inches in thickness; one layer is fourteen inches in thickness.

On the N. W. ¼ section 5 (east), Franklin township, Mr. Milton Lavering has a quarry in the bluffs of a ravine, which expose about thirty feet of alternating sandstone and shale layers. The sandstone is soft, fine-grained, and micaceous. The mica scales appear specially on the planes of bedding. Although this stone is usually soft, and crumbles under pressure, or on exposure to the weather, some of it is harder, yet equally fine-grained, and in beds of about a foot. It is quite distinguishable from the Berea grit as seen at Mt. Gilead, or at Leesville, in Crawford county. It sometimes shows, at Mr. Lavering's, masses of hard, blue, silicious limestone. Irvin Lefever has a slight exposure of similar beds on his farm, three-fourths of a miles south-east.

The Berea Grit.—The quarries in the Berea grit near Iberia are owned by O. C. Brown, section 23, J. J. McLaren, section 34, David Colmery (not now worked), John T. Quay, Benjamin Sharrock. Stone also shows on Mr. Gurley's land, a quarter of a mile south-east from McLaren's quarry. That of Mr. Brown covers the horizon in which fall all the others. The section here is as follows, in descending order. The beds lie so nearly horizontal that no dip can be distinguished:

Section in the Berea Grit at Iberia, Morrow County.



No. 1.	Drift	3 feet.
" 2.	Thin beds of sandstone, with distinct quartzose grains; beds 2 to 5 inches	18 " to 22 feet.
" 3.	Heavy beds of sandstone (1 to 3 feet), with evident quartzose grains, yet finer than the Berea grit	18 " to 22 "
" 4.	Shale (in a talus, poorly seen)	30 "

The thirty feet of shale (No. 4, above) is obtained by measuring from the level of the water in the Rocky Fork of Olentangy Creek, which passes near Mr. Brown's quarry, to the bottom of the sandstone in the quarry. This interval is known to be occupied by shale, but its special characters are hid by the sloping turf-covered talus. It can only be seen about six inches below the sandstone, where it is fine and blue, and in beds one-half to one and a half inches. It thus appears that the heavy beds of the Berea continue intact down to the shale, as in Crawford county, although at Mt. Gilead the heavy sandstone graduates below into a thin-bedded and shaly sandstone, before the beginning of the shale.

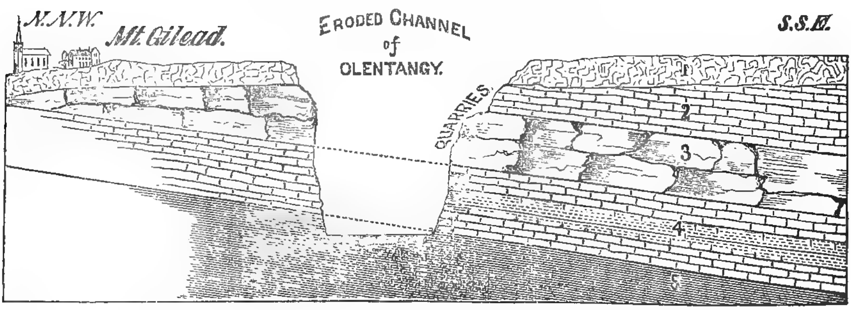
The face of the stone where quarried by Mr. Brown presents some indications of a fault of about four feet. A perpendicular seam cuts the beds from the top to the bottom. An unusual accumulation of shale and slaty layers on one side of this seam marks a horizon about midway in the thin beds of the quarry (No. 2 of the above section), terminating against the seam abruptly, with no continuation at that point. At a point, however, about four feet lower, the same kind of shale and slaty layers appear on the opposite side of the seam, and prolong the horizon in that direction so far as the stone is exposed.

The quarry of Mr. McLaren has five feet of thin beds and nine feet of thick beds, embracing portions of Nos. 2 and 3 of Brown's quarry. Mr. Sharrock's quarry is entirely in the flagging of No. 2 of Mr. Brown's, exposed ten feet. Mr. Quay's is the same as Mr. Sharrock's.

The quarries at Mt. Gilead are in the banks of the East Branch of the Olentangy, or Whetstone Creek. Here there is a slight dip toward the south south-east, and the following section can be made out, in descending order:

			Feet.	Inches.
No.	1.	Drift, stratified in some places	15	...
"	2.	Berea grit, thin beds	10	...
"	3.	Berea grit, thick beds	6	...
"	4.	Thin beds of sandstone, with shale	19	7
"	5.	Shale	22	1
		Total exposed	57	8

SECTION OF THE BEREA GRIT AT MT. GILEAD.



Notes on the foregoing Section.—No. 1 has a brown color at the rock banks, but a blue clay is met in town in wells, with a thickness of four to ten feet in some places, showing the usual characters of the hard-pan clay.

No. 2. The thin beds of Berea grit seem to be constant, and immediately above the heavy beds. They have been seen in every place, both in Morrow and Crawford counties, where the heavy beds have been exposed in quarrying.

No. 3 is somewhat thinner here than in the section at Iberia and in those in Crawford county.

No. 4 is not regular in the alternation of beds, nor in its horizon of contact with No. 3. Beds of sandstone sometimes occur below the horizon of separation here adopted. The most of the material is sandstone. The shale glistens as if with mica, and the surface is soapy and shining when dry. It is appropriately but not correctly called "soapstone" by the quarrymen.

No. 5 graduates below into a blackish slate, which crumbles and becomes blue, making a blue marl. This member is not well seen here. No red shale can be seen, nor any indications of it.

No. 4 contains various mud-markings and irony concretions, many of which have a deceitful resemblance to fossil remains. The irony nodules, or concretions, have often a marl ball within a scale of one-fourth inch of real iron. Some deposits appear like real hæmatite iron ore. There are also calcareous concretions, or irregular masses of more calcareous shale or rock, which are hard and firm, of a blue color, and contain iron pyrites. They seem to be of the same nature and origin as the silicious limestone of Mandeville's quarry (N. E. ¼ section 13, North Bloomfield), but less abundant here.

Calcareous and chalybeated waters issue from springs along the banks, and make copious deposits of their carbonates on the face of the bluffs.

Quarries are owned at Mt. Gilead by Charles Russel, George Wieland, and by Smith Thomas.

About three and a half miles south-east from Cardington, in Lincoln township, occur several quarries on the horizon of the Berea grit, the exposures being caused by the upper forks of Alum Creek. They all lie within the area of a square mile, and are owned by D. M. Mosher, David Steiner, Morgan B. Brooks, and Corwin Conard. The beds are about horizontal, or show a gentle dip east. The section at Mosher's quarry is as follows, in descending order:

No. 1.	Hard-pan Drift	8 to 10 feet.
" 2.	Flagging	4 to 5 "
" 3.	Heavy stone	7 to 8 "
" 4.	Shale and thin stone (seen)	1 foot.

Mr. Steiner's quarry shows a singular fault or variation of bedding An oblique seam crosses the face of the exposure, and on the freshly quarried edges the bedding is very evident. On one side of the seam, which may be called the lower side, the beds are nearly all thick, running from five to eight inches above, and reaching twelve inches below. These thick beds terminate on reaching the seam or joint, their ends being obliquely beveled in consonance with the angle of the slope of the seam. On the other side of the seam the beds are conspicuously different from the above. The most of them are very thin, running from one inch to three inches, and the remainder, the lowest, are sometimes eight inches thick, varying from five inches.

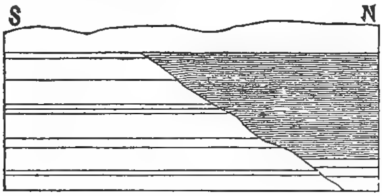


Diagram of the Bedding of the Rock at Mr. Steiner's, 3½ miles south-east of Cardington.

SECTION AT THE LEFT (SOUTH) END OF STEINER'S QUARRY.

No. 1.	Drift	4 ft.	6 in.
" 2.	Beds 5 to 8 inches	6 "	
" 3.	Beds 8 to 12 inches	3 "	
	Total	13 "	6 "

SECTION AT THE NORTH END OF MR. STEINER'S QUARRY.

No. 1.	Drift	4 ft.	
" 2.	Thin beds (1 to 3 inches)	6 "	
" 3.	Thicker beds (5 to 8 inches)	2 "	6 in.
	Total	12 "	6 "

SECTION AT MR. CONARD'S QUARRY.

No. 1.	Hard-pan Drift	3 ft.	
" 2.	Thin beds of about 2 inches	3 "	6 in.
" 3.	Beds 12 inches	2 "	
	Total	8 "	6 "

SECTION AT MR. BROOKS'S QUARRY.

No. 1.	Hard-pan Drift	10 ft.
" 2.	Sandstone, beds 2 to 4 inches	8 "
" 3.	Sandstone, beds 8 to 12 inches	6 "
" 4.	Shale (reported)	1 "
	Total	25 "

Below No. 4 of the section at Mr. Brooks's quarry, sandstone is said to occur again; but it is probably closely underlain by shale, and belongs to the transition beds seen in No. 4 of the general section at Mt. Gilead. It is noticeable that the most valuable portion of the Berea grit, viz., the heavy beds near its base, becomes much thinner in passing south into the central part of the State; that the whole becomes finer-grained, and that thin beds of alternating sandstone and shale succeed the thick beds before the main shale bed appears.

The Berea grit is also exposed and slightly wrought on Mr. T. N. Hickman's land, S. E. ¼ section 11, Gilead, and on Furbay Conant's, near Mr. Hickman's.

Bedford Shale.—The only evidence there is of the continuance of the Bedford shale into Morrow county consists of the difference between the Cleveland shale and that seen to lie below the quarry of Mr. Brown at Iberia, and immediately below the sandstone and shale (No. 4) at Mt. Gilead. The Cleveland, as seen at Mt. Gilead and one or two points further south, is of a dark or blackish color, somewhat slaty. The shale underlying the heavy stone at Iberia is blue and fine, not showing any slaty structure, and may represent the Bedford.

Cleveland Shale.—This shale, which is regarded by Dr. Newberry as the base of the Waverly group, and thus as forming the base of the great Carboniferous system, may be seen in the section at Mt. Gilead. It occupies the lowest portion of the shale of No. 5, and lies in the bed of the stream. It is supposed to have a thickness of about 50 feet, and to be followed by the Erie shale and sandstone (400 or 500 feet in Cuyahoga county), which is followed by the Huron shale (the great black slate). There is an exposure of similar shale in the low banks of the creek near S. Woodbury, on N. W. ¼ lot 9, in the northern part of Peru township, where the following section, in descending order, may be made out:

Section in Cleveland Shale near South Woodbury.

No. 1.	Silicious limestone. This is of the same very hard texture, blue color, and general appearance as the limestone at Mandeville's quarry, belonging to the Cuyahoga shales and sandstone; also the same as some very hard nodules in the sandstone. It is here in one continuous bed. It breaks with difficulty, and with silicious fracture		3 in.
" 2.	Blackish slate, somewhat like the slate at Cardington (Huron), but more similar to that at the bottom of the section at Mt. Gilead, seen	6 ft.	
	Total	6 ft.	3 in.

The exact relations of this exposure to the great group of shales that make up the interval between the Hamilton and the Berea grit, it is impossible to state. It is thought, however, that the horizon of the bottom of the Berea grit passes about half a mile east of this point, judging from the topography; and if that be correct, there is no doubt this shale belongs to the Cleveland.

On the contrary, the frequent slight exposures of black slate throughout Peru township, and especially in the banks of Alum Creek, make it evident that the underlying Erie shale, if it exists at all, must be reduced to a few feet in thickness. The absence, then, of the Erie shale, or its great attenuation, makes it uncertain whether the above exposure may not belong to the Huron. It bears a resemblance to some portions of the Huron. In the absence of fossils, it will be necessary to leave its designation conjectural.

The Erie Shale.—The existence of this shale in Morrow county is altogether hypothetical. The most southern point at which it has been observed is in Polk township, in Crawford county. It is not known to exist in Delaware county, which lies next south of Morrow, but it may have the thickness there of a few feet. This horizon, owing to its shaly character, is generally deeply buried under the Drift. On the accompanying map this shale is represented as running out, but the evidence to that effect is not conclusive.

Huron Shale.—This shale underlies the western tier of townships, its eastern limit leaving the county near the south-west corner of Bennington township and the north-west corner of Washington township. It is well exposed at a number of places, especially along the valley of the East Branch of the Olentangy, in Westfield and Cardington townships, and along Alum Creek, in Peru township. The exposure at Cardington amounts to about twenty feet. It is here in very thin beds ($\frac{1}{32}$ to $\frac{1}{4}$ of an inch), and parts, under the weather, into small chips. When wet it has no unctuous feel, but keeps its color and texture. It is rather firm, and of a black color. It contains no concretions, or hard masses. An incrustation of alum forms on the exposed edges of the beds, but very little pyrites can be seen. The beds have a slight dip east.

The black slate, or Huron shale, is exposed in the banks of the creek on lot 13, land of Annis Oliver, and at other points below. At Benedict's mill, lot 16, twenty feet may be seen. It is here, also, of a very homogeneous character, like that at Cardington.

This exposure is approximately forty feet below that at South Woodbury. At West Liberty the following section, in descending order, may be seen:

No. 1.	Hard-pan Drift	20 ft.	
" 2.	Thin slate	6 "	
" 3.	Blue, silicious limestone, like that at South Woodbury. In one bed		4 in.
" 4.	Thin, homogeneous slate	30 "	
	Total	56 ft.	4 in.

Along Alum Creek, about half a mile north of the county line, the Huron shale is well exposed. Indeed, there is nearly a constant exposure of the black slate along that creek south from South Woodbury to the county line. The excavation by the creek is, on an average, about twenty-five feet in the slate. Many of the little ravines joining the creek show it in their banks. In the south-western part of the township of Peru are what are known as "slate knobs" along the Olentangy, which have a sparseness of soil and too easy drainage, making them poor for agriculture.

At Westfield the black slate is exposed in the banks of the East Branch of the Olentangy, on the land of J. B. Trindle. It was also struck in digging for the foundations for the flouring mill half a mile below Westfield.

The Drift.—The whole county is heavily covered with northern Drift. It embraces stones of all sizes, irregular patches of stratified gravel and sand, and much clay. The mass of the whole is made up of that usually denominated "blue clay," although the blue color is only found at the depth of fifteen or twenty feet, the action of the air and water on the iron and other substances contained in it having produced hydrated, impure peroxides that pervade the soils and the clay to about that depth. The Drift is usually perfectly unassorted; yet at Mt. Gilead, where there seems to have been an accumulation of standing water about the foot of the glacier, the upper portion of the Drift clay is very fine, and free from stones and gravel. This clay here also shows the exceptional character of stratification, although the laminæ are considerably disturbed, not lying so true and nearly horizontal as in the laminated clays at Fremont or at Cleveland. The average thickness of the Drift would probably not exceed forty feet. It seems to be thicker in the northern part of the county than in the southern.

About a mile above Mt. Gilead the left bank of the East Branch of the Olentangy consists, so far as seen, of hard-pan, containing bowlders throughout from top to bottom, and measures sixty-four feet nine inches. This was a fresh exposure, where the washing over the dam had laid it bare. Only ten feet of the blue hard-pan can be seen, the lower portion being hid by *debris*. The thickness of the oxidated Drift was about eighteen feet. One very large northern bowlder was seen projecting from the bank, just above the lowest part of the brown hard-pan. Half a mile below Westfield the banks of the same creek show thirty-one feet seven inches of Drift, made up according to the following section, in descending order:

SECTION OF THE DRIFT NEAR WESTFIELD, MORROW COUNTY.

No. 1.	Hard-pan (unstratified)	21 ft.
" 2.	Gravel (stratified)	10 " 7 in.
	Total thickness	31 ft. 7 in.

The black slate is exposed at this place in the bed of the creek, and the above shows nearly the full thickness of the Drift. This conspicuous bed of gravel has been excavated for use in the neighborhood, and its position (below a heavy bed of unassorted Drift) resembles that of a similar bed of assorted materials seen near Upper Sandusky. (See Geology of Wyandot County, p. 639, Vol. I.)

The appearance of the Drift in Morrow county also indicates a greater age than in counties further north. This is one of the most noticeable features of the Post-Tertiary deposits of north-western and central Ohio. In traveling south from the northern, and especially the north-western portions of the State, the observing geologist sees the increasing coarseness of the surface of the Drift, the deeper and wider excavations of the river valleys, and the deeper oxidation from the blue color to the yellowish brown. He sees the superficial lamination of the fine clay that is found in the valleys of nearly all the streams that flow northward into Lake Erie entirely disappear long before reaching the summit of the watershed. The streams are plainly older in the central part of the State than in the north-western. Instead of only occasional exposures of the bed rock in their valleys, the rock is almost constantly seen along their banks. Instead of having bluffs composed entirely of loose Drift material, their banks show sometimes an erosion in the rocks to the depth of forty or fifty feet. This difference can not be due to the occurrence of more fragile and destructible formations in the central and southern portions of the State, for the formations lie in outcrop in belts running across the State from north to south. Moreover, instead of a deeper erosion in the softer rocks, where a stream passes from one formation to another, in certain cases the greater erosion is in the harder formation, as when it happens to lie further to the south or south-east. (See Report on the Geology of Delaware County.)

There is another striking phenomenon connected with the subject of the relative ages of the Drift deposits in the north-western and the central portions of the State. In those streams which flow northward and join the Lake Erie valley there is a steady *diminution* in the exposure of the bed-rock, due to the denuding action of the streams on the Drift, in going north from the watershed. The most frequent exposures are in the valleys of the tributaries, spite of the greater erosive power of the larger volume of water further north. The exposures of the rock that occur over large tracts in north-western Ohio are either confined to the lake shore, where the power of the waves has removed the Drift, or to the "lacustrine area," where the same power has washed the Drift from the rock at points outside of the river valleys. On the contrary, in the valleys of those streams that flow southward from the watershed there is a steady *increase* in the amount of exposure of the underlying rock, until the banks become constantly rocky, and at last show sixty to a hundred feet excavation in the solid rock. This increasing erosion of the rocks in the valleys of the southward-flowing streams, in passing southward, is noticeable even within the limits of Morrow county. In the township of Canaan the black slate is not exposed at all, and in Tully township, Marion county, it is only exposed at two or three points, although crossed by streams in both townships. In Crawford county, which lies immediately north of Morrow, there is not a single exposure of the black slate, although it is crossed repeatedly by the largest streams of the county. On the contrary, in the southern part of Morrow county, the banks of Alum Creek afford almost a constant exposure of the black slate, and some of the small tributary valleys, that are dry except in the freshet season of the year, are also deeply dug in the same formation. From this the conclusion is inevitable that whatever the force or forces that deposited the Drift in Ohio, they operated latest toward the north-west. As there is no essential difference in the composition and arrangement of the Drift toward the south, it is necessary to infer either that the cause of the Drift was one of great duration, or that it has recurred in full force in the north-western part of the State since its withdrawal from the central part. The same *kind* of force must be applied to both localities.

Glacial marks were seen at a single locality in Morrow county. They were noted on fragments removed by the quarrymen at the quarry of Mr. David Steiner, three and a half miles south-east of Cardington; but their direction could not be ascertained.

Wells and Springs.—In the eastern half of the county there is no difficulty in obtaining water for the household and for dairy purposes. The sandstone underlying is apt itself to give a ferruginous character to the springs that issue from it; but the most of the springs and wells that give an irony taste derive the iron, as a carbonate, from the Drift gravels and sands with which that part of the county is well supplied. That kind of water is very often met with in the eastern part of the county. In the western half of the county the water of wells and springs is very often sulphurous. Some very strong sulphur springs occur in that part of the county, issuing directly from the black slate. Some very remarkable and copious sulphur springs occur in Peru township. The following list, with the adjoined columns, will convey a very good idea both of the thickness of the Drift and of the nature of well water obtained in different parts of the county:

WELLS AND SPRINGS.

Owner's name.	Location.	Feet above the rock.	Feet in the rock.	Total depth.	Through what.	Remarks.
D. W. Mosher	Lincoln town'p	14	......	14	Gravel and sand	Good water.
Fountain Kenny......	"	22	......	22	Clay and gravel	Good water, on the rock.
William Powell........	"	18	......	18	Clay, then sand	Good water.
J. Wood..................	3 miles east of Cardington.....	18	......	18	....	"
Richard Wood.........	S. Woodbury...	30	......	30	Clay and gravel	"
Annis Oliver	Lot 13, Peru tp.	12	......	12	....	" in gravel.
John Osborn...........	Lot 18, "	16	......	16	In quicksand...	Good water.
"	" "	17	......	17	In gravel	"
"	" "	4	5	9	....	Sulphur water.
"	Lot 8, "	27	2	29	Clay and hard-pan	"
Sarah Gray..............	Lot 13, "	14	......	14	On slate	"
H. J. Rexroad	West Liberty...	22	8	30	In gravel, on slate..............	Strongly chalyb'te.
Lawrence McDani ls	Lot 7, southern part of Peru ..	19	16	35	Clay................	
Joseph Eaton..	Lot 21, ½ in S.W. West Liberty..	18	......	18	Clay and hard-pan	Irony, strongly artesian.
"	"	24	......	24	"	"
James Culver...........	Lot 35, Bennington.........	25	......	25	Blue clay	
"	"	21	......	21	Blue clay and gravel	Good water.
"	"	35	......	35	Blue clay	Very little water.
S. Julian	Sec. 16, South Bloomfield.....	20	......	20	Blue clay and sand	Good water.
Andrew French	"	24	......	24	Blue clay and gravel	"
William Smith.........	Bloomfield P.O.	18	......	18	Blue clay	"
M. A. Sprague.........	"	25	......	25	....	Only supage water.
J. W. Ramey	"	22	......	22	Blue clay	Copious water.
Ransom Howe.........	Sparta	10	......	10	Brown clay and gravel	Good water.
Antiphas Dexter......	"	14	......	14	"	"
Dr. Aug. Sweatland..	"	29	......	29	....	" } deepest in town.
J. C. Cook...............	"	33	......	33	Clay and sand..	"
John Maguire	"	11	......	11	"	"
William Hultz	"	10	......	10	"	"
Charles Harris.........	Lot 16, Chester	13	......	13	....	"
Daniel Leonard........	½ mile east of Chesterville...	50	......	50	....	"
Lewis Leonard.........	"	42	......	42	....	"
Daniel Lyon............	Chesterville.....	33	......	33	....	"
E. W. Miles	"	14	......	14	....	"
Daniel Brown	"	8	......	8	....	"
Timothy Drake........	Lot 26, Franklin	9	......	9	....	"
Average depth at	Franklin, lot 26	18	......	18	....	
Abram Cole	Sec. 34, Gilead..	12	......	12	Blue clay	"
James Duncan.........	Sec. 34, Washington..........	12	10	22	Blue clay and shale	"

MATERIAL RESOURCES.

Quicklime, Building Stone, Brick.—The county is entirely destitute of stone for making lime. The quarries in the Corniferous limestone at Delhi, in Delaware county, have furnished most of the quicklime used in the county. Since the construction of the chartered roads, the operators of which are allowed to collect toll of travelers, many consumers have been diverted from Delaware county to lime-kilns in Marion, to which access from Morrow county is still free. The county is well supplied with building stone of the best quality. The openings in the Berea grit at Iberia, Mt. Gilead, and near Cardington are widely known, and supply a great extent of territory with stone of an excellent quality. It has already been remarked that the grain of the Berea grit becomes finer in the central parts of the State, while at the same time the heavy-bedded portion becomes much reduced. This is noticeable in Morrow county, where it is considerably used for purposes for which it would not be well adapted in the northern portion of the State. There is no way of ascertaining the annual product of these quarries, owing to the frequent change of ownership and the lack of records of sales. The prices at Iberia, given by Mr. Brown, are as follows. They would not vary much from those at Mt. Gilead and Cardington, although Mr. Brown has unusual natural facilities for working his quarry:

Small thin stone for common walls and foundations sells for $1.00 per perch of 25 cubic feet; spalls, 40 to 50 cents per wagon load; flagging, 8 cents per square foot; stone, four to six inches thick, $1.50 to $2.00 per perch; best heavy blue, even and fine-grained stone, for bases to monuments, 10 to 40 cents per cubic foot.

Gravel and sand from the Drift are abundant in the eastern portion of the county. It is not usual to meet with these materials in the Drift in the shale and slate area. For brick, tile and common red pottery, the clays of the Drift, when sufficiently free from small stones, are well adapted. Yet there are not many manufacturing establishments of this kind in the county; only three were met with in the survey of the county. This probably is due to the abundant supply of good building stone and the prevalence of a heavy forest in the settlement of the county. The material used by Messrs. Miller and Smith, at Mt. Gilead, is fine, entirely free from gravel, and somewhat indistinctly assorted, though not arranged in layers like that at Fremont, in Sandusky county. The bank presents a massive section of fifteen feet, appearing somewhat like the "Bluff formation" of the Missouri river, though less arenaceous. It passes below into clean, gray quicksand. It makes a very fine brick, of even texture and perfect outline, the angles and corners being well filled. Near

Cardington Mr. Abram Hickson makes brick and tile, and on section 7, Troy, Mr. W. T. Appleman makes enough to supply the demand in a limited neighborhood.

Salt.—At West Liberty Mr. James Flemming owns land on which, in the year 1818, a well was sunk to the depth of about 330 feet. From the brine obtained a few bushels of salt were manufactured. Mr. Barton Whipple, of West Liberty, the only man who could be found cognizant of the facts, reports, by letter, that there were no indications of salt or any salt-lick within forty rods of the well. The well was drilled by A. Walker, but the water did not rise to the top. By means of a thin copper tube, 75 feet in length, and a pump, they succeeded in raising enough to make about fifteen bushels of salt. The tube then "collapsed," and no further efforts were made to extract the brine. Four years ago another drill was made at the same place for the purpose of reaching oil, and Mr. Whipple says the same deposit of brine was struck at about 330 feet. It is the impression of some that the location of the well at West Liberty was determined by the occurrence of "deer-licks" in that neighborhood.

A well was drilled a few years ago west of Iberia, near the county line, for the purpose of finding oil. It passed through shale and slate so far as it was prosecuted, which was to the depth of 200 feet. This shows the strike of the Berea grit to be at some point further east, and the exposure of the same in Tully township, Marion county, a few miles west of this well, must be an outlying mass.

For mineral paint the shale lying below the Berea grit seems to be adapted. It has been used to good advantage by Mr. Brown at Iberia. It is dried, ground, and mixed with boiled linseed oil, making a blue paint. It is also worthy of being tested as a fire-clay and for pottery.

Several deposits of bog ore were met with in the survey of the county. It occurs on land of Samuel Elder, S. E. ¼ section 24, Washington, and on that of James Thomas, in the same section. The hydrated peroxide which constitutes the ore in most bog deposits here seems to be associated with a considerable spathic iron ore, or carbonate of iron. At Mt. Gilead there is a copious deposit of carbonate of iron on the rock bluffs of the creek, associated with calcite. Other deposits of bog ore were seen in the eastern part of the county. One is in section 5, Franklin township, land of Calvin Blair and of John Blair. A small deposit of crag, or cemented gravel, may be seen on Milton Lavering's land, in the left bank of the North Fork of Owl Creek, section 5, Franklin. It is due to the discharge of calcareous water from the bank, the source of which it is not easy to explain.

The economical value of the black slate consists in the supplies of oil and gas for which it is noted both in Ohio and Virginia, as well as in Pennsylvania. There are no productive oil or gas wells in Morrow county, but there is much reason to suppose the formation which supplies them in other places is equally charged with these mineral products in this county. Many copious gas jets have been struck in the area of the slate in digging common wells. In one case, near West Liberty, the discharge was so sudden and so great that the laborers were greatly in danger of suffocation. An associate who descended thoughtlessly to aid those overpowered lost his life. A passing stranger being summoned, he in like manner was overcome, and died before he could be rescued. Those who were in the well in the first place were finally raised and resuscitated. Other similar gas streams have been encountered in other parts of the slate area. Sometimes the water in wells shows a constant slow escape through it of gas in the form of bubbles, indicating a continuous discharge of this substance from the black slate throughout the Drift. This subject has been fully discussed by Dr. Newberry in the first volume of the final report.

The chief material resource of Morrow county lies in the rich and varied soil with which it is furnished. It is necessarily an agricultural county, rather than a mining or manufacturing county. It partakes largely of the prominent features that are common to the most of northwestern and northern Ohio, yet it has not that flatness of surface and sameness of agricultural capacity witnessed in the counties included in the "lacustrine area," or even in those of the extensive tract in northwestern Ohio known as the Black Swamp. It is just south of the great watershed, or rather lies on its broad summit, just far enough south to have a slow drainage into the Ohio river. Its soil depends almost entirely on the northern Drift, and not on the character of the underlying rock.

CHAPTER XXXVII.

REPORT ON THE GEOLOGY OF DELAWARE COUNTY.

BY N. H. WINCHELL.

SITUATION AND AREA.

Delaware county embraces the geographical center of the State. It lies immediately south of Marion and Morrow, and north of Franklin, which contains Columbus, the State capital. On the east it joins Knox and Licking, and on the west Union. Its area, officially stated at 283,289 acres, embraces 81,975 acres of arable land, 104,649 acres of meadow or pasture land, and 96,665 acres of uncultivated or woodland. Its average value per acre, exclusive of buildings, is $33.44, that of Franklin county being $57.42, and of Hamilton, which contains the city of Cincinnati, $84.39.

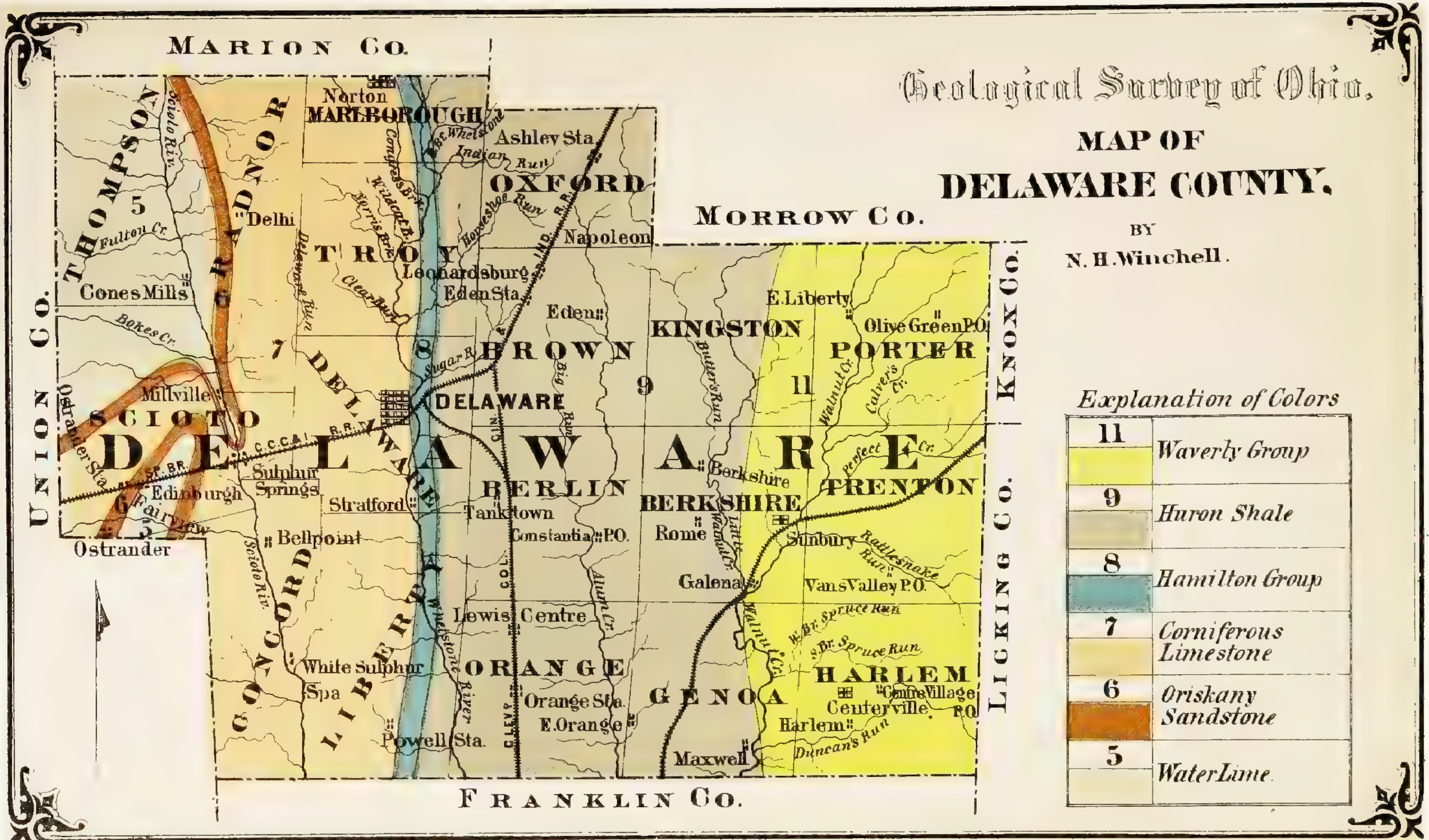
NATURAL DRAINAGE.

The Scioto and Olentangy Rivers cross the central portion of the county from north to south. These streams, with their tributaries, constitute the drainage system of the county. The Scioto is the larger stream. They are both subject to sudden and very great increase of volume in freshet time. They afford many excellent water-power privileges, some of which have been improved by the erection of mills for flouring and manufacturing. As they are inclosed, throughout most of the county, by high banks that are often rocky, they may be dammed with ease and security to adjoining lands.

SURFACE FEATURES.

The eastern portion of the county is rolling, particularly the sandstone districts. This is due partly to the original unequal deposit of the Drift, and partly to the effect of streams which have dug their channels through it, and into the rock, in some instances, to the depth of fifteen or twenty feet.

The area of the shale and black slate was at first generally flat, but the streams and all little ravines have so roughened the surface that it should now be called rolling, or undulating, although there are yet many wide flat tracts. The belt underlain by the shale and black slate is separated from the limestone belt by the valley of the Olentangy, which,


Geological Survey of Ohio.
MAP OF
DELAWARE COUNTY.
BY
N. H. Winchell.
Explanation of Colors
11 Waverly Group
9 Huron Shale
8 Hamilton Group
7 Corniferous Limestone
6 Oriskany Sandstone
5 Water Lime.
MARION CO.
MORROW CO.
KNOX CO.
LICKING CO.
FRANKLIN CO.
UNION CO.
DELAWARE
THOMPSON
RADNOR
MARLBOROUGH
TROY
OXFORD
BROWN
KINGSTON
PORTER
SCIOTO
DELAWARE
BERLIN
BERKSHIRE
TRENTON
CONCORD
LIBERTY
ORANGE
GENOA
HARLEM
Norton
Ashley Sta.
Delhi
Napoleon
Leonardsburg
Eden Sta.
Eden
E. Liberty
Olive Green P.O.
Cones Mills
Millville
Ostrander Sta.
Edinburgh
Fairview
Ostrander
Sulphur Springs
Stratford
Bellpoint
Tanktown
Constantia P.O.
Berkshire
Rome
Sunbury
Galena
Vans Valley P.O.
Lewis Centre
White Sulphur Spa
Powell Sta.
Orange Sta.
E. Orange
Maxwell
Harlem
Centerville
Centre Village P.O.
Scioto Riv.
Fulton Cr.
Bokes Cr.
Delaware Run
Clear Run
Norris Br.
Wildcat B.
Congress Br.
Indian Run
Horseshoe Run
Sugar R.
Big Run
Butter's Run
Walnut Cr.
Calvert's Cr.
Perfect Cr.
Little Walnut Cr.
Rattlesnake Run
W. Br. Spruce Run
S. Br. Spruce Run
Duncan's Run
Whetstone River
Alum Cr.
Strobridge & Co. Lith. Cin. O.

with its tributaries, constitutes an important system of drainage. The whole limestone district, which embraces all that part of the county west of the Olentangy River, except that underlain by the Waterlime, is moderately undulating, the surface being worn by erosion into shallow depressions, which, near their junction with larger streams, become ravines bounded by steep bluffs. The district of the Waterlime is flat, especially in the townships of Radnor, Thompson, and Scioto. The deeply eroded valleys of the Scioto and Olentangy constitute the most marked topographical features of the county. In the southern part of the county these valleys are deeply cut in the underlying rock. The divide between them at a point west of Powell is one hundred and twenty-five feet above the Scioto. That interval is made up mostly of the beds of the underlying limestone, the Drift not having an average thickness of over twenty-five feet. The descent to the Olentangy is usually very gentle, occupying sometimes the space of a mile or more on either side; while the valley of the Scioto is narrower, and its banks more frequently rocky and precipitous. The valley of the Olentangy is excavated for the most part in the black slate or the underlying shale, but that of the Scioto is cut in solid limestone strata. This fact may account for the greater breadth of the former.

In the north-western part of the county the valley of the Scioto is strikingly different from the southern part. It has here the features that the same valley presents in Marion and Hardin counties. The bluffs are never rocky. The general level of the country is but little above the level of the water in the river. The stream has not yet cut its channel throughout this part of its course through the Drift, and in traveling along its valley one is forcibly reminded of the strong resemblance of the face of the country to the Black Swamp region of north-western Ohio. It is a natural and reasonable inference that this portion of the country has had a very different superficial history from the southern and eastern parts, and one that allies it more to the Lake Erie valley than to the Ohio slope. These Black Swamp features prevail in the townships of Radnor and Thompson, and in the north-western part of Scioto.

RAILROAD ELEVATIONS.

		Above Lake Erie.	Above the Ocean.
Morrow county line (C. C. C. & I. R. R.)		405 feet.	970 feet.
Ashley (C. C. C. & I. R. R.)		412 "	977 "
Eden	"	405 "	970 "
Delaware	"	378 "	943 "
Berlin	"	381 "	946 "
Lewis Center	"	387 "	952 "

Soil and Timber.—The soil generally is dependent on the nature of the northern Drift. In this the various essentials, such as iron, lime, phosphorus, silica, magnesia, alumina, and soda, are so thoroughly mixed and in so favorable proportions that the strength and fertility of the soil are very great. The depth of the soil has the same limit as the Drift itself, which is, on an average, about twenty-five feet. The soil is more gravelly and stony in the rolling tracts. The stones come partly from the underlying rock, but mainly from the Drift. They are common along all the valleys of streams and creeks and in shallow ravines. They are made to appear superficial by the washing away of the clayey parts of the Drift, and are not due to any Drift agency acting since the deposition of the great mass. The north-western part of the county has a heavy clayey soil, with some exceptions. This clayey, flat land is comparatively free from superficial bowlders. Very little gravel can be found except in the line of gravel knolls that passes north-westwardly through Radnor township. The valleys of the streams, however, show a great many northern bowlders, as in other parts of the county. Besides these general characters of the soil of the county, a great many modifications due to local causes will be seen in passing over the county. There are some marshy accumulations, which, when duly drained, are found to possess a soil of remarkable ammoniacal qualities, due to decaying vegetation. The alluvial river margins possess a characteristic soil, strongly contrasting with the generally clayey lands of the county. They are lighter and warmer, while they are annually renewed, like the countries of lower Egypt, by the muddy waters of spring freshets, and are hence of exhaustless fertility.

The whole county was originally wooded with deciduous trees, which were associated, in the eastern portion, with a few species of conifers. Rev. J. H Creighton, of Delaware, has kindly furnished the following list of

TREES, SHRUBS, AND WOODY VINES FOUND GROWING IN DELAWARE COUNTY.

Abies Canadensis	Michx.	Betula nigra	L.
Acer saccharinum	Wang.	Bignonia capreolata	L.
" rubrum	L.	Crataegus cordata	Ait.
" dasycarpum	Ehr.	" oxycantha	L.
Ampelopsis quinquefolia	Michx.	" coccinea	L.
Alnus incana	Willd.	" flava	Ait.
Amelanchier Canadensis	Torr & Gr.	Cornus florida	L.
Asimina triloba	Dunal.	" Canadensis	L.
Aesculus glabra	Willd.	" paniculata	L'Her.
Benzoin odoriferum	Nees.	" alternifolia	L.
Betula papyracea	Ait. (?)	Carya alba	Nutt.

Carya tomentosa	Nutt.
" glabra	Torr.
" microcarpa	Nutt.
" porcina	Nutt.
Clematis Virginiana	L.
Corylus Americana	Walt.
Celastrus scandens	L.
Castanea vesca	L.
Cercis Canadensis	L.
Carpinus Americana	Michx.
Cephalanthus occidentalis	L.
Celtis crassifolia	Lam.
Diervilla trifida	Moench.
Euonymus atropurpureus	Jacq.
" Americanus	L.
" obovatus	Nutt.
Fagus ferruginea	Ait.
Fraxinus Americana	L.
" viridis	Michx. f.
" quadrangulata	Michx.
" sambucifolia	Lam.
Gleditschia triacanthus	L.
Hamamelis Virginica	L.
Hydrangea arborescens	L.
Juglans nigra	L.
" cinerea	L.
Juniperus Virginiana	L.
Liriodendron tulipifera	L.
Lonicera grata	Ait.
Morus rubra	L.
" nigra	L.
Menispermum Canadensis	L.
Nyssa multiflora	Wang.
Negundo aceroides	Moench.
Ostrya Virginica	Willd.
Populus alba	L.
" balsamifera	L.
" grandidentata	Michx.
" tremuloides	Michx.
" angulata	Ait.
" monilifera	Ait.
Pyrus coronaria	L.
Prunus serotina	Ehr.
" Virginiana	L.
" Chickasa	Michx.
Ptelea trifoliata	L.
Platanus occidentalis	L.
Pinus mitis	Michx.
" rigida	Mill.
Quercus macrocarpa	Michx.
" alba	L.
" Prinus	L.
" palustris	DuRoi.
" bicolor	Willd.
" falcata	Michx.
" tinctoria	Bart.
" nigra	L.
" aquatica	Catesby.
" rubra	L.
" Phellos	L.
" coccinea	Wang.
Rosa etigera	Michx.
" lucida	Ehr.
" rubiginosa	L.
" blanda	Ait.
" Carolina	L.
Robinia pseudacacia	L.
Ribes Cynosbati	L.
" lacustra	Poir.
Rhus glabra	L.
" typhina	L.
" toxicodendron	L.
Sambucus Canadensis	L.
Sassafras officinale	Nees.
Salix fragilis	L.
Smilax rotundifolia	L.
Spiraea opulifolia	L.
" salicifolia	L.
Staphylea trifolia	L.
Salix humilis	Marshl.
" alba	L.
" longifolia	Muhl.
" nigra	Marshl.
" discolor	Muhl.
" lucida	Muhl.
Tilia Americana	L.
Tecoma radicans	Juss.
Thuja occidentalis	L.
Ulmus Americana (pl. Clayt.)	Willd.
" fulva	Michx.
Viburnum prunifolium	L.
" opulus	L.
" acerifolium	L.
Vitis cordifolia	Michx.
" aestivalis	Michx.
Vaccinium macrocarpon	Ait.
Zanthoxylum Americanum	Mill.

This list may be increased by adding *Gymnocladus Canadensis*, Lam. (Kentucky coffee-tree), seen in Radnor township, and *Prunus Americana*, Marshall. The red mulberry (*Morus rubra*, L.) is rather common, growing in situations that prove it indigenous to the county. It is also common, in its native state, in most of north-western Ohio. The Balm of Gilead (*Populus candicans*, Ait.) and the common locust (*Robinia pseudacacia* L.) are also generally seen in cultivation.

GEOLOGICAL STRUCTURE.

The geological range of the county is from the base of the Carboniferous system to the Waterlime in the Upper Silurian. The oldest, and hence the lowest, geological horizon is in the north-western portion of the county, occupying Thompson and a part of Scioto townships. The outcropping belts of the formations cross the county from north to south. The townships of Radnor, Marlborough, Troy, Delaware, Concord, Liberty, and Scioto are underlain by the Corniferous, including also what there may be of the Hamilton. The belt between the Olentangy and Alum Creek is occupied mainly with the outcroping edge of the Huron shale, including the underlying blue shale seen beneath the Huron at Delaware, in the banks of the Olentangy. How far east of Alum Creek the black slate extends it is impossible to say, but it probably includes the western portions of Kingston, Berkshire, and Genoa. The fragile shales that immediately underlie the Berea grit have a narrow belt of outcrop through Kingston, Berkshire, and Genoa. The Berea grit underlies the most of Porter, Trenton, and Harlem. The overlying Cuyahoga shales and sandstone, called Logan sandstones in the southern part of the State, have but a feeble representation in Delaware county. They would undoubtedly be encountered by drilling in the extreme eastern portion of the eastern tier of towns. The various strata making the series of Delaware county are as follows, in descending order:

Cuyahoga shales and sandstones.
Berea grit.
Cleveland shale.
Huron shale.
Olentangy shale.
Hamilton and Upper Corniferous limestone.
Lower Corniferous limestone.
Oriskany sandstone, or conglomerate.
Waterlime.

Cuyahoga Shales and Sandstones.—At Condit, in Trenton township, on the line between sections 1 and 2, may be seen an exposure of the Cuyahoga, in the bed of Perfect's Creek. It is on land of Oliver Greatrax, and has the following section, in descending order:

No. 1.	Sandstone, of the grit of the Berea, not glittering and earthy, in beds of 1 to 4 inches, seen	3 ft.	
" 2.	Shale—blue, hard	1 "	
" 3.	Sandstone, same as No. 1, but in thicker beds of 4 to 6 inches	2 "	
" 4.	Shale, like No. 2		8 in.
" 5.	Sandstone, same as No. 1, seen	4 "	
	Total	10 "	8 "

The bedding of this quarry is irregular, the pieces coming out in all shapes lenticularly, and varying in thickness; but the stone is very good, the grain being firmer and more like that of the Berea than any seen elsewhere in the Cuyahoga.

S. W. ¼ section 2, Trenton. In the left bank of Perfect's Creek, on the land of Norman Overturf, the following section may be made out, in descending order:

SECTION ON NORMAN OVERTURF'S LAND, TRENTON TOWNSHIP.

No. 1.	Thin-bedded, shaly sandstone, glittering with mica, especially on the sides of the bedding	3 ft.	
" 2.	Beds more even—2 to 5 inches; grit similar to that of the Berea	4 "	6 in.
" 3.	Very thin and shaly, rather slaty		6 "
" 4.	Beds 2 to 4 inches		6 "
" 5.	Slaty sandstone		4 "
" 6.	Beds 2 to 6 inches, seen	1 "	
	Total	9 "	10 "

The slaty beds of this section, which are wavy and ripple-marked, lie irregularly among stone that is of a coarser grain and heavier bedding, the heavy beds showing the unusual phenomenon of tapering out, allowing the horizon of the slaty layers to rise and fall in the course of a few rods.

This section, or parts of it, is seen again in the left bank of the Walnut, below the mouth of the Perfect Creek, on Mr. Overturf's land. It is also exposed a few rods further north, along the left bank of Walnut Creek, on Monroe Vance's farm. At the latter place some very good flagging has been obtained from the bed of the creek, but the thickest beds are not over four inches, the most being less than an inch. They afford here a fine surface exposure, showing a peculiar sheety and wavy arrangement. They rise and fall, shooting up and down at various angles and in all directions, and are often ripple-marked, reminding the observer very much of similar thin layers of the Waterlime of the Upper

Silurian. Similar beds are exposed on John Ferrier's land, next above Mr. Vance's. They continue also through the farms of Andre Wiants, Hosea Stockwell, Nelson Utley, and James Williamson, a mile and a half above Mr. Vance's, showing the same characters, and are somewhat used for walling wells and for common foundations. Below Mr. Overturf's section, Mr. Reason Criss owns a bluff of similar stone on the right bank of the Walnut. Passing down the Walnut, from the mouth of the Perfect, lower beds of No. 6 of the section above given on Mr. Overturf's land are visible, making in all six feet of beds varying from two to six inches in thickness. Although these beds generally have that thickness, this number also embraces wavy beds of not more than one-eighth to one-half inch thick, which strike diagonally across the face of the bluff, sometimes rising and falling, and running out in either direction, with a tapering point, within twenty-five feet, the thickness of the slaty beds not being altogether more than four inches. Thus the valuable beds are cut up into lenticular pieces of differing thicknesses, and rendered easy of quarrying. With the exception of these wavy beds, the whole of Overturf's section might be embraced in one number, the beds represented by Nos. 1, 3, and 5 being like the above in No. 6, and very unreliable, and without extension horizontally.

Passing further down the creek, just before reaching widow Boyd's quarry, the base of the foregoing section shows thicker beds of six to fourteen inches, to the amount of about three feet; but before reaching the quarry they disappear in the bank, and no more is seen of them. But at the quarry of Mrs. Boyd there is a high bank of about twenty feet, embracing some of the rock of the foregoing section, and running down so as to cover the foregoing thick beds. Here the thickest stone taken out is fourteen inches, but no bed is constantly of that thickness. Indeed, the whole of it, even in the bed of the creek where the quarrying is done, appears thin-bedded, and it is difficult to say where the horizon of the above thick beds really is. It is certain, however, that to complete the downward section from Overturf's to this place it is necessary to add:

No. 7. Beds heavier, sometimes 14 inches, with some slaty beds... 5 ft. 6 in.

At Mrs. Boyd's quarry some fine stone for heavy bridge abutments is being taken out (summer of 1872). It is of a fine grain, blue color, and a thickness of about eight inches. When it comes from below the water, sometimes the thinner slaty beds are compacted and adhere together, so that the stone appears nearly all in beds of four to fourteen inches.

Descending the creek still further, there occurs an interval of no exposure, but from the dip of the beds where last seen, and from the character of the stone where next exposed, it is certain the creek has made its way to a lower horizon in the formation. It is necessary to add, therefore:

No. 8.	(Seen above the bridge over the creek, east from Sunbury, and near Boyd's qurrry; also below the bridge at the top of the bluff, right bank.) Irregular, rough, full of oblique divisional planes, fragmentary, and sometimes concretionary, and in large masses	6 ft.
" 9.	Regular beds of 2 to 4 inches	4 "
" 10.	Massive, or concretionary and irregular, with oblique divisional planes, somewhat irony, with shaly deposits and partings, seen	12 "

The shale sometimes crumbles out of No. 10, leaving the heavier stone, thus showing a tendency to caverns; but these holes are not of great depth, because of the unstable character of the rest of the rock. In some places No. 9 is entirely lost, and Nos. 8 and 10 unite, making a very rough and angular stone, with a thickness of twenty feet or more. The bed of the creek here is made up of irregular angular pieces, instead of flat, thin fragments, as at Mrs. Boyd's quarry and above. This section, showing more or less of the beds of Nos. 8, 9, and 10, continues to form the bluffs of the stream as far down as the dam. A few rods below the dam the left bank is thirty-eight feet high, and is covered with a deposit of travertine, or carbonate of lime, from the top to the bottom. There is a flow of calcareous water over the bluff. This deposit is porous, and must have at least an average thickness of three feet. Pieces of that thickness have fallen down from the bluff. This carbonate has here no stains as of iron, noticed at Iberia, in Morrow county, although it occupies a similar situation geologically. This travertine has been burned, and is found to make a very white and strong quicklime.

The origin of the calcareous water which deposits this travertine is involved in much doubt, there being no limestone in that neighborhood, nor near that geological horizon.

Just below this travertine, on the same side of the stream, is John Landon's quarry, situated a short distance above the mill. This contains the base of the section of rough stone already given (Nos. 8, 9, and 10), and shows as follows:

No. 10.	Additional to No. 10	8 ft.
" 11.	Alternations of beds of shaly sandstone of 2 to 6 inches, and of good beds of solid stone of 6 to 20 inches. The individual layers of the slaty sandstone are not more than ¼ of an inch thick*	22 "
" 12.	Shale	4 " 6 in.

* These partings of slaty stone between the heavy beds aid in quarrying.

Opposite the mill of Mr. McFarland, Mr. Landon owns another quarry, situated a little further down. At this place the exposed section is as follows, continuing the numbering from above:

No. 11.	As above	18 ft.	
" 12.	Shale, as above	4 "	6 in.
" 13.	Heavy sandstone, in one bed, sometimes concretionary.	2 "	
" 14.	Shale	1 "	
" 15.	In one bed, sandstone	1 "	10 "
" 16.	Shale in the bed of the creek, thickness unknown.		
	Total thickness of section	76 "	8 "

The shale of No. 12 is apt to contain thin but very even beds of good sandstone. Indeed, one heavy bed of sandstone, valuable for railroad bridges, and for that purpose here quarried, entirely embraced in this shale, gradually thins out horizontally toward the north, and disappears entirely in the distance of 22 feet. This is a valuable quarry and furnishes heavy stone. The same is true of Sprague and Burr's quarry, which is across the creek and near the mill of Mr. McFarland. It is in the beds of No. 11 of the foregoing section.

Passing down the creek to the mouth of the Rattlesnake Creek, no further view of the shale underlying the sandstone is obtained. The bluffs are bold and rocky on either side, large fallen masses lying at the base, breaking the force of freshet currents and concealing the shale from sight.

The foregoing section of the lower portion of the sandstone, Nos. 1 to 16 inclusive, includes the Berea grit. It shows the imperceptible change that takes place between the Cuyahoga and the Berea. There seems to be no marked horizon setting off one from the other, yet there is a lithological difference that mainly consists in the heavier beds and the coarser grain of the Berea. The mica specks are also wanting generally in the Berea, although it is probable they would be found in the inclosed shale. The Berea may be said to include Nos. 8, 9, 10, 11, 13, and 15; the Cuyahoga would embrace Nos. 1, 2, 3, 4, 5, 6, and 7. The underlying shale is represented within the sandstone layers of the base of the Berea grit by Nos. 12 and 14; showing a gradual transition, so far as this section is concerned, from shale to coarse-grained sandstone, and then to the fine and shaly beds of the Cuyahoga. The very rough and fragmentary condition of Nos 8 and 10 should be specially noted. It occurs within the Berea, and has not been seen elsewhere in that formation.

Berea Grit.—Besides the foregoing sections in the Berea grit, it is also quarried by Mr. John Knox, in the banks of the Rattlesnake Creek, about half a mile above its junction with the Walnut. This quarry, worked by Messrs. Landon and Fish, shows the following downward section :

No. 1.	Drift	2 ft.	
" 2.	Beds two to three inches	12 "	
" 3.	Beds six to eight inches	3 "	
" 4.	Slaty beds		2 in.
" 5.	Concretionary, rough, worthless	2 "	2 "
" 6.	Heavy beds, four to ten inches	5 "	
" 7.	Interval hid.		
" 8.	Thicker beds in the creek, not well seen.		
	Total	22 "	4 "

This quarry is probably in the upper portion of the Berea grit. A quarter of a mile above Mr. Knox's quarry is that of Mr. Alfred Williams. This shows about fifteen feet of beds of two to four inches. About a mile and a quarter north of Harlem, along the South Branch of Spruce Run, is Homer Merritt's quarry. The upper portion of his section consists of thin layers of two to six inches. Thicker layers of fourteen or sixteen inches are near the bottom of the quarry. At Harlem Mr. Carey Paul owns a quarry, worked by Daniel Bennett, which embraces about twelve feet in perpendicular section, of uniform beds of two to six inches. Mr. A. S. Scott's land joins Paul's below, and contains two opened quarries that supply, like Mr. Paul's, considerable valuable stone. The horizons of Mr. Scott's quarries are identical, and embrace the following descending section :

Section at Scott's Quarry, in Harlem Township.

No. 1.	Drift	3 ft.
" 2.	Beds three to four inches, with shaly interstratification	12 "
" 3.	Beds eight to twelve inches	4 "
	Total	19 "

These quarries are in the southern corner of Harlem township, on small tributaries to Duncan's Creek, and are probably in the upper portion of the Berea grit.

Still further south, and adjoining Mr. Scott's, is Sherman Fairchild's section, which embraces good stone, and lies in a very favorable situation for drainage of the quarry. It is composed of beds of two to eight inches, with shale, making six feet exposed.

In the N. E. ¼ section 1, Berkshire, on the farm of Truman Perfect, beds belonging to the Berea have been considerably wrought formerly. The exposure occurs along a ravine which also crosses Mr. C. C. Bricker's farm, where similar beds have been opened, but feebly worked. In the north-west corner of Porter township Mr. Seymour Chambers owns a small opening in beds that belong to the Berea. The quarry is in the left bank of Walnut Creek, and shows five feet of beds that are from two to three inches in thickness. In the N. E. ¼ section 4, Kingston, Mr. James Stark has opened the Berea along the Little Walnut. The beds are thin, varying from two to four inches.

In general, the Berea grit in Delaware county is a very excellent stone for all purposes of building, and is very extensively wrought at Sunbury. It appears, however, to be of a finer grain than in the northern part of the State, and the massive beds that characterize it in Lorain county are entirely wanting.

Cleveland Shale.—The Bedford shale, which occurs below the Berea in the northern part of the State, seems not to exist in Delaware county. The Cleveland, likewise, has not been certainly identified. This is partly owing to the meagerness of the exposure of the beds of that horizon in Delaware county, and partly to the difficulty of distinguishing, without fossils, the Cleveland from the black slate (Huron shale). This uncertainty is augmented by the attenuation or non-existence of the Erie shale, which separates them by a wide interval in the northern part of the State. There are a few exposures of black or blackish shale in the banks of Walnut Creek in Berkshire township that may be referred to the Cleveland.

This stratigraphical horizon is also exposed below Mr. James Stark's quarry, on section 4, in Kingston township, near a saw-mill. Fragments of sandstone and of silicious limestone are strewn along the bed of the creek, mingled with northern bowlders. The limestone bed from which these fragments were derived was met in digging for the foundations of the mill. It is in a single bed, and is comparable to that which occurs at South Woodbury, in Morrow county. It is here, however, five to eight inches thick, and is said to be inclosed in the shale. The shale is blue, varying to purplish, through the presence of bituminous matter. It crumbles under the weather. Passing from the mill, a few rods down the creek there are seen two beds of this limestone, the upper about one and a half inches in thickness and the other about three inches. They are separated by four inches of shale, and have a coarse-grained, rusty coating, as at Mandeville's quarry in North Bloomfield, Morrow county.

Huron Shale.—This shale has a full development in Delaware county. Its outcropping belt is from eight to ten miles wide, and is divided by Alum Creek into about equal parts. It graduates downward into a shale which is much less bituminous and has a bluish color, and which lies directly on the blue limestone quarried at Delaware. It has occasional outcrops on the west side of the Olentangy, but that stream lies, almost without exception, along the western edge of the black slate or of the shale underlying. Alum Creek, and nearly all of its small tributaries, afford frequent sections of the Huron shale; but they are so unconnected, and have so great a resemblance one to the other, that they can not be correlated. Hence no correct statement of the thickness of this shale can be given. It has been estimated at about 300 feet.

It would be impossible to mention every point at which this shale is exposed in Delaware county; hence only those outcrops will be noted at which some features are disclosed which throw light on the general character of the formation.

In the bank of the East Branch of the Olentangy, near the center of section 1, Marlborough township, at Kline's factory, the following section, in descending order, was taken. It belongs to the lowest part of the Huron:

SECTION AT KLINE'S FACTORY.

No. 1.	Thin, bituminous and brittle, similar to the exposure at Cardington, Morrow county	7 ft.	
" 2.	Blue shale; calcareous, hard and compact, parting conchoidally; less hard and enduring than limestone; concretionary, irregular and bilging; seen in the bed of the river; this may not be a constant layer; seen		6 in.
	Total	7 "	6 "

Thirty or forty rods below the bridge over the Olentangy, just below the union of the East and West Branches, Troy township, the same horizon is exposed in the left bank of the river, on Jos. Cole's land, covering, however, more of both numbers, as follows:

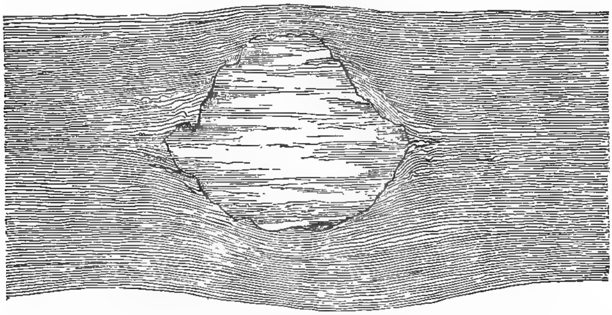
SECTION IN HURON SHALE ON JOS. COLE'S LAND, TROY TOWNSHIP.

No. 1.	Black slate, the weathered surface of which is divided into very thin beds; includes two beds, of an inch or two each, of less bituminous shale, which is blue, if damp, but brown when dry and rusted	23 ft.	
" 2.	Blue shale, yet in regular, thin bedding		6 in.
" 3.	Same as No. 1		4 "
" 4.	Bluish or purplish shale, in thin beds	3 "	6 "
" 5.	Black slate		8 "
" 6.	Massive blue shale, weathering out superficially in small rounded pieces or short cylinders, the upper ends of which are convex and the lower concave, the equivalent of No. 2 at Kline's factory	1 "	3 "
" 7.	Blue bedded shale; seen		3 "
	Total	32 "	6 "

The black slate also appears in the bed of the river about a mile below Cole's, on the land of David Dix and Henry Main, and in the bed of Horseshoe Run, in the south-east part of Troy township.

In No. 1, above, are large concretions of hard, black limestone, which are horizontally marked with parallel ridges or rings. When broken, some of them show small gashes or wafer-like cavities. These concretions are common near the base of Huron shale, and are often quite round, though they more usually show the form illustrated by the figure below.

CONCRETION IN THE BLACK SLATE, DELAWARE COUNTY, THREE AND A HALF FEET IN DIAMETER.



Besides those black concretions, there are some irregular calcareous masses that are blue and very hard. These calcareous masses in the lower portion of the Huron seem to indicate the waning of that condition of the ocean that deposited the Hamilton.

At Delaware, a quarter of a mile below the railroad bridge over the Olentangy, the Huron shale appears in the left bank of the river, underlain by the shale which has been regarded the equivalent of the Hamilton. There are no fossils in this underlying shale at Delaware proving its Hamilton age, and it will be referred to in the following pages, to avoid a possible misuse of terms, as the Olentangy shale. The slate is of its usual thin beds, with some calcareous layers, which are black, and about half an inch thick, hardly distinguishable from the slate itself. Here are also the round, calcareous concretions, technically called *septaria*, common to the lower portion of the black slate. The line of contact of the slate with the shale underlying is quite conspicuous at some distance from the bluff, the shale weathering out faster, allowing the tough beds of slate to project.

SECTION AT DELAWARE, COVERING THE LOWER PART OF THE HURON SHALE AND THE WHOLE OF THE OLENTANGY SHALE.

No.	1.	Black slate (Huron shale)	30 ft.	
"	2.	Blue shale, without fossils, in thin beds or massive	8 "	
"	3.	Blue limestone		4 in.
"	4.	Shale, like No. 2	1 "	4 "
"	5.	Blue limestone		3 "
"	6.	Shale, like No. 2	5 "	
"	7.	Alternations of blue shale and black slate	4 "	
"	8.	Blue shale, like No. 2	4 "	
"	9.	Shale, with concretions of blue limestone that part under the weather conchoidally like massive shale. These hardened calcareous masses are not regularly disposed with respect to each other, but fill most of the interval of six feet. They are six to eight inches thick, and two to three feet wide horizontally*	6 "	
"	10.	Shale ? (sloping talus), not well exposed	10 "	
"	11.	Bituminous, nearly unfossiliferous, limestone, of a black or purplish-black color, hard and crysta line. This black limestone shows a few indistinct bivalves. One, which is large and coarse, appears to be *Avicula pecteniformis*, Hall; seen	3 "	
"	12.	Interval, rock not seen	5 "	
"	13.	Section at Little's quarry, in the blue limestone (see page 96). The upper portions of this are quite cherty and pyritiferous. It may be	25 "	
		Total	101 "	11 "

Above Delaware the black slate and the Olentangy shale are frequently seen in the left bank of the river. The strike of the slate runs a little east of the river at the city, passing through and forming the bluff on which East Delaware is situated. The concretions of black limestone are from three inches to three and four feet in diameter, and sometimes much larger. Of these Dr. J. S. Newberry says, in the Report of Progress for 1869, p. 19:

" Much of the doubt which has hung around the age of the Huron shale has been due to the fact that it has been confounded with the Cleveland shale, which lies several hundred feet above it, and that the fossils (without which, as we have said, it is generally impossible to accurately determine the age of any of the sedimentary rocks) had not been found. Yet, with diligent search, we have now discovered not only fossils sufficient to identify this formation with the Portage of New York, but the acute eye of Mr. Hertzer has detected, in certain calcareous concretions which

* No. 9 here appears the same as No. 6 near the base of the section at Cole's, in Troy township.

occur near the base, at Delaware, Monroeville, etc., fossils of great scientific interest. These concretions are often spherical, are sometimes twelve feet in diameter, and very frequently contain organic *nuclei*, around which they are formed. These *nuclei* are either portions of the trunks of large coniferous trees allied to our pines, replaced, particle by particle, by silica, so that their structure can be studied almost as well as that of the recent wood, or large bones. With the exception of some trunks of tree ferns which we have found in the Corniferous limestone of Delaware and Sandusky, these masses of silicified wood are the oldest remains of a land vegetation yet found in the State. The Silurian rocks every where abound with impressions of sea weeds, but not until now had we found proof that there were, in the Devonian age, continental surfaces covered with forests of trees similar in character to and rivaling in magnitude the pines of the present day.

"The bones contained in these concretions are those of gigantic fishes, larger, more powerful, and more singular in their organization than any of those immortalized by Hugh Miller. These fishes we owe to the industry and acuteness of Mr. Hertzer, and in recognition of that fact I have named the most remarkable one *Dinichthys Hertzeri*, or Hertzer's terrible fish. This name will not seem ill-chosen, when I say that the fish that now bears it had a head three feet long by two feet broad, and that his under jaws were more than two feet in length and five inches deep. They are composed of dense bony tissue, and are turned up anteriorly like sled-runners; the extremities of both jaws meeting to form one great triangular tooth, which interlocked with two in the upper jaw seven inches in length and more than three inches wide. It is apparent, from the structure of these jaws, that they could easily embrace in their grasp the body of a man—perhaps a horse—and as they were doubtless moved by muscles of corresponding power, they could crush such a body as we would crack an egg-shell."

One mile north-west from Delaware, Mr. Nathan Miller struck the black slate, on the west side of the Olentangy, at the depth of twenty-one feet, in digging a well. It may also be seen along a little ravine tributary to the Delaware Run, near Mr. Miller's farm, on the land of C. O. and G. W. Little. Limestone only is seen in the bed of the run a few rods further west. It is blue and fossiliferous. A short distance still higher up the run the black member (No. 11 of the section taken in the Olentangy at Delaware) is seen in the bed of the same run.

About a mile and a half below Stratford a little stream comes into the Olentangy from the east, bringing along in freshet time a good many pieces of black slate. About a hundred rods up this little stream the beds of the black slate appear *in situ* in the tops of the bluffs, the Olentangy shale, with its full thickness of about thirty feet, being plainly exposed near its junction with the slate, while in the river the limestone beds of the Upper Corniferous are spread out over a wide surface exposure.

In Liberty township, two and a half miles south of Stratford, the black slate may be seen on the farm of Mr. J. Moorhead, on the west side of the Olentangy, in the banks of a ravine the distance of a mile from the river. For a considerable distance from this point, in descending the Olentangy, the banks show frequent exposures of the limestone. Near Mr. Wm. Case's quarry, five and a half miles below Stratford, the black slate may be seen by ascending a little ravine that comes in from the east. The section here is given in describing the Upper Corniferous.

Just at the county line the slate appears in full force again in the left bank of the river, little streams bringing fragments from the west side as well as from the east. A perpendicular exposure on land owned by Granby Buell of about forty feet consists of about five feet of shale at the bottom. It is also seen on the west of the Olentangy, by ascending a ravine near the county line, on Archibald Wood's land, and again, by ascending another ravine about three-quarters of a mile north of the county line, on the land of F. Bartholomew, and it seems to extend about two miles west of the Olentangy at its point of exit from Delaware county.

Olentangy Shale.—This name is given to that bluish and sometimes greenish shale which is so extensively exposed in the banks of the Olentangy River, in Delaware county, and which underlies the black, tough, but thin beds of the Huron shale. It has a thickness of about thirty feet. No fossils have been found in it. It is interstratified with a little black slate, and in some of its exposures it bears a striking resemblance, at least in its bedding, to the Huron shale. The section which has already been given of its exposure at Delaware is the most complete that has been taken, and very accurately represents its bedding and characters wherever seen in the county. It lies immediately upon a hard, blackish, sometimes bluish, crystalline, pyritiferous limestone, or on the beds that have been denominated Upper Corniferous in reports on the counties of Sandusky, Seneca, and Marion. In the county of Franklin, and further south, it is said to be wanting, and the black slate lies immediately upon the same limestone beds. It is also wanting in Defiance county, the black slate there also lying immediately on the beds that contain the only Hamilton fossils there yet discovered. This shale embraces occasionally a course of impure limestone that has a blue color and a rude concretionary appearance. On account of easy quarrying, it is a constant temptation to the people to employ it in foundations. It is found, however, to crumble with exposure after a few months or years, and change into a soft shale or clay. Large blocks of it are washed out from this shale just below Waldo, in Marion county, by the force of the water coming over the dam at the mill, and have been somewhat used by Mr. John Brundage, near Norton, in Marlborough township.

This shaly limestone near the base of the Olentangy shale is immediately underlain by a very hard crystalline limestone, which is sometimes black, but frequently purplish, containing pyrites in abundance and very few evident fossils. It is exposed and quarried just below Waldo, in Marion county, but is nowhere wrought in Defiance county. It is a persistent layer, and occurs in Defiance county. In the report on the geology of Marion county it has been referred to the Hamilton, where it probably belongs, and seems to represent the Tully limestone of New York.

The following section in the Olentangy shale will further illustrate the bedding and nature of this member of the Devonian. It occurs along the banks of a little creek that enters the Olentangy River from the west, on land of F. Bartholomew, south-east of Powell:

SECTION IN THE OLENTANGY SHALE, IN LIBERTY TOWNSHIP.

No. 1.	Black slate, with black limestone concretions..	20 ft.	
" 2.	Blue shale, bedded like the slate, but softer	3 "	
" 3.	Black limestone, in a broken, lenticular, or concretionary course		8 in.
" 4.	Same as No. 2	5 "	4 "
" 5.	Black slate		2 "
" 6.	Shale, same as No. 2	2 "	
" 7.	Blue, irregular, shaly limestone, appearing concretionary; the same as that washed out of "blue clay" near Waldo; comes out in blocks; in one course		4 "
" 8.	Same as No. 2		10 "
" 9.	Same as No. 5		3 "
" 10.	Same as No. 2		2 "
" 11.	Same as No. 5		1 "
" 12.	Same as No. 2		6 "
" 13.	Same as No. 5		1 "
" 14.	Same as No. 2	1 "	2 "
" 15.	Same as No. 5		4 "
" 16.	Same as No. 2	1 "	
" 17.	Same as No. 5		1 "
" 18.	Same as No. 7		8 "
" 19.	Shaly (not well seen)	15 " ?	
" 20.	Hard, dark blue, bituminous limestone, with much chert and pyrites; the chert is black, and hard as flint; beds three to twelve inches (well exposed)	9 "	6 "
" 21.	Thinner blue beds, with vermicular or fucoidal marks, and little chert; fossiliferous; sometimes coarsely granular and crinoidal, but mainly earthy or argillaceous, and tough under the hammer; within, this is in beds of six to twelve inches	6 "	

No. 22.	Limestone in thin or slaty beds, so contorted and yet agglomerated by chert (which forms nearly one-half of the mass) that the whole seems massive; the chert is dark..	3 ft. 6 in.
" 23.	Beds of blue limestone of four to ten inches, alternating with chert beds of one to four inches; these limestone layers weather into beds of one to two inches..............	4 "
" 24.	Thin slaty beds, with alternating chert beds, the latter about an inch thick; where this number forms the bed of the creek it does not appear slaty, but massive and smooth, like a very promising building stone; the creek, where it enters the river bottoms, is on this number, and nothing more is seen..	6 "
	Total..	80 " 8 "

These limestone beds have been quarried for the building of Mr. Bartholomew's residence. They are none of them conspicuously fossiliferous.

Hamilton and Upper Corniferous.—These names are here associated, because whatever Hamilton fossils have been found in the county have been detected in that formation that has been described in reports on other counties as Upper Corniferous, and because it seems impossible to set any limit to the downward extension of the Hamilton, unless the whole of the blue limestone be Hamilton. The shale which has been described as Olentangy shale was at one time regarded as the only equivalent of the Hamilton, from the occurrence of Hamilton fossils in a shaly outcrop at Prout's Station, in Erie county. But after the survey of the county revealed no fossils in that shale, it became evident that it could not be the equivalent of the very fossiliferous outcrop at Prout's Station, and should not bear the name of Hamilton. That shale partakes much more largely of the nature of the Huron than of the Hamilton. The name Corniferous is made by Dr. Newberry to cover the whole interval between the Oriskany and that shale, the Hamilton being regarded as running out into the Corniferous, its fossils mingling with typical Corniferous fossils. In the State of Michigan, however, the term Hamilton has been freely applied to these beds, the Corniferous, if either, being regarded as reduced. The lithological characters of the Michigan Hamilton are the same as those of the Upper Corniferous in Ohio, and it is hardly susceptible of doubt that they are stratigraphically identical. In Ohio there is a very noticeable lower horizon that should limit the Hamilton, if that name be applicable to these beds, and if palæontological evidence will not limit it.*

* A few words of explanation are necessary in connection with the remarks of Prof. Winchell, which follow:

1st. The shale bed, which is described above under the name of Olentangy shale, The blue color, close, crystalline texture, frequent argillaceous deposits, and regularity of beds, as well as the occurrence of Hamilton fossils through the whole of the Upper Corniferous, as described in the reports on the counties of Sandusky and Seneca, and more especially of Paulding and Defiance, are indications that the Hamilton characters pertaining to the formation are confined to the upper thirty-five feet. These characters are very well displayed in the quarries at Delaware, Marion, and Sandusky, while the characters of the Lower Corniferous, as the term has been used by the writer, are seen at the quarries at Delhi, in Delaware county, and at Marblehead, north of Sandusky Bay. It is also well exposed in the creek bluffs at Bellepoint, in Delaware county, although at that place the beds exposed lie below the Delhi beds.

The upper surface of these beds can be seen on the Olentangy, near Norton, on the land of J. B. Wyatt, Mary Wyatt, and of John Brundage, where they have been opened for building stone. They are also quarried near Waldo, in Marion county, in a similar situation, in the bed of the Olentangy. The only other undoubted exposure of the very highest beds belonging to this formation that is known occurs near Delaware, likewise in the bed of the Olentangy. It is mentioned in the section of

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is supposed by Prof. Winchell to be the rock specifically referred to as the probable equivalent of the Hamilton. In this he is in error, as the bed referred to as a possible representative of the Hamilton in Delaware county is one described by Mr. Hertzer as a light-blue marly stratum, containing concretions with fish remains different from those of the overlying Huron. It would seem from Prof. Winchell's report that he has not encountered this deposit. His Olentangy shale, without some evidence to the contrary, I should regard, as he does, as merely a subdivision of the Huron shale.

2d. The Tully limestone ? of Prof. Winchell's sections is certainly Hamilton, as I have obtained from it *Tropidoleptis carinatus, Pterinea flabella, Nyassa arguta, Spirifera mucronata*, etc. That it is the equivalent of the Tully limestone is not indicated by any evidence yet obtained.

3d. The relations of the limestone called Hamilton by Prof. Winchell—the equivalent of the "Sandusky limestone" of our reports—which I have considered a portion of the Corniferous group, is discussed in the remarks on the Hamilton group, Vol. I., Part. I., pp. 144–149, and in the report on Erie county, which forms part of this volume. By reference to the passages referred to, I think it will be seen that the weight of evidence is decidedly in favor of its being of Corniferous age.

The cherty layers which lie between the Huron shale and the quarry-stone at Delaware are probably Hamilton, but the quarry-stone itself, though containing some fossils which are common to the Hamilton and the Corniferous, has never yielded me any exclusively Hamilton fossils. On the contrary, I have obtained from it quite a number of Corniferous species—such as *Spirifera gregaria, S. macra, Strophodonta hemispherica, Pentamerus aratus*, which are never known to ascend into the Hamilton.

J. S. N.

the shale outcropping there, under the head of the *Huron Shale*, and is described as a black limestone, hard and crystalline. (No. 11, p. 90, of the section at Delaware covering the Olentangy shale.) It is also included in No. 20 of the "section in the Olentangy shale, in Liberty township."

The exposure near Norton does not show so dark a color, but varies to a blue. It occurs there in even, thick courses, that would be extremely difficult to quarry except for the natural joints by which the layers are divided into blocks. The same is true of its outcrop near Waldo. In both places it is a hard, ringing, apparently silicious, tough, and refractory limestone, some of the blocks being over two feet thick. It is a very reliable building stone, but the abundance of pyrites that is scattered through it makes it very undesirable for conspicuous walls. It is exceedingly fine-grained, and but slightly fossiliferous. At these places not more than four or five feet of this stone can be seen, but it has an observed thickness in the southern part of the county of about nine and a half feet. It seems to retain a persistent character, for the same stratum is seen to form the top of the Upper Corniferous in Defiance county, on the west side of the great anticlinal axis. It is believed to be the equivalent of the Tully limestone of New York.

Below these very hard and heavy layers comes the stone quarried extensively at Delaware. The quarry of Mr. G. W. Little shows about eighteen feet of bedding, in courses three to fifteen inches thick. It is for the most part in a very handsome, evenly-bedded blue limestone that shows some coarse chert, and, in places, considerable argillaceous matter, which renders the walls built of it liable to the attacks of the weather. The features of the Hamilton here seem very conspicuously blended with those that have been designated more distinctively as belonging to the Corniferous. The fossils are not abundant throughout the whole, but between certain thin beds many bivalves—*Cyrtia Hamiltonensis*, *Spirifera mucronata*, *Strophomena* (*rhomboidalis?*), *Strophomena demissa*—and one or two species of *Discina*, and various vermicular markings, are common. In some of the heavier beds the fish remains that have been described by Dr. Newberry, from the Corniferous at Sandusky, are met with, as well as the large coils of *Cyrtoceras undulatum*.

Mr. Little's section is as follows, in descending order, dip east:

SECTION IN THE HAMILTON AT DELAWARE, OHIO—QUARRY OF C. W. LITTLE.

No. 1.	Beds thin (because weathered) and faded, showing rather gray than blue, fossiliferous with bivalves, specially with *Strophomena* (*rhomboidalis?*), shown	2 feet.
" 2.	Thin, irregular beds, consisting mostly of chert nodules	2 "

No. 3.	The mass of the quarry: blue limestone, with some bands of impure chert; beds usually two to five inches, but sometimes ten to fourteen inches; contains *Cyrtia, Discina, Strophomena, Spirifera*	16 feet.
	Total	20 "

In the vicinity of Delaware are several other quarries in the same beds, viz.:

G. W. Campbell's, a short distance north-west of Mr. Little's, on the same section.

Harris Allen's quarry is about a mile south-east of Mr. Little's, in the right bank of the Olentangy. It is on the same horizon, and presents the same features. At Mr. Allen's quarry some blue flagging may be seen in process of decay under the action of water and frost, returning apparently to shale or clay, the fossils, *Cyrtia* and *Sprirfera*, becoming disengaged, producing a deposit that may be compared to the shale in which these fossils abound, and which has been termed Hamilton, where an outcrop occurs in Erie county. This quarry also shows *Tentaculites*, the same as at the quarry of Mr. Kawlin, at Sandusky.

Peter Zimmerman's quarry is a little above Mr. Allen's, but in the same layers. They both show a slight dip north or north-east. The same rock is more or less exposed in the river from Delaware to the mill, three miles below. Daniel Kline's quarry is situated here, also Jos. Slough's.

The bed's quarried by Mr. Little are exposed in the left bank of the Olentangy, about two miles above Delaware, on land of Matthis Kruck. They form here a rapid across the river, and have been quarried. They have also been a little wrought by Frederick Ziegler and Wm. Siegfried, as well as by Thomas Slough, all adjoining or near Mr. Kruck. Stone from the river along here has been used in the construction of several farm residences and barns. Mr. Slough's large mill is also built of it.

The same or similar beds are seen in the Olentangy at the center of Troy township, and have been opened for building on the land of J. C. Main and of W. G. Norris.

Peter Wiser's land, on the right side of the creek, half a mile below the mouth of Norris Run, shows this stone, and it has here been opened also for quarrying.

At Stratford there is ample exposure of the Hamilton beds similar to the section already taken at Mr. G. W. Little's, though but little active quarrying. Several houses, barns, mills, and churches at Stratford village have been erected of this stone.

About two miles below Stratford are James Bieber's mill and quarry.

Beds the same as the Delaware stone. Mr. J. A. Clark's is half a mile above Mr. Bieber's.

Between two and three miles below Stratford the Lower Corniferous appears on both sides of the river, and is described under the head of Lower Corniferous. But about fifty rods still further down the right bank, shows the Hamilton, or Upper Corniferous, again, having a thin and almost slaty appearance as the edges of the layers are exposed in the river bluff. In some parts these beds here are thickly crowded with *Spirifera*, *Cyrtia*, and *Strophomena;* these, indeed, being the only conspicuous fossils. These beds closely overlie the above mentioned Lower Corniferous, although the superposition could not be discovered, showing the continuance of Hamilton fossils well down into the Delaware stone.

At a point about five miles and a half below Stratford, Mr. William Case has a quarry on the left bluff of the river, in beds at the horizon of the base of the Delaware stone. A little above this quarry a ravine joins the river from the east, its sides affording a fine connected section through the Olentangy shale, and the whole of the Delaware limestone, into the Lower Corniferous. The shale and overlying Huron are seen in ascending this ravine, about fifty rods from the river. Descending this ravine, and including the rock exposed below Mr. Case's quarry, where a very prominent bluff is formed by the erosion of the river, the following succession of beds appears:

Section Through the Olentangy Shale and Hamilton Limestone, Five and a Half Miles below Stratford.

No. 1.	Black slate (Huron shale), seen	10	feet.
" 2.	Blue, or bluish-green, bedded shale; non-fossiliferous, embracing sometimes layers of black slate, like No. 1, of 3 or 4 inches in thickness; poorly exposed (Olentangy shale), about	30	"
" 3.	Bituminous, dark blue, or black limestone; non-fossiliferous, rather rough, hard, and with some black chert, or flint (Tully limestone?)	1	"
" 4.	Thin, blue, tough, finely crystalline beds, containing considerable black chert, or flint, associated with pyrites; in the lower portion in beds of 4 to 16 inches; but little fossiliferous (Tully limestone?), about	8	"
" 5.	Beds 4 to 6 inches, slightly fossiliferous; embracing some bituminous, slaty shale in irregular deposits about crowded concretions (Hamilton limestone?)	14	"
" 6.	Tough, bluish-gray, slaty beds of impure limestone, of the thickness of $\frac{1}{4}$ to $\frac{1}{2}$ an inch, with considerable chert (Hamilton?)	8	"

No. 7.	Heavier beds (6 to 20 inches), but of the same texture as the last; fossiliferous; blue; the horizon of the best quarries at Delaware, showing the usual fossils and lithological characters (Hamilton?)	6 feet.
" 8.	Crinoidal beds, fossiliferous, of a lighter color; not showing blue; generally massive, or 8 to 36 inches, but weathering into beds of 3 to 5 inches (Corniferous limestone)	6 "
" 9.	Heavy or massive beds of crinoidal limestone, which weathers off by crumbling into angular pieces of an inch or two; light gray, or buff; with large concretions of chert between it and the last. This seems to contain all the fossils characterizing the Lower Corniferous, as that term has been used in reports on other counties. Below, becoming more bituminous, less crinoidal, but equally fossiliferous (Corniferous limestone), seen	11 "
	Total seen	94 "

There is a strong dip here to the east. Mr. Case's quarry is in No. 7. From this place to near the county line the Delaware limestone is exposed frequently along the right bank of the river, but nowhere affording so complete a section as that at Case's, till finally it entirely goes below the water, and the shale and slate take its place in the banks.

About a mile and a quarter south of Bellepoint, on the west side of the Scioto, the Upper Corniferous is opened by W. T. Ropp, M.D, and William Cutler. The amount exposed is about three feet, though a "sink-hole" in the center of Dr. Ropp's quarry, which allows the disappearance of a considerable stream in freshet time, affords the means of an imperfect inspection of about ten feet more. Beds lie nearly horizontal, or show a slight dip north. Dr. Ropp's well, fifty rods north of his quarry, struck the same limestone. After passing fifteen or eighteen feet into the blue stone, the beds quarried at Delhi were encountered. At the river, directly east of Cutler's quarry, the lower portion of the Corniferous is seen on Dr. Ropp's land exposed about ten feet. About midway up the bank, intermediate between the quarry and the river, the Delhi beds are seen in prominent outcrop on the land of Dr. Ropp. About half a mile south of Cutler's quarry the heirs of Leander Stone own a quarry in similar limestone. One mile still further south Mr. Perry Marsh has another quarry in the same beds, situated in a ravine tributary to the Scioto. Beds from four to six inches. Brainerd Willis has a quarry three-quarters of a mile south of Bellepoint, about a quarter of a mile east of the Scioto, said to be in the blue limestone. Elijah Kent has a blue stone quarry opposite the sulphur spring, on the east side of the Scioto, situated half a mile from the river. The line of the separation between the blue Delaware limestone and the Delhi limestone seems to cross the Scioto at or near Bellepoint, perhaps a little south of that village.

About three-quarters of a mile below Sulphur Spring Station, Wild Cat Run joins the Scioto from the east. It is deeply and almost astonishingly cut into the hard limestone beds, across which it keeps a fresh section of the layers finely exposed. At the top of the bluff, where one reaches the general level by ascending the bed of this ravine (dry the most of the year), Mr. Peter Burlet has a fine quarry in the Delaware beds of the Corniferous. Near him Fred. Burlet has another. From the latter there is a continuous exposure to the level of the Scioto, where Mr. Richard Colvin's quarry and kilns for lime-burning are operated by Charles G. Schmidt. Uniting all these exposures, the following section may be made out, in descending order:

SECTION AT COLVIN'S LIME KILNS, NEAR BELLEPOINT.

No. 1.	Blue, hard beds, of from 4 to 10 inches, of Delaware stone, seen in the quarries of Peter and Fred. Burlet	9 ft.	
" 2.	Heavy layers of Delhi stone; thin-bedded when weathered. Sixteen or seventeen years ago these beds were extensively wrought for the abutments and piers of the railroad bridge over the Scioto, near here. Very heavy, large blocks were taken out, yet these layers are generally seen but 3 or 4 inches thick where weathered. Fred. Burlet's quarry is just on the top of these layers, including 3 feet of the Delaware stone. The ravine below Fred. Burlet's shows of these Delhi layers about	28 "	
" 3.	Bluish, hard, less fossiliferous, but having some large cephalopods; beds heavy	10 "	
" 4.	Very fossiliferous with corals, particularly with a large, massive, globular *Favosites*, with *Stromatopora*, *Chætetes*, and crinoidal remains; the bedding becoming thinner than in the last, and tortuous, with bituminous deposits and films. The color is brown, the stone much softer than in No. 3 *	3 "	6 in.
" 5.	Six-inch beds of soft, bituminous, even-grained, magnesian limestone, with some chert, seen		6 "
	Total exposed	56 "	6 "

Colvin's quarry is in the Delhi beds of the Lower Corniferous, near the bottom. The common fossils are seen here in the usual abundance. The

* Perhaps Nos. 3 and 4 should be in one, the fossils and bituminous matter varying from one horizon to the other, causing the difference in lithological aspect.

stone is also somewhat blue, or brown-blue, and hard, near the bottom. The bituminous matter which, when very finely disseminated, seems to cause the bluish and brownish colors, is stronger near the bottom, but the stone remains hard and sonorous.

Lower Corniferous.—That limestone which, in reports on the counties of Sandusky, Seneca, Crawford, and Marion, the writer has designated "Lower Corniferous," is divisible, on account of strong lithological and palæontological differences, into two well-marked members. The upper member, well exposed and extensively burned for lime at Delhi, in Delaware county, lies immediately below the blue limestone quarried at Delaware, as may be seen by reference to the last foregoing section, and has a thickness of about twenty-eight feet. It is of a light cream color, crystalline or saccharoidal texture, quite fossiliferous, and usually seen in beds of three or four inches. It is rather hard and firm under the hammer. It makes a lime not purely white, but of the very best quality. When this stone is deeply and freshly exposed, it is seen to lie in very heavy layers, and as such it would furnish a fine crinoidal marble for architecture. Its most conspicuous fossils are brachiopods of the genera *Strophomena* (?), *Atrypa*, *Chonetes*, and others, with one or two genera of gasteropods, and occasionally a specimen of *Cyrtoceras undulatum.* There may also be seen in these beds different species of Cyathophylloids, trilobite remains, and fish-spines and teeth. This member of the Lower Corniferous occupies the position, relatively to the Hamilton, of the Corniferous limestone of New York, though it is not possible at present to say it is the equivalent of that formation. It would thus be the upper member of the Upper Helderberg of that State. It has a thickness of about twenty-eight feet.

Below the Delhi limestone is a fossiliferous belt of limestone, often of a bluish color and bituminous character, ten to fifteen feet thick, characterized by corals in great abundance. In the central part of the county of Delaware this belt is chiefly fossiliferous in the lower three or four feet, the remainder being rather hard, but of a blue color. The southern part of the county, however, seems to be without this bluish and highly coralline member, the Delhi beds coming immediately down on the second division of the Lower Corniferous. The corals found here are Favosites, Cœnastroma, Stromatopora, and Cyathophylloids. This belt is met with in Crawford county, and seems to prevail toward the north as far as Erie county.

The second division of the Lower Corniferous is a light colored, even-bedded, nearly non-fossiliferous, vesicular or compact magnesian limestone, which makes a good building stone, being easily cut with common hammer and chisel, and has a thickness of about thirty feet. It is apt to appear somewhat bituminous and of a dirty or brown color when constantly wet, but under the weather it becomes a light buff. The upper half of this stone is in beds of two to four inches, the lower in beds of one to three feet. Near the bottom it becomes arenaceous, and even conglomeratic, passing into the Oriskany sandstone, which has a sudden transition to the Waterlime of the Lower Helderberg. It seems to have many of the lithological features and the persistency of the Onondaga limestone of New York, and may be provisionally parallelized with that formation The fossils are generally absorbed into the rock, casts or cavities only remaining; yet a Cyathophylloid and a coarse Favositoid coral have been seen.

Where the Scioto crosses the southern boundary of the county the following section was taken, in descending a ravine from the east, on the land of Abram Butts:

Section near the South Line of Delaware County, in the East Bank of the Scioto.

No. 1.	Delhi beds; this stone is very fossiliferous. It is hard, sonorous, and more or less crinoidal, some joints being seen in almost every fracture. It is light-colored, rarely showing a blue or a bituminous tint. It presents mural surfaces, with a crumbling disintegration, under the weather, the pieces falling out being an inch or two across. This is a characteristic of these beds (Corniferous limestone)	20 ft.
" 2.	Cherty beds of two to eight inches, of very much the same texture and color as No. 1, but almost without fossils (Onondaga ltmestone ?)	10 "
" 3	Heavy-bedded, even, magnesian limestone; fit for a cut-stone; sometimes popularly called sandstone; beds eight to twenty inches, but including some thinner and more bituminous layers about midway, embraced in the thickness of about a foot; this has a light buff color when long exposed, but if much wet it shows a brown color, with bituminous films; no fossils seen; no chert (Onondaga limestone ?); seen	14 "
	Total	44 "

These beds, or similar ones, are more or less exposed from the county line northward, along the banks of the Scioto, as far as to Millville. About eighty rods south of Sulphur Spring Station the Delhi beds strike away from the river toward the east, the river running on the lower member (No. 3) of the last section. But about a mile above the Springs these beds return to the left bank of the river, giving it a height, including the underlying magnesian beds, of about forty feet.

About two miles below Sulphur Spring Station is John Spero's quarry, in the left bank of the Scioto. It is in the Delhi beds, exposed twelve or fourteen feet. Stone is hauled from here to Delaware and burned for lime by Mr. G. W. Corbin.

The water in Mill Creek, at Bellepoint, is on No. 3 of the foregoing section, taken near the county line, and has excavated a channel in it to the depth of fifteen feet, with a heavy-bedded, firm stone of the same kind in the bed of the creek. Above these heavy layers is a thickness of twelve feet of cherty beds, varying from four to nine inches, but usually from four to six. John Jones's lime-kiln is excavated in these beds. John Courtwright, four and a half miles below Bellepoint, has a quarry in the same horizon. Daniel Kelly's quarry is on the east side of the Scioto, a mile and three-quarters below Bellepoint. A quarter of a mile below Millville, on the east side of the river, are the quarry and kilns of Mrs. Margaret Evans. The hard, bluish layers of No. 3 of the section at Colvin's lime-kilns are here wrought for lime-burning, though the bedding here is less heavy than at Colvin's, being generally about three inches. In the river bank, some distance below the quarry, but just west of it, the Waterlime is exposed, and was formally burned for lime. It is distinguished as "the white stone," from the whiteness of the quicklime made from it, that from the Lower Corniferous being a little dark or ashen. East from Evans's kiln, a third of a mile from the river, are several sink-holes seen on the land of W. S. Sipes. On examining these, the Delhi beds are found to be about fifteen feet below the surface. What portion of that interval is taken up with those beds, or what is occupied with Drift, it is impossible to say; but the blue beds of the Delaware stone should be *in situ* very near that horizon. These sinks are on the plains, about eighty feet above the river. The whole tract of land between the Scioto and the Olentangy, in Delaware county, is liable to these sink-holes. Very many were met in the survey that are not mentioned in this report.

The so-called "fire-stone" of William Warren's quarry, half a mile west of Millville, is the same as that burned for quicklime by Mrs. Evans, but is overlain at Warren's quarry by two feet of Delhi beds. It is exposed also half a mile further north, on land of C. F. Burner and Thomas Jones.

The stone placed in the piers of the highway bridge over the Scioto, at the mouth of Bogg's Creek, was taken from the quarry of Rev. C. H. Perkins. It is in heavy beds, soft and vesicular, becoming firm after exposure to the air, and belongs to the lowest member of the Lower Corniferous, No. 3 of the section near the south county line. The quarry is located on a run tributary to Prairie Run, on the east side of the Scioto, one mile above Millville. The stone church near this place is made of the layers of No. 3 of the section at Colvin's lime-kilns.

Samuel Perry's lime-kiln is situated about two miles above Millville, and a mile east of the Scioto. It is one of that series known as *the Delhi kilns.* His quarry affords an exposure of ten feet in the Delhi stone. The stone is not strictly white, nor even buff, on fracture, but in contrast with the blue beds of the Delaware stone it has been denominated white. It is a light gray, with brownish mottlings, caused by bituminous matter, weathering buff. The strike of these beds can be traced by the topography north from Perry's quarry, and they are exposed so as to induce more or less lime-burning on the land of William Lawrence, William P. Jones, V. Dildine, John Powell, and P. Jones, and have a gentle dip generally to the east or south-east. The quarry of Philip Jones is so situated as to include about six feet of the bluish stone seen at Colvin's lime-kilns lying below the Delhi beds. The upper portion of his quarry is in the Delhi beds, as follows:

No. 1.	Delhi beds	4 ft.
" 2.	Blue beds, much resembling the Upper Corniferous, but less fossiliferous, and more apt to be bituminous. They are hard and crystalline, with frequent small deposits of calcite	6 "
	Total	10 "

The gravel pike from Delhi to Middletown runs on the strike of the Lower Corniferous, from a mile north of Delhi to Middletown, indicated by a series of gravel knolls and ridges, which have a common direction, about north-west.

Ascending Mill Creek from Bellepoint, the Lower Corniferous is frequently exposed. About half a mile from Bellepoint, on Richard Fry's farm, and on those of Samuel and Homer Cole, nearly a mile further, are bluffs of the heavy, even beds of the Lower Corniferous, which have been compared to the Onondaga limestone of New York State. At Cole's the section is as follows, in descending order:

SECTION ON MILL CREEK.

No. 1.	Very fossiliferous, bituminous beds, 2 to 4 inches, with *Stromatopora*, *Cœnostroma*, *Chætetes*, *Favosites*, *etc.*, seen	4 ft.	6 in.
" 2.	Heavy, non-fossiliferous, magnesian beds, buff when dry; suited for a cut-stone	18 "	
" 3.	Conglomerate, embracing pebbles, sometimes four inches in diameter, of Waterlime. These are water-worn and embraced in a matrix of arenaceous magnesian limestone; no quartz pebbles seen. (Oriskany)	1 "	6 "
" 4.	Waterlime, seen	2 "	
	Total	26 "	

No. 1 (above) is the equivalent of No. 4 of the section at Colvin's lime-kilns. The bluish beds which these overlie probably are in some instances very fossiliferous, and are then undistinguishable from this. It seems as if this member may have either character, namely, *almost non-fossiliferous, bluish, or exceedingly crowded with corals, and charged with bituminous matter in the form of films, scales, and unequal deposits between the beds*, the horizons being identical. When the blue color permeates the upper portion, without fossils, it seems to be due to an even dissemination of bituminous particles, in fine subdivision, through the waters giving the calcareous sediment, the well-preserved corals and other fossils being restricted to certain localities. No. 2 of this section embraces Nos. 2 and 3 of the section at the south county line in the east bank of the Scioto. The thin, cherty layers are not so well defined as usual, and the thickness of both is somewhat reduced. This is here all a good building stone, almost free from chert.

At a point two miles west of the Scioto, ascending Mill Creek, the Lower Corniferous disappears entirely, the Waterlime appearing at the surface. The general surface features do not indicate the change, the whole being eroded by creeks, and made rolling or undulating. The Drift is faded, the rock shattered, and deeply penetrated by infiltration of dirt. The boundary line between the Lower Corniferous and the Waterlime passes through Priestley Said's farm, where there are little quarries in both.

South from Ostrander one mile, on the south side of Mill Creek, in a little ravine from the south, is Benjamin Bean's quarry. It is in the fossiliferous member of the Lower Corniferous which underlies the Delhi beds. It embraces many corals and some brachiopods. It is probably the equivalent of No. 4 of the section at Colvin's lime-kilns, already given. Hence the formation shows a dip back to the west, leaving but a narrow belt of Waterlime. Passing down Mill Creek from the bridge near Bean's quarry a quarter of a mile, no rock is visible in the banks, which are of Drift and about fifteen feet high. Fragments, however, lie about, which belong to the Delhi beds and to the bluish stone directly below them. About twenty rods still further down, the Waterlime appears in the bed of the creek.

The Delhi beds are exposed in the banks of the Olentangy about two and a half miles below Stratford, with a dip to the north. The rock here appears massive, but under long exposure parts into beds of one to three inches. It is crinoidal and crumbling. The bluff seems to be separable into two parts, as follows:

No. 1.	Bedded 3 to 6 inches, light-colored, persistent, and overhanging; crinoidal	6 ft.
" 2.	Massive, crumbling, light-colored	6 "
	Total	12 "

After an interval of about fifty rods the Upper Corniferous returns; but a mile and a half still further down the crinoidal beds reappear in the right bank of the river. They are seen in the public road, and have been opened a little by quarrying.

Oriskany Sandstone.—In Delaware county the Oriskany is much reduced in thickness from what it is in the northern part of the State, but its composition is much coarser, reaching that of a real conglomerate. It is not over two feet at any point where it has been seen. The pebbles embraced in it are entirely of the Waterlime, and uniformly rounded as by water action. Some are four inches in diameter, but in thin pieces. The last section given (that on Mill Creek) shows its position in the strata. It is there plainly exposed, and fades out, without change of bedding, into the lowest part of the Lower Corniferous, which sometimes, as in the county of Sandusky, has been seen to be somewhat arenaceous several feet above the strong arenaceous composition of the Oriskany. The exposure on Mill Creek, and that in the left bank of the Scioto near the lime-kiln of Mrs. Evans, are the only points in the county at which this conglomerate has been seen.

Waterlime.—As already mentioned, the Waterlime appears in the left bank of the Scioto, near Mrs. Evans's lime-kiln, a quarter of a mile below Millville, and has been somewhat used for quicklime. It rises here fifteen feet above the water of the river at summer stage. It is probable that the bed of the river is on the Waterlime for a mile below this point, and even to Sulphur Spring Station.

The quarry of John Weaver, about half a mile below Cone's Mill, is in the Waterlime. The exposure is here in a ravine tributary to the Scioto from the west. The situation is favorable for profitable quarrying and lime-burning. The stone is drab, and much shattered. It turns a light buff after weathering, some of it becoming as white as chalk.

Half a mile above Millville the Waterlime rises in the right bank of the Scioto about fifteen feet, the road passing over it. It is visible in the bed of the Scioto at the crossing known as *the Broad Ford.* At Cone's mill is a fine surface exposure of the Waterlime. It has been somewhat wrought at this place. The beds are quite thin and slaty, and of a blue color. The texture is close and the grain very fine. In the bed of the Scioto a stone spotted with drab and blue is quarried a short distance below Middletown. It is in even beds of four to eight or ten inches, and is very valuable for all uses. It is a part of the Waterlime. Stone of the same kind is found in Bogg's Creek, two miles from the Scioto, on land of John Irwin. In Thompson township the Waterlime is seen on the farms of Simon Charles and Jonathan Fryman, a mile and a quarter west of the Scioto, at the road-crossing of Fulton Creek. It is in thin, blue beds, the same as at Cone's mill, and has been used somewhat in cheap foundations. Bogg's Creek, where it enters the Scioto, is on the Waterlime.

General Section of the Limestones of Delaware County, with their Supposed Equivalents in New York State.

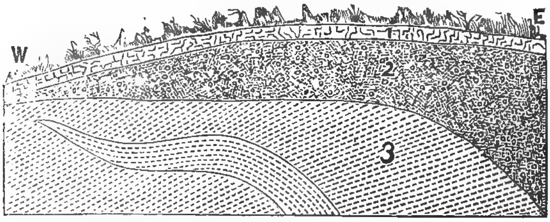
Ohio.	Thickness in Feet.		New York.
Fissile, argillo-bitum'ous shale	30	150	Genesee (part).
Very hard, heavy-bedded, pyritiferous, dark limestone	4 to 9	10	Tully limestone.
Blue, even-bedded, four to six inches, argillaceous — the "Delaware stone"	35	In central New York 1,000	Hamilton. (Sandstone in eastern New York; limestone in western New York, and thinner.)
Wanting	....	100 to 200	Marcellus.
The Delaware beds (brachiopods)	28	30 to 50	Corniferous limestone.
Bluish, often very fossiliferous, with corals, and bituminous	10		
Even but thin-bedded, cherty, harsh, cream-colored	12	10 to 20	Onondaga limestone.
Heavy-bedded, harsh, cream-colored, sometimes vesicular	15		
Wanting	....	4 to 5	Schoharie grit. } Only in eastern N. Y.
Wanting	....	50	Cocktail grit.
Conglomerate	2 to 3	20	Oriskany.
Wanting	....	....	Delthyris shaly limestone.
Wanting	....	....	Pentamerus limestone.
Waterlime	About 30 in county.	100	Waterlime.

The Drift.—Several interesting features pertaining to the Drift, proving the glacier origin of this deposit and all its features, were first noticed in Delaware county. Allusion has already been made, under the head of *Surface Features*, to the valley of the Scioto, and the contrast its upper part presents to its lower. Throughout the county generally the beds of all streams are deeply eroded in the underlying rock, although their banks are not constantly rocky. This fact is more and more evident to the observer in traveling from the north-western part of the county to the south-eastern. The north-western corner of the county, including the townships of Thompson, Radnor, and the northern part of Scioto, has the features of the flat tract in north-western Ohio known as the Black Swamp. The banks of the Scioto are low (ten or fifteen feet), and consist of Drift, the rock rarely being known in its bed. The Drift appears fresher and the surface is smoother than in the rest of the county. A short distance above Millville the banks begin to be rocky, the excavation beginning in the Waterlime, over which it has been running since it left the western part of Hardin county, but without making the slightest excavation, rarely revealing it in its bed by rapids. Within a mile from Millville the amount of erosion in the underlying rock increases to a remarkable extent, and at Sulphur Spring Station, about two miles below Millville, the erosion in the rock amounts to sixty or seventy feet. From there southward the rest of the Scioto valley is between high, rocky banks. This exemption from erosion in the upper waters of the Scioto can not be due to the harder nature of the rock there, because the Waterlime is much more rapidly worn out under such agencies than the Lower Corniferous, on which it enters at Sulphur Spring Station. The composition of the Drift about the headwaters of the Scioto is the same as about the lower portions of its course. It is in both cases a hard-pan deposit, made up of a mixture of gravel stones, bowlders, and clay, rarely showing stratification or assortment—such a deposit as is, without much difference of opinion, attributed to the direct agency of glacier ice. The conclusion is inevitable that the lower portion of the Scioto has been at work digging its channel in the rock much longer than the upper portion. The slope is in both cases toward the south, at least that portion of it in Delaware county; and that agency, whatever it was, which served to make this change in the valley of the Scioto from no excavation to deep rock erosion, could not have been quiet, standing waters over one portion of the valley and not over the other, since such waters would have retired last from the lower part of the valley, and we should there expect less instead of more erosion. The only possible way to explain this phenomenon, in the light of plausible theories, is to refer it to the operation of the last glacial epoch, or to the operation of a glacial epoch which projected the ice field only so far south as to cover the upper part of the Scioto valley, leaving the lower portion of the valley, which probably pre-existed, to serve as a drainage channel from the ice itself. Subsequently, when the ice withdrew, the upper tributaries were located in such places as the contour of the surface allowed or demanded.

There are other evidences that the townships of Radnor, Thompson, and the northern part of Scioto were for a time under glacial ice, while the rest of the county was uncovered, and suffered all the vicissitudes of surface erosion. The average thickness of the Drift in Radnor township, judging by the phenomena of wells and the height of the river banks, as well as from the rocky exposures, is about twenty feet. Toward the river, bowlders are common on the surface. In Thompson township the thickness seems also to be eighteen or twenty feet. In descending the Scioto along the right bank, after passing Fulton's Creek, there is a noticeable thickening of the Drift, and two Drift terraces follow the river for a couple of miles with considerable distinctness. They are each about fifteen feet in height, the upper one sometimes reaching twenty feet, and are separated in many places by a flat belt of land, the surface level of the lower terrace. Below these is the river flood-plain. This second, or upper river terrace, comes in apparently from the west, and appears just at the point where the rock begins to be excavated by the river. It makes the thickness of the drift about thirty or forty feet. After passing Millville and Sulphur Spring Station, the upper terrace disappears in a general slope to the river, and it cannot be identified at any point further south. This thickening of the Drift is in the form of a moraine ridge, which, passing west of Ostrander about a mile, is intersected by the Marysville pike a little west of the county line. From its summit toward the west the descent is seventy-five or one hundred feet, when a flat is reached like that in the north-western part of Delaware county. This moraine has not been traced through Union county. The reader is referred to another chapter on the Drift in north-western Ohio by the writer for a full dissussion of this subject.

A singular line of gravel knolls and short ridges pertaining to the glacier Drift crosses Radnor township, coming into the county from the north at Middletown (which is on the Scioto, in Marion county), and passing about a mile to the west of Delhi. It is traceable nearly to Millville. It is intersected by the gravel road about a mile north of Delhi. The road then follows it to Middletown, where it becomes lost from further obervation. This interesting series of ridges is not arranged in a single, continuous line, but the separate ridges overlap each other, rising and falling at irregular intervals. Sometimes the line appears double; low places on one side are in some places made up by full deposits on the other. On either side the country is flat. The soil is of close clay, and the roads very muddy in rainy weather. The Delhi beds of the Lower Corniferous are exposed at a number of places in close proximity to these gravel knolls, proving the strike of the formation to be exactly coincident with this strip of gravelly land. Toward the east is the enduring Corniferous; toward the west, the easily disrupted Waterlime. There is a general but very gentle slope to the west. The material in these ridges is stratified sand and gravel, which has been considerably used in constructing the gravel roads that intersect that part of the county. One of these sand and gravel deposits is opened for such purposes on the land of Mrs. Rachel Fleming, on the east side of the Scioto, near the mouth of Bogg's Creek, and shows the following alternation of parts:

SECTION IN GRAVEL BANK, SOUTH PART OF RADNOR TOWNSHIP.



1. Soil and hard-pan, 2 feet.
2. Gravel and sand; stratification confused or wanting.
3. Handsome strata of sand obliquely stratified.

The outward appearance and composition of this series of gravel ridges are the same as of those ridges well known in the country as "hogs'-backs," yet they are less prominent than some others that have been described in north-western Ohio. (See Report on the Geology of Hardin county, also Report on Geology of Allen county.) Their long continuance and their more uniform height make them in some respects comparable to those very long gravel ridges that have been described in north-western Ohio, and referred to the effect of glaciers crossing a number of counties consecutively. Their real origin, however, is not that of terminal glacier moraines, but is the same as of those isolated gravel knolls known as "hogs'-backs." Similar lines of gravelly, rolling land following and marking the boundary between two geological formations have been mentioned in reports on the geology of Crawford and of Morrow counties. Such boundary lines, when between two formations of unequal endurance under the glacier, would be the place where most frequently deep fissures in the ice would be produced by the efforts of the great sheet to adapt itself to the unevenness of its bed. In such fissures, and along such openings, running water would appear, and would most effectually carry away the transportable clayey portions of the Drift with which it might come in contact. During the prevalence of the ice, such washed and, perhaps, stratified Drift would be liable to a further transportation, but when the margin of the glacier finally passed northward over any point on such boundary line, the final effect of th water issuing from the ice at that point would be left undisturbed, and would be preserved to the present time. The obliqueness of the stratification, and the sudden changes in the kind and arrangement of material making up the strata, together with an occasional mass of unassorted glacier clay included in the stratified portions, not only indicate the force and direction of the torrents of water and an interrupted supply of Drift, but also the presence and agency of thick glacier ice at the time of deposition.

Wells and Springs.—There are in the county a number of copious, strongly sulphurous springs, the best known of which are those at Delaware, and near Sulphur Spring Station. Besides these, others are found in various parts of the county, styled chalybeate, and others magnesian.

The most frequented is that on the grounds of the Ohio Wesleyan University, at Delaware, which is strongly sulphurous. Of this, Prof. H. Mitchell, in giving his analysis of the water, says, according to Howe's Historical Collections of Ohio, 1848:

"Of gaseous products, I find that one wine pint of the water, taken immediately from the spring, contains, of sulphuretted hydrogen gas, 12 cubic inches; of carbonic acid gas, 3 inches. One hundred grains of the deposit, which resulted from evaporating several gallons of water, yielded, on analysis, of muriate of soda, 48 grains; of lime, 20 do.; sulph. magnesia, 16 do.; sulph. lime, 8 do.; carbonate of soda, 5 do.; total of the above, 97 grains. The above results show that these waters approach as nearly to the well-known waters of Aix-la-Chapelle and Harrowgate, as those do respectively to each other. They are directly deobstruent, and calculated to remove glandular enlargements, as well of the liver as of the other viscera. In cases of slow fever, disturbed state of the functions of digestion, or more confirmed dyspepsia, morbid secretions from the kidneys or bladder, gravel, or chronic eruptions on the skin, I can strongly recommend their use; and, though last, not least, their power of subduing general constitutional irritation, and quieting and restoring tone to the system when it has been necessary to have recourse to the frequent and long-continued action of calomel or other mercurial preparations, is, I am persuaded, of the greatest efficacy."

The sulphur springs at Delaware, located near the Ohio Female Wesleyan University, and on land of G. W. Little, are of the same general character.

The same may be said of the very copious sulphur spring in the left bank of the Olentangy, on Mr. Wm. Case's land, in the southern part of the county. This, however, presents the most copious natural flow of highly sulphurous water known in the county.

The artesian sulphur spring at the Reform and Industrial School for Girls, at Lewis Center P. O., was formerly a place of much resort. This well was drilled in 1820. The water rises from the depth of about ninety feet, at which a cavity was struck which let the augur drop two feet. A chemical examination of the water from this well is reported by Prof. E. S. Payne to show the following mineral substances:

Sulphureted hydrogen gas,	Sulph. lime,
Carbonic acid gas,	Oxide of iron,
Chloride of magnesium,	Carbonate of lime,
" sodium,	Sulphuret of calcium,
" calcium,	Iodine,
Sulph. magnesia,	Traces of organic matter.

Temperature, 52° Fah.

A chalybeate spring on the same grounds shows, according to Prof. E. S. Payne—

Sulph. iron,	Iodine,
Oxide of iron,	Carb. lime,
Carb. acid gas,	Potassa,
Sulph. of magnesia,	Sulph. lime,
Chloride of calcium,	Traces of organic matter.

Temperature, 56° Fah.

A so-called magnesian spring on the same grounds shows, by the same authority—

Sulph. magnesia,	Carb. of lime,
Chloride calcium,	Iodine (small),
Oxide of iron,	Potassa (small),
Sulph. of lime,	Traces of organic matter,
Earthy phosphates,	Carbonic acid gas.

Temperature, 54° Fah.

Another spring, near these, was found by Prof. Payne to afford the following impurities. This is denominated a "saline chalybeate spring":

Sulph. lime,	Carbonate of lime,
" magnesia,	Traces of potassa,
Chloride of calcium,	Traces of organic matter.
Oxide of iron,	

Temperature, 55° Fah.

A sulphur spring occurs also on John Phillips's farm, one and a half miles south-west of Delhi.

In the survey of the county the following observations made on the common wells were recorded. On the N. E. ¼ section 4, Kingston, Mr. James E. Stark has a number of artesian wells, known as "springs":

Owner's name.	Location.	Feet above the rock.	Feet in the rock.	Total depth.	Through what.	Remarks.
James Chambers ...	Sec. 2, Porter township	25	......	25	Blue clay	Good water.
James Eckels.........	Ashley	18	......	18	....	"
" "	"	17	......	17	Blue clay	"
James Brundage.....	Marlborough..	56	......	56	Blue clay and gravel	46 ft. of good water.
G. W. Corbin.........	S. Delaware...	19	......	19	Brown hard-pan and sand	Good water.
Wm. Waldron	S.E.cor. sec. 2, Kingston	23	......	23	....	Good water, nearly 20 ft.
James Stark	N. E. ¼ sec. 4, Kingston	17½	......	17½	....	Artesian; sulphury.
" "	" ...	20	......	20	....	Nearly soft water.
Buckeye House......	Olive Green...	40	......	40	In blue clay	No water.
" "	" ...	20	......	20	....	5 ft. water.
G. Pace	Sunbury	21	......	21	Yellow clay, 7 ft. Blue clay, sand, and gravel	Good water.
Jos. Letts..............	"	19	......	19	....	"
John McFarland.....	"	21	......	21	....	"
C. C. Bricker.........	N. E. ¼ sec. 1, Berkshire ...	24	......	24	....	"
" "	" ...	20	......	20	....	Sulphury water.
D. B. and S. Turnpike Co..............	Toll-gate 1¼ miles E. of Delaware	28	......	28	Brown and blue clay......	"
Nathan Miller	1 mile N.W.of Delaware	21	10	31	Clay and black slate	Good water.
J. Moorhead..........	2½ miles S. of Stratford	11	15	26	Clay and limestone	In the river bottoms slightly sulphurous.
" "	"	8	16	24	Clay, gravel, and rock	In the river bottoms very slight sulphur taste. Water good.
W. P. Ropp	1 mile S. of Bellepoint ...	12	17	31	Brown clay and rock	Good water.
W. F. Sipes...........	½ mile S. E. of Millville......	6	56	62	....	"
Geo. McCowl.........	3 miles W. of Delaware	16½	1½	18	....	"
Thomas Griffiths.....	3½ miles W. of Delaware	22	......	22	....	Iron water.
John Baker...........	1½ miles S. W. of Delhi......	17½	2½	20	Clay, sand, and rock	"
" "	"	18	......	18	....	"
John Gast.............	Sec.2,Radnor..	27	......	27	....	"
Nicholas J. Money..	Thompson tp.	12	......	12	Clay and sand..	"
" " ..	Ostrander Sta.	28	......	28	....	"

MATERIAL RESOURCES.

Lime and Building Stone.—Beginning with the lowest in the geological series of the county, we find a close-grained, drab limestone. The beds, so far as seen in Delaware county, are usually less than six inches in thickness, yet at one place, near the north line of the county, it is taken from below the water of the Scioto in beds of six to ten inches. Although this stone is rather hard and close-grained, it is also apt to be brittle, and in its undisturbed bedding to be checked into small angular pieces. It occupies low, sheltered places, owing to a tendency to be destroyed by the elements. It is easily disrupted, even by the use of the crowbar or pick, and seldom needs blasting. These qualities render it a poor stone for construction, and it is seldom used except for quicklime. When it has not been bleached, and weakened by long exposure to the elements, it makes a lime nearly as strong as any that can be burned in Delaware county, and much whiter than that made from the Hamilton or the Corniferous. Near Mrs. Evans's kiln, where it has been used in conjunction with the Corniferous, it is distinguished as the "white stone" by the workmen, from the whiteness of the quicklime it affords.

The Oriskany, which succeeds to the Waterlime, has no economical value whatever. In some parts of the State it is a very pure, silicious sandstone, in heavy beds, but in Delaware county is conglomeratic with Waterlime pebbles, and it graduates upward into the lower member of the Lower Corniferous, the supposed equivalent of the Onondaga limestone of New York State.

The remainder of the Devonian limestones constitute a group which are noted for their various economical uses. The heavy, buff limestone overlying the Oriskany is rather coarse-grained and rough to the touch, but lies in heavy layers of uniform thickness and texture. Its color is pleasant and cheerful, especially when dressed under the hammer and laid in the wall. It is sometimes vesicular or cherty, when its value as a building material is considerably less; yet in all cases it answers well for any heavy stone-work, as bridge piers and abutments, aqueducts, and all foundations. In some parts of the State this member of the Corniferous is extensively wrought, and sawn into handsome blocks for stone fronts. Ample facilities are afforded along the Scioto river, at a great many places, for the working of this stone. Its value as a building material and the accessibility of its layers, render it a little surprising that no opening worthy the name of a quarry has been made in it within the limits of Delaware county. As a cut-stone it ranks next to the Berea grit in its best estate, which is found in the eastern part of the county, and where once introduced into the markets of the county, particularly in the western portions, it would draw custom from a wide range of country west and north, where no good cut-stone can be found. The little quarry of Rev. C. H. Perkins, in Radnor township, which furnished the stone placed in the abutments of the bridge over the Scioto near the mouth of Bogg's Creek, is the only opening in these beds within the county, and does not show the best qualities of the stone. Some of the most favorable points for quarries in this limestone are near the south county line, in the banks of the Scioto, or in some of its tributaries. The banks of Mill Creek at Bellepoint, and also for a couple of miles above, are almost equally favorable.

The next member of the Lower Corniferous is that described as thin-bedded, cherty, buff limestone, and differs but little from the last. Owing to the thinness of the bedding it is only useful for quicklime, of which it makes a quality very similar to the heavier beds below.

The bluish limestone next overlying is not constant in its characters; indeed, in some sections, covering the same horizon, it was found wanting. In its place may sometimes be seen a few feet of very fossiliferous, bituminous limestone. The blue color is believed to be due to the more even dissemination of bituminous matter through the entire rock, instead of its preservation in fossil forms. When the bitumen is present in considerable quantity, the black films and thin, irregular scales that disfigure and destroy the rock for building purposes, do not materially injure it for making quicklime. They readily volatilize in the kiln, but the fresh lime is of a little darker color. When this member is not highly coralline and bituminous it makes a very firm and useful stone for all uses in walls and foundations. The quarry of Mrs. Evans, about a fourth of a mile below Millville, is in this stone.

It is to the "Delhi stone," however, that the county is indebted for the greatest quantity of quicklime. These beds lie immediately over the "bluish stone" last mentioned. The layers are generally not over three or four inches in thickness. They are rather hard and crystalline. They are often crinoidal and very fossiliferous. The color is rather light, and the lime made is heavy and strong. It contains very little sediment that cannot slack, and brings the best price in the markets; yet it is not so white as that made from the Waterlime, nor is the stone so easily burned as the upper part of the Niagara limestone. In the absence of a better quality of stone for walls and common foundations, this limestone is very commonly employed, but the irregularity of its bedding and the thinness of its layers will effectually prevent its use in heavy stone-work. In deep quarrying the bedding would become thicker and the variations of color and texture due to its fossils and crystalline tendency might make it take rank as a handsome marble. The lime burned from the various quarries about Delhi is from this stone. Yet the quarry of Mr. P. Jones exposes also the upper part of the bluish limestone last mentioned.

Overlying the Delhi beds is the well-known "blue limestone" of Delaware county, extensively quarried and used for building at Delaware. This is a hard and crystalline stone, variously interspersed with bituminous and argillaceous matter. When these impurities are wanting the bedding is usually about six inches in thickness, but may reach ten or twelve. When they are abundant the bedding becomes slaty, and the stone is much injured for purposes of building. These argillaceous layers which part the bedding soon succumb to the weather, and cause the calcareous layers to chip out or to break by superincumbent pressure of the wall. Numerous instances of such defective masonry could be pointed out in the city of Delaware, showing the treacherous character of much of this blue stone. Stone-cutters will be at no pains to remove such shaly matter from the stone, but rather prefer to leave it, even to the damage of important buildings, since it gives them less labor to cut. The effect of the elements is much greater on this stone when it is placed on edge in the wall, instead of being laid as it was deposited by nature in the quarry. The beds of sedimentation ought always to be laid horizontally instead of perpendicularly. Although this stone is very firm and crystalline in its best estate, it is yet susceptible of being cut into all useful forms for sills, caps, keystones, and water-tables, and is largely used both at Sandusky and Delaware for these purposes. Its dark color makes it specially adapted to foundations, where a light-colored superstructure is intended and to all Gothic architecture. For lime it is very little used, owing to the difficulty of calcination, compared to other accessible limestones, and the heavy sediment of argillaceous matter that will not slack. Yet the lime it makes, although rather dark-colored, is said to be very strong and hot.

The following statistics in reference to the burning of lime, compared with similar statistics given in reports on Sandusky and Crawford counties, will convey an idea of the comparative value of different formations in north-western Ohio for the manufacture of quicklime, and the utility of the close or draw kiln used in some places:

STATISTICS.

Owner's Name.	Situation.	Formation.	Cords per 100 bushels.	Hours burned.	Pays for mixed wood.	Weight per bushel of bulk.
Philip Jones	Delhi	Corniferous	2½	54	$2 75	67 lbs.*
Wm. P. Jones	"	"	2¾	50	2 75	Unknown.
Samuel Perry	"	"	2½	52	....	68 lbs.
G. W. Corbin †	Delaware	"	4 4-9	60	(poor) 2 00	Unknown.
Richard Colvin	Bellepoint	"	3	60	....	71 to 72?
Margaret Evans	Millville	"	2⅔	48	....	71 ?
S. Marshall	N. E. ¼, sec. 14, Spencer, Allen county	Waterlime	2	50	1 25	70 ?
James Lilly	Streughn, Van Wert county	"	2	45	2 00	60
B. Bohnert & Co	Sec. 8, Union tp., Van Wert Co.	"	2½	?	1 50	70 to 71
Thompson & Brown	Mill Creek, Union Co	Corniferous	2½	100‡	2 00	Unknown.

Quicklime sells generally at eighteen cents per bushel at the kiln, but sometimes at twenty cents. The lime of the Delhi beds is of a brownish-white color, with darker spots and specks. The annual average product of the quarries of Philip Jones, Wm. P. Jones, and Samuel Perry, near Delhi, aggregates 11,420 bushels. The kilns of Mr. Corbin, at Delaware, consume much more wood per one hundred bushels than any other in the county—indeed, more than any in north-western Ohio. They are of very large capacity, and usually are not entirely filled. The kilns of Mr. Colvin are also pronounced ill-shaped by Mr. Schmidt, who has run them for several years. There are no kilns in the county made on the latest improved plan. No progress whatever is exhibited in the methods employed. They are the same as the methods adopted by the earliest manufacturers, and should give place to the improved methods of some of the late patents.

The uses of the Huron Shale.—The only known use that can be made of the Huron shale, with strong probabilities of success and profit, is in the manufacture of hydraulic or water cement. The manufacture of petroleum, illuminating gas, and of roofing-slate, has, in each case, proved profitless. Some have employed it as a material for roads, but it is found

* Result of many trials.
† Hauls stone from John Spero's quarry, on the Scioto.
‡ Kiln holds 400 bushels. The fire passes through a volume of fourteen feet height of stone.

to soon pulverize and to disappear as dust, or to pass off by the action of drainage water. With an occasional renewal, it may be used in that way. A successful enterprise in the manufacture of hydraulic lime from the lower portion of the black slate is in operation at Defiance, Ohio. It is known as the *Auglaize cement*, and promises to become a rival of those cements known in the principal markets of the country.

The shale which overlies the black slate is very similar to the Olentangy shale immediately below it. They are both worthy of being tested thoroughly as fire-clay, or for the manufacture of a light-colored pottery, or "Milwaukee brick."

THE WAVERLY SANDSTONE.

Of the sandstone which comes next in the series very little need be said. Its excellences are well known, and have been attested by the experience of builders throughout the country during the last forty years. It is the same (geologically) as the famous *Berea sandstone*, and is included within the Carboniferous rocks. Yet it has been observed to become much finer-grained and better adapted to bases for monuments, for grindstones and whetstones, and for ornamental architecture, in the central counties of the State, than in counties further north. It is now being extensively used in the construction of bridges and culverts for the new railroads in the eastern part of the county. Since the great conflagration at Chicago, sandstone is being more frequently employed for walls of buildings than ever before.

Brick and Tile.—The surface of the Drift clay is employed in the manufacture of these articles by the following establishments:

James E. Robinson, Ashley	Brick.
Wm. Robinson, Olive Green	"
John Knox, Trenton township	"
Jacob Williams, Harlem township	"
—— —— Rich, "	"
Eli Downing, "	"
Abram Springer, Delaware,	"
Joseph Haas, "	"
Frank Curley "	"
Geo. Sherrer, "	Tile and brick.
James E. Robinson, Eden (last year)	"
Swan Roloson, 1½ miles S. W. of Stratford	"
Wm. H. Edmonds, 1 mile west of Powell	"
Arthur Robinson, 3½ miles west of Millville	Tile.

CHAPTER XXXVIII.

REPORT ON THE GEOLOGY OF VAN WERT COUNTY.

BY N. H. WINCHELL.

SITUATION AND AREA.

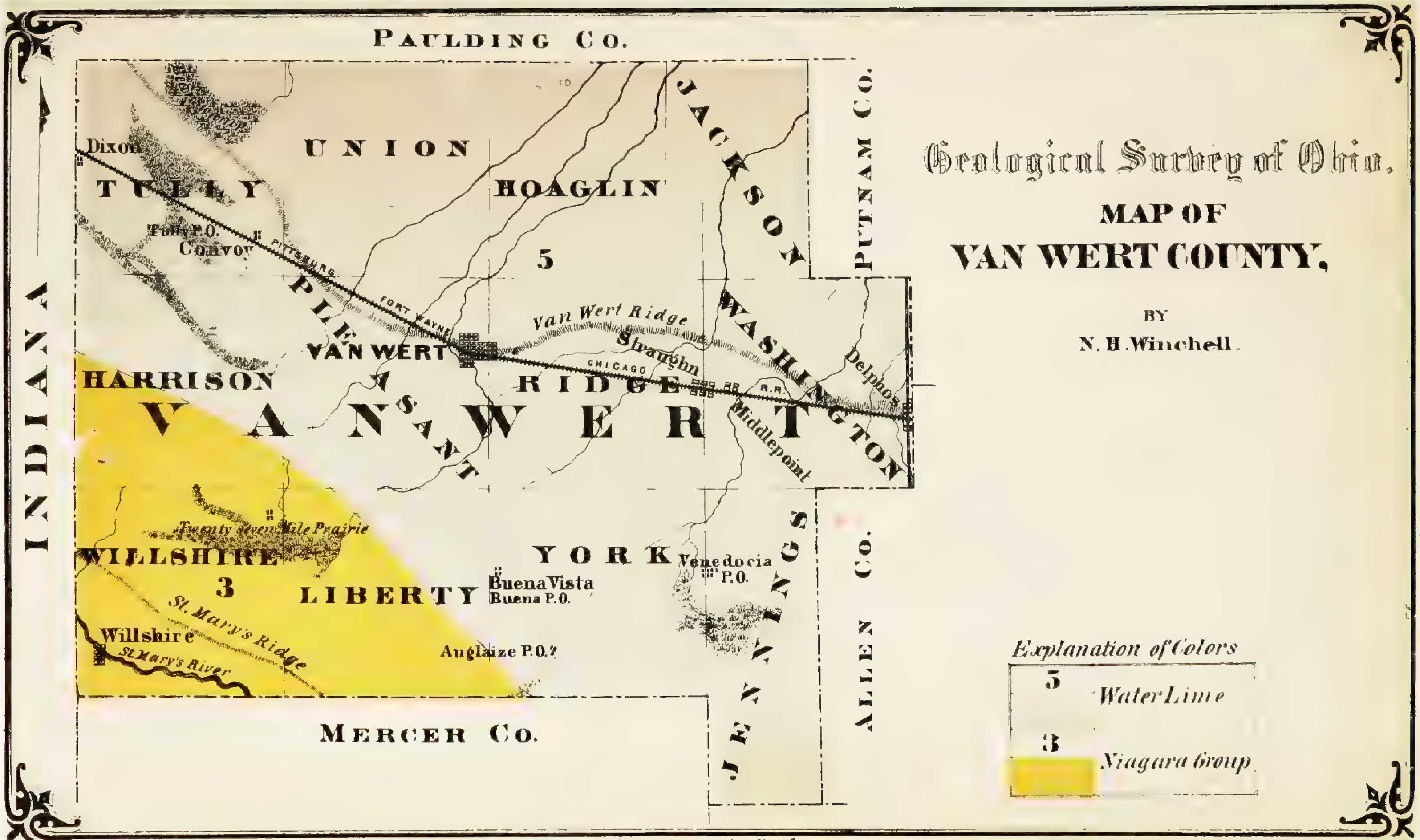
This county lies on the Indiana border, three other counties intervening between it and the State of Michigan. Allen and Putnam counties lie east, and Mercer south. Paulding county joins it on the north. It contains 258,592 acres, of which 51,142 are denominated arable or plow land, 21,042 meadow or pasture land, and 186,408 uncultivated or wood land. The average value per acre is $11.15, or, including buildings, $11.87. The county forms nearly a square. It has a projection in the middle of the east side including half a town.

NATURAL DRAINAGE.

The surface drainage consists in a number of gentle, small streams that flow north-easterly, joining the Auglaize River in Putnam and Paulding counties. There are several large, uncultivated prairie or marshes, which are subject to inundation in spring time. These give rise to some of these small drainage streams.

SURFACE FEATURES.

By saying the county is *flat* the general character of the surface is expressed. It lies in the Black Swamp, the features of which have been already described in reports on other counties, and in a former chapter devoted to the Drift in north-western Ohio. In the south-west corner this county is crossed by the St. Mary's River, which brings into that part of the county a few miles of the more undulating surface characterizing the St. Mary's ridge. Through the center of the county, in a north-west and south-east course, runs the gravelly Van Wert ridge. North of this ridge there is no variety of surface whatever. There is a gentle, very regular descent, sometimes hardly enough to sufficiently drain the land for easy agriculture, from this ridge to the north line of the county, and beyond to the Auglaize River.



Strobridge & Co. Lith. Cin. O.

The following points of elevation above Lake Erie are obtained from the surveys and profile of the Pittsburgh, Fort Wayne and Chicago Railroad. It will be remembered that Lake Erie is 565 feet above the ocean:

	Feet.
Delphos	211
Middlepoint	211
Van Wert	213
Convoy	218
Dixon	225

The following elevations were derived by aneroid barometer, making connection with the above railroad elevations:

	Feet.
Jennings's Prairie	256
S. W. ¼, sec. 31, Union township, on the ridge	183
Section 24, Tully, on the Van Wert ridge	178
" " " bench	188

Soil and Timber.—The soil is clayey, and is in need of artificial drainage. The farms that are located on the Van Wert ridge have a greater market valuation than any others in the county. The whole county was originally densely forest-covered, with the exception of the marshes, called prairies, in Jennings, Willshire, Liberty, Harrison, and Tully townships.

In the survey of the county the following species of trees were seen growing native:

Fagus ferruginea—Beech	Ait.
Quercus alba—White Oak	L.
Acer saccharinum—Sugar Maple	Wang.
Platanus occidentalis—Sycamore	L.
Carya alba—Shag-bark Hickory	Nutt.
Fraxinus Americana—White Ash	L.
Cornus florida—Flowering Dogwood	L.
Ulmus Americana—American Elm (pl. Clayt., Willd)	L.
Zanthoxylum Americanum—Prickly Ash	Mill.
Quercus rubra—Red Oak	L.
Fraxinus quadrangulata—Blue Ash	Michx.
Amelanchier Canadensis—June Berry	Torr and Gray.
Crataegus coccinea—Thorn	L.
Quercus Prinus—Swamp White Oak	L.
Gleditschia triacanthos—Honey Locust	L.
Carpinus Americana -Water Beech	Mich.
Juglans nigra—Black Walnut	L.
Ostrya Virginica—Ironwood	Willd.
Salix nigra—Black Willow	Marsh.
Morus rubra—Mulberry	L.

Tilia Americana—Basswood	L.
Populus monilifera—Cottonwood	Ait.
Æsculus glabra—Buckeye	Willd.
Quercus macrocarpa—Burr Oak	Michx.
Populus grandidentata—Large-toothed Aspen	Michx.
Prunus Americana -Plum	Marsh.
Acer rubrum—Swamp Maple	L.
Fraxinus sambucifolia—Black Ash	Lam.
Gymnocladus Canadensis—Kentucky Coffee Bean	Lam.
Prunus serotina—Black Cherry	Ehr.
Populus tremuloides—Trembling Aspen	Michx.
Rhus glabra—Sumach	L.
Cratægus tomentosa—Black Thorn	L.
Populus balsamifera—Balm of Gilead	L.
Quercus palustris—Pin Oak	DuRoi.
Juglans cinerea—Butternut. [Seen only on the Van Wert ridge]	L.
Asimina triloba—Pawpaw	Dunal.

GEOLOGICAL STRUCTURE.

The rocks of the county belong to the Upper Silurian. The upper member of the Niagara, the equivalent of the Guelph of Canada, or of the Racine limestone of the West, is the lowest in outcrop in the county. It underlies a tract of uncertain limit in the south-western part of the county, and is exposed in the St. Mary s River, at Willshire. Over this lies the Waterlime, belonging to the Lower Helderberg.

The former is a porous, magnesian limestone, of rather repulsive aspect, its naturally light color being generally stained with iron-rust. In quarrying it shows a blue color. It lies in thin beds of three to five inches, occupying usually the protected and most retired points of outcrop, owing to the rapidity with which it disintegrates under the forces of nature.

The latter is, in Van Wert county, very similar in general appearance, but it has different fossils, and is harder. It is less porous. It has a drab color, but the color is lighter in Van Wert county, and in counties further north, than it is in Allen and Hardin counties, where it is often blue, or even becomes so bituminous as to be black and slaty. Its most slaty character is seen in Wyandot county. In Van Wert county, and also in Putnam, it is not slaty, or very rarely so, and shows very little bituminous matter. It burns to a very white lime in the township of Union, where there is a surface exposure, but in Washington township, near Delphos, it is thinner bedded and more bituminous, the lime also becoming darker.

Niagara Limestone.—The only exposure of this stone known within the county is at Willshire, in the bed of the St. Mary's River, and in a small ravine tributary to it at the same place. It is here porous and somewhat fossiliferous, in beds of about three inches. It has been wrought to a limited extent on the land of Mrs. Ann Ramsey for quicklime and common foundations.

The Waterlime.—This limestone underlies the remainder of the county; but affords but few known exposures. It is burned for quicklime at Streughn, by James Lilly, and was formerly also quarried at the same place by Samuel Kessler. The stone here is the same as that seen in Union township, where it is also quarried and calcined on an extensive scale by B. Bohnert & Co. It is of a light color, with a little tendency to a drab, porous and fossiliferous. It makes a beautiful white lime, the average weight of which is said by the owners to be sixty pounds per bushel. It burns easily and cheaply, and sells for twenty-five cents per bushel. At Streughn it rises to within four feet of the surface, and is overlain by hard-pan Drift. Glacier marks immediately below the Drift run north, 15° E., by pocket compass. The section at Streughn is as follows:

SECTION IN THE WATERLIME AT STREUGHN.

No. 1.	Hard-pan	4 ft.
" 2.	"Gray stone," i. e., spotted, drab, porous and compact; the porous parts of a lighter color and show no bituminous matter, glistening and crystalline; not difficult to quarry; beds two to four inches	5 "
" 3.	"Black stone," i. e., bituminous; but the bituminous matter is evenly disseminated through the whole, so as to color it uniformly; slightly porous; without visible fossils; harsh to the touch; heavier and in heavier beds than No. 2; seen...	2 "
	Total	7 "

Both these members make an excellent white lime. The stone has much the aspect of the Fremont stone, in Sandusky county, but it is not so hard nor so close-grained. The fossils seen are principally a small shell resembling *Leperditia alta*. But there are also one or two species of brachiopods, commonly seen in this formation; yet the lithological characters of No. 2 are not those common to the Waterlime. It is with some difficulty distinguished from the Niagara. This outcrop occurs in a very flat and monotonous tract of country, but the upward swell in the rock surface produces a slight elevation in the surface of the Drift. The exposure is not due to erosion, as that of a stream, but is in the open plains, and is owing to the unusual thinness of the Drift.

The Waterlime is seen again in N. E. ¼ section 14, Spencer, Allen county, where Mr. S. Marshall owns a quarry. This is located in the bed of a little stream (Jennings's Creek), and shows the usual features of the formation. It is thin-bedded, but rather close-grained and hard, in wavy bedding, showing some bituminous deposits. This lime is very much darker than that at Streughn, but averages seventy pounds per bushel, selling at the same price. It resembles the quicklime from the same formation made at Lima, in Allen county. The bottom of this creek is rocky for a mile and a quarter. The stone occurs on the land of Joseph Feierbach, F. W. Courts, and Mat. Boche.

At Delphos, S. W. ¼ section 24, Washington, the Waterlime has formerly been taken from the bed of Jennings's Creek, and burned for quicklime by L. G. Roebuch. The stone is rather rough, and in thick, somewhat cavernous beds, with considerable calcite. Thinner beds also occur.

In Union township (N. W. ¼ section 8) the quarry of B. Bohnert & Co. is in a gentle anticlinal in the Waterlime, or in that member of the Lower Silurian which is quarried at Streughn. It may be some other member of the Lower Helderberg. The exposure is not sufficient in the county to identify, without doubt, its horizon. It is hard, light-drab, yet often porous, in beds of two to six inches, which run irregularly and break into angular pieces of all sizes. Although its color is a light drab, yet it has some spots almost a cream-color. It is occasionally variegated somewhat with blue, and looks then very much like Niagara. No fossils are visible except a fine Favosites coral, a small Orthoceras, Atrypa sulcata, and Leperditia alta. (?) It shows about eight feet.

At the quarry the surface of the rock is not glaciated. The soil is not more than eighteen inches, and of a black color, and the Drift is almost wanting. The rock is rounded and smoothed rather by the slow action of water and air than by ice.

A gray, close-grained limestone, that in hand-samples takes a good polish, is met also on the land of Thomas P. Johnson, S. W. ¼, section 17, Union, in surface exposure. It is in the Waterlime. On the N. W. ¼, section 4, Ridge, on the land of the heirs of Wm. Palmer, stone was struck in digging a ditch. It is a drab-gray, crystalline Waterlime, in beds of four to six inches, or perhaps thicker. It has not been opened to any extent.

The Drift.—The only exception to the generally unstratified and unassorted composition of the Drift in Van Wert county, is seen in the Van Wert ridge, which crosses the county through Tully, Pleasant, Ridge, and Washington townships. The cities of Van Wert and Delphos are situated on it. It consists generally of gravel and sand, in varied and oblique stratification. In a few places it has been penetrated to the depth of over thirty feet without meeting much gravel. In those cases it contains the common hard-pan Drift only, the same as that which prevails on either side of the ridge. This occurs in some wells at Van Wert. Water of excellent quality for domestic use is almost invariably found in penetrating the gravel of the ridge, and occasionally an artesian well is obtained, having a depth of but few feet. Such are usually on the northward slope. The underlying hard-pan clay being impervious to water, and the ridge lying in a slight depression of its surface, the water of surface drainage naturally gathers in the trough, and is held as in a reservoir by the gravel, by which it is also filtered and cleansed from impurities injurious to health, while it is apt to take up the salts of the protoxide of iron. Capillary attraction also serves to hold the water within the gravel, thus preventing it from completely draining off at the low places, or into the streams that intersect it. If wells find no water in this gravel, they are necessarily sunk below the hard-pan; and at Van Wert a second water-bearing stratum of sand and gravel is found lying on the bed-rock. From this a number of artesian wells are derived. Their head and source must be several miles further south, the descent being to the north, and the county being very flat. The confining stratum is the hard-pan Drift. In west Delphos wells are shallow. Some are in gravel, probably penetrating the Van Wert ridge. Such are eleven or twelve feet deep. Others are fifteen to eighteen feet, striking the rock. At Middlepoint, and southward, in Washington and Jennings townships, wells are twenty to twenty-five feet deep, frequently going to the rock. At Van Wert, in the central part of the city, some of the cellars which are dug in the gravel of the ridge have springs of good water. One man walled his well by inserting two flour barrels. The following is a record of a well drilled by the city corporation, at Van Wert, reported by Mayor Geo. C. Wells:

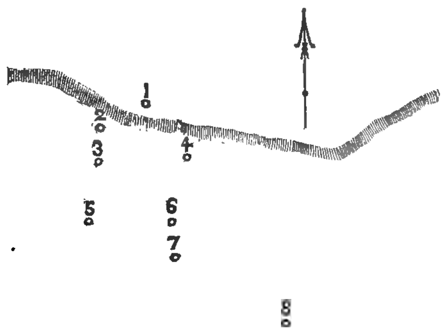
Soil	$1\frac{1}{2}$	ft.
Subsoil	$2\frac{1}{2}$	"
Yellowish-brown clay; traces of iron and sand	11	"
Dark, bluish-gray sand	2	"
Sky-blue clay, little or no stone, including two inches of gravelly hard-pan	5	"
Bowlders and gravel, with water which rose to within fifteen or eighteen inches of the surface	9	"
Limestone	1	"
Waxy, light-blue clay	5	"
Crystalline, compact or slightly porous, dark-drab limestone, appearing a little granular	22	"
Fine-grained drab waterlime, very hard drilling	28	"
Blue clay, very waxy; light blue	6	"

Limestone, about	1 foot.
Blue clay, rather coarse	9 feet.
Total depth	103 "

(Rock not entered again.)

Wells in the southeast part of Tully are eighteen to twenty feet. At Van Wert natural springs occur along the south side of the ridge, This is the first exception known to the observed location of such springs in the "Spring Row," as in other counties, which is on the north side of the ridge. There are some others at Van Wert on the north side also. On Mr. E. R. Wells's farm, four miles west of Van Wert, is red soil, charged with protoxide of iron, and other evidences of extinct springs, on the north slope of the ridge. In all deep wells (*i. e.*, those that pass through the blue clay) at Van Wert, the water rises nearly or quite to the surface, and considerable effort has been put forth to secure such constant flow at various places in the city, although the shallow wells are unfailing and easily obtained.

DIAGRAM SHOWING POSITION OF ARTESIAN WELLS AT VAN WERT, WITH RESPECT TO THE VAN WERT RIDGE.



These artesian wells which rise from the water-bearing gravel below the Drift clay, together with others in different parts of the county, prove the Drift to be about 40 feet thick in Van Wert county.

The Van Wert ridge is sometimes double. Such an instance may be seen north from Streughn. The first one lies within half a mile of that village, but the principal ridge road is half a mile further north, located on the second ridge. Both rise abruptly from the adjoining flat land, having descent in both directions. They seem to be perfectly identical in form and composition, although the former can only be traced two or three miles toward the west, when, turning a little more to the south, it slowly sinks away and disappears in the general Drift. A similar gravel ridge was noticed running north-west and south-east about half a mile in sections 21 and 22, Union township, nearly parallel with the main gravel ridge, separated from it about three miles, and on the Lake Erie side. It is not known how far this might be traced. In section 24, Tully township, the ridge on which the road from Van Wert is located runs out, or sinks away. The road then crosses a narrow belt of clay land and ascends, within a quarter of a mile, another ridge lying further north, which determines the location of the road further west. In section 14, Tully township, the Van Wert ridge runs along the inner side of another ridge or bench in the general surface, its summit being ten feet lower than that of the bench. They are separated a quarter to a half mile. This bench consists of the common hard-pan clay of the country, and shows no descent toward the south. Further south-east it passes through Convoy, the Van Wert ridge running about a mile further north-east, and through sections 17, 18, 22, and 23 in Pleasant township, beyond which place it has not been identified. This bench rises about five or six feet above the level land to the north, in Pleasant township, about ten feet in Tully township, south of the Bear Swamp, and thirty feet at New Haven, Indiana, to which place it may be followed, the "ridge road" between Van Wert and Fort Wayne passing several times, between those two cities, from the Van Wert ridge to the bench, and *vice versa.* The Van Wert ridge crosses the Maumee about three miles below Fort Wayne, where it is known as the *Irish ridge,* and for about a mile a road runs on it. The country there, however, being densely wooded, its location is unknown for several miles, although it has been followed about six miles east from New Haven.

Glacier marks were observed within the county at but one point. At Streughn they occur on the Waterlime (?) running north 15° east.

Wells and Springs.—Besides the foregoing observations on the phenomena of wells and springs in Van Wert county, the following minutes were taken. This list will afford a pretty reliable basis on which to predicate the thickness of the Drift in the county, since the water-bearing stratum, when not in the Van Wert Ridge, is generally that last member of the Drift, consisting of gravel and stones, which well-drillers often denominate hard-pan, especially if cemented along its upper surface by lime, and which, when so cemented, is often mistaken for the bedded rock itself.

Owner's name.	Location.	Feet above the rock.	Feet in the rock.	Total depth.	Through what.	Remarks.
Jos. Oslendorf	Delphos	18	......	18	......	On the rock.
James Ward	"	15	......	15	......	"
Evan Evans	N. E. ¼ sec. 9 (N), Jennings	18	......	18	......	Good water.
D. T. Cook	Middlepoint	21	......	21	Blue clay	On the rock.
Albert Fife	"	24	......	24	"	"
Isaac Grosscost	"	16	......	16	"	"
Andrew Cook	Sec. 1, Liberty	37	?	......	......	In the rock.
George Hood	Sec. 4, Ridge	9½	......	9½	Soil and blue clay	In bowlders.
Widow Gillen	Sec. 9, Ridge	12	......	12	Gravel	On the ridge.
Dr. P. J. Hines	Van Wert	36	......	36	Gravelly, 12 ft.; gravel, 1 ft.; blue clay, 15 ft.; gravel and hard-pan, 8 ft.	"
"	"	45	......	45	Blue clay	Just on S. edge of the ridge.
Reuben Frisbie	"	10	......	10	Gravelly	On the ridge.
Davis Johnson	"	12	......	12	Gravel, 12 ft.; blue clay, 2 ft.	"
Widow Buckingham	"	8	......	8	In gravel	"
Heinly and Hertz	"	40	4	44	Blue clay	Artesian.
D. H. Clippinger	"	40	......	40	Blue clay, 36 ft.; bowlders, etc., 4 ft	"
W. F. Exline	S.W. ¼ sec. 17, Liberty	40	......	40	......	Good water.
Van Wert Woolen Mills Co.	Van Wert	28	......	28	Blue clay, 26 ft.; bowlders, etc., 2 ft	Artesian.
David Bonewitz	Sec. 35, Tully	18	......	18	Blue clay and sand	Sulphury.
Pitts. Ft. Wayne and Chicago R. R. Co.	Van Wert	60	141	201	......	Water at bottom of Drift. None below.
Fire Dep't well	"	39	62	101	......	Water at bottom of Drift, and 2 or 3 ft. below. Filled again.
O. P. Clark	"	40	......	40	Blue clay	Strongly artesian.
M. Boner	"	40	......	40	"	Artesian.
Union Mills Co.	"	30	......	30	In bowlders	Slight flow.
E. R. Welles	N. W. ¼ sec. 8, Pleasant	22	......	22	Blue clay and quicksand	Good water rises within 6 feet of the top.
Rob't M. Thompson	N. E. ¼ sec. 21, Pleasant	35?	......	35?	......	Artesian.

MATERIAL RESOURCES.

The rocks of the county hold no minerals of economical value. They can only be used for quicklime and for ordinary foundations. The wealth of the county will always be largely agricultural. The soil is very fertile and enduring, but is rather heavy and wet for the quick growth of crops. The farms of the county are undergoing more or less thorough artificial drainage, and will be valuable in a corresponding ratio. The heavy forest with which the surface is largely covered is an important item of wealth, which, although retarding the opening of farms and the occupancy of the county, is yet destined to be of great benefit to the county. Extensive stave manufactories are established at Van Wert and Delphos.

Lime.—The lime-kilns at Streughn and on section 8, Union township, are the only important establishments of the kind in the county. They are of the old style, and have to be emptied after burning before filling again. At Streughn two cords of wood burn sufficiently one hundred bushels of lime, requiring forty-five hours, at the cost of two dollars per cord. Lime sells at twenty-five cents per bushel. Most of it goes to Fort Wayne, and thence is shipped throughout Indiana. Stone at the quarry brings $1.50 per perch. These kilns are worked by William Wehrs. Two constant draw-kilns were formerly run at the same place by Mr. J. E. Noble, consuming one and a half cords of wood per one hundred bushels.

Messrs. Bohnert & Co., in Union township, ship lime, *via* Convoy, to Van Wert, Fort Wayne, and Chicago, at twenty cents per bushel, wholesale. It retails at thirty cents per bushel. There are six kilns here of the common kind, burning two and a half cords of mixed wood per one hundred bushels of lime, at $1.50 per cord. From the kilns a wooden railroad conveys the lime about six miles to the station at Convoy.

Brick and Tile.—The Drift clay of the county is well fitted for the manufacture of red brick and tile, and the following list embraces all known establishments of this kind:

Joseph Fetter, Delphos	Brick.
Hummel & Metzker	"
Steinmetz Brothers, three miles north-west of Delphos	"
Samuel Norris, Van Wert	Brick and tile.
Thomas Lahue, "	Brick.
Amos Price, "	"
Tucker Brothers	Tile.

CHAPTER XXXIX.

REPORT ON THE GEOLOGY OF UNION COUNTY.

BY N. H. WINCHELL.

SITUATION AND AREA.

Union county lies next west of Delaware, which is the most central county in the State. It embraces 272,318 acres, of which 72,770 are arable or plow land, 67,670 meadow or pasture land, and 131,873 uncultivated or woodland (see "abstract of the valuation of taxable real estate of Ohio," in the the year 1870, by the Auditor of State, James H. Godman.)

NATURAL DRAINAGE.

The surface drainage all passes into the Scioto valley, by streams which flow with gentle current in a south-easte ly direction. They rise in the Logan county Corniferous area, a region of very rough or hilly surface, rising several hundred feet above the surrounding Waterlime flats, and toward the south-east enter upon another area of Corniferous, which, although presenting different surface features, yet is not so broken as the Logan county area.

There is a remarkable uniformity in direction and alternation in these streams. The principal valleys have a slope to the east or south-east, toward the Scioto, the valley of which is excavated over a hundred feet in the bed rock, in Delaware county. To one who has closely observed the systems of drainage in the various counties, and has aimed to ascertain, from the effects seen, the causes that located streams in various parts of north-western Ohio, this alone suggests the halting retreat of a glacier across the county, throwing down greater accumulations of Drift, where it remained stationary for a length of time. Such would be the divides between the streams, the valleys being in those belts where the Drift was left thinner. But, with a single exception, nothing of this is indicated by the surface features, so far as the time devoted to the survey would disclose. The whole county was very carefully examined. In counties further north-west, where such moraines are seen to guide the drainage diagonally across the general slope of the surface, the tributary


Geological Survey of Ohio.
MAP OF
UNION COUNTY,
BY
N. H. Winchell.
Explanation of Colors.
7 Corniferous Limestone
6 Oriskany Sandstone
5 Water Lime.
HARDIN CO.
MARION CO.
LOGAN CO.
DELAWARE CO.
CHAMPAIGN CO.
MADISON CO.
FRANKLIN CO.
UNION
JACKSON
WASHINGTON
CLAIBORNE
YORK
TAYLOR
LEESBURG
LIBERTY
DOVER
PARIS
ALLEN
MILL CREEK
UNION
DARBY
JEROME
Woodland
Essex
Rush Cr.
Rush Creek P.O.
GREENVILLE TREATY LINE
Byhaha
Williams P.O.
York P.O.
Richwood
York Centre
Sommerville
Bokes Cr. P.O.
Fulton Cr.
Bokes Cr.
A. & G. W. R.R.
Pharrisburg
Broadway
Newton
Sta.
Blues or Little Mill Cr.
Mill Cr.
Pottersburg
Dover
Allen Center
MARYSVILLE
R.R.
Watkinsville
C. C. C. & I.
Franklin
Jerome P.O.
New California P.O.
COL. CHI.
Millford Centre P.O.
IND. CEN.
Big Darby Cr.
Unionville Centre P.O.
Little Darby Cr.
Irwin P.O.
Plain City P.O.
Strobridge & Co. Lith. Cin. O.

streams all join the main streams from the same direction, but in Union county streams enter the main valleys from opposite sides. The surface between the streams is flat, and there is no evidence of a thickening of the Drift, except between Big Darby and Mill creeks. The Big Darby is the largest stream of the county.

SURFACE FEATURES.

Between Big Darby and Mill creeks there is a very noticeable thickening of the Drift. It rises into long ridges and high knolls, which consist of hard-pan or glacier Drift. Northern bowlders and stones are on the surface and in the soil indiscriminately, though the same is true to some extent throughout the county. This ridge of Drift is greatly developed at New California, where wells are sunk to the depth of fifty-four feet without meeting anything but "blue clay," the water obtained being bitter. West and south of Marysville two or three miles, the surface is high and rolling, with clay hills. Toward the north and east it is flat, with gravel near the surface in some places. Between Milford Center and Unionville "clay knobs" and rolling land can be seen north of Darby Creek, while toward the south and in Union township the "Darby plains" extend several miles. Wells at Pottersburg penetrate the Drift over sixty feet without meeting the rock, but obtain good water at that depth. About Newton there is a very rolling and bluffy tract of land, some of the wells obtaining bitter water in "blue clay" at fifty-two feet. This rolling strip of clay knobs dies out toward the south and west, and toward the north and east. Throughout the rest of the county the surface is very nearly flat, wells being usually less than twenty-five feet. This belt of clay knobs crosses the entire county, although it seems to turn a little toward the north in Jerome township.

The following elevations above Lake Erie are taken from profiles of railroads that cross the county:

Richwood	369 ft.
Broadway	422 "
Peoria	
Dover	
Marysville	425 "
Milford	
Unionville	
Plain City	

The following points of elevation were obtained by aneroid barometer, connecting with railroad stations:

Marysville (with Bellefontaine)	325 ft.
New California	375 "
Hill east of New California	395 "
Plain City	225 "
Hills west of Marysville	355 "
Peoria	410 "
Newton	460 "
Flat one-fourth mile east of East Liberty, Logan county	490 "
Top of hill two miles west of East Liberty, "	805 "
Top of hill two and a half miles west of East Liberty, Logan county	880 "
Surface of Mad Run, Zanesfield, Logan county	565 "
Divide between Mad Run and Goose Creek, near Zanesfield	780 "
Water in Goose Creek, Zanesfield	695 "
Divide between Goose Creek and McKee's Creek, Zanesfield	915 "
Surface of McKee's Creek, east of Bellefontaine	765 "
Divide between McKee and Blue Jacket creeks	845 "
Surface of Blue Jacket Creek, east of Bellefontaine	680 "
Depot C. C. C. and I. R. R., Bellefontaine (railroad profile)	640 "
St. John's, Auglaize county, hill south of village	491 "
St. John's, street in front of Bitler House	430 "
St. John's, surface of little stream west of village	390 "

[The last three points, when connected with Wapakoneta, gave, respectively, 504 feet, 443 feet, and 405 feet.]

Pharisburg, Union county	304 ft.
Essex, "	359 "
North-east corner Washington township	389 "
York Center	399 "
East Liberty, Logan county	565 "
Middleburg	625 "
Survey No. 5,270, Allen township, Union county	485 "
Allen Center	435 "
Milford Center	315 "

Soil and Timber.—The soil is one derived entirely from the Drift, and may be denominated in general a gravelly clay. It exhibits the well-known characteristics of fertility and endurance that mark all the Drift soils of north-western Ohio. It shows a very fair sprinkling of stones and bowlders, but in some places is very fine and heavy. It is only along the immediate river banks, on the bottom lands, that the sandy element prevails, and it is then confined to the alluvium.

The trees of the county consist of the usual deciduous varieties. The following species were noted:

Acer saccharinum—Sugar Maple	Wang.
Fagus ferruginea—Beech	Ait.
Ulmus Americana—Elm (pl. Clayt.)	Willd.

Quercus tinctoria—Black Oak	Bart.
Tilia Americana—Basswood	L.
Cornus florida—Dogwood	L.
Carya alba—Shag-bark Hickory	Nutt.
Carya porcina—Pig Hickory	Nutt.
Platanus occidentalis—Sycamore	L.
Æsculus glabra—Buckeye	Willd.
Zanthoxylum Americanum—Prickly Ash	Mill.
Acer rubrum—Soft Maple	L.
Carpinus Americana—Blue Beech	Michx.
Quercus alba—White Oak	L.
Quercus macrocarpa—Burr Oak	L.
Ulmus fulva—Slippery Elm	Michx.
Fraxinus Americana—White Ash	L.
Fraxinus sambucifolia—Black Ash	Lam.
Gleditschia triacanthos—Honey Locust	L.
Celtis occidentalis—Hackberry	L.
Crataegus coccinea—Thorn	L.
Salix nigra—Black Willow	Marsh.
Juglans nigra—Black Walnut	L.
Quercus castanea—Chestnut-leaved Oak	Willd.
Prunus serotina—Black Cherry	Ehr.
Pyrus coronaria—Wild Apple	L.
Ostrya Virginica—Ironwood	Willd.
Populus monilifera—Cottonwood	Ait.
Asimina triloba—Pawpaw	Ait.
Populus tremuloides—Trembling Aspen	Michx.
Cercis Canadensis—Judas Tree	L.
Quercus palustris—Pin Oak	DuRoi.

GEOLOGICAL STRUCTURE.

The rocks of the county embrace the following limestones, including, also, the Oriskany sandstone:

Hamilton, or Upper Corniferous, Lower Corniferous, Oriskany,	Devonian.
Waterlime	Upper Silurian.

By the Hamilton is here meant the blue limestone which is quarried at Delaware, and which is regarded by Dr. Newberry as partly Hamilton and partly Corniferous. It has been mentioned frequently by the writer in reporting on counties in north-western Ohio, under the designation of Upper Corniferous, in order to keep it distinct from the underlying limestone, which is plainly Corniferous. In the coloring of the county maps it is not separated from the Corniferous, but is embraced under the same coloring as the Corniferous. The blue stripe which is named "Hamilton Group" represents in part the shale which underlies the black slate, and which has been specially designated "Olentangy shale" in the report on Delaware county, to which the reader is referred for a statement of the subdivisions of the Ohio Corniferous, and of their supposed equivalents in New York. The Lower Corniferous is well represented in the quarries in Mill Creek township. The Oriskany has not been seen within the county, but it is probably conglomeratic, since it has that character in Delaware county. These limestones, with the Oriskany, make up the Devonian, so far as represented within the county. The rock which immediately underlies the Oriskany belongs to the Upper Silurian. It is the Waterlime member of the Lower Helderberg. The Devonian is found only in the south-eastern part of the county, although there are some evidences, in the form of large fragments, that it extends as far west as Marysville. It underlies the most of Mill Creek and Jerome townships. The rest of the county is occupied by the Waterlime.

The Hamilton or Upper Corniferous.—This limestone occupies but a small area in the south-eastern part of the county. It is hard and blue, and identical with the blue stone quarried at Delaware. Any favorable outcrop in that section should be thoroughly opened for building stone. This part of the county, though, is mainly covered with a heavy forest, and the strike of the formation is not known. Hensell & Fox, near Frankfort, have the only quarry in the county in this stone.

The Lower Corniferous.—The Delhi stone of the Lower Corniferous is quarried at a number of places in Mill Creek township. The quarry of Thompson and Brown, six miles south-east of Dover, exposes about four feet of fossiliferous, sometimes crinoidal limestone, in beds of two to four inches. It is principally burned for quicklime, but is also sold for cheap foundation stone. The lime which it makes is like that already described made from the same beds at Delhi, in Delaware county. The fossils seen here are *Cyrtoceras undulatum*, a handsome little *Strophomena*, a large Cyathophylloid coral, the pygidium of a trilobite, and various remains of fishes. There are also common a large *Strophomena* and a small Cyathophylloid. The quarry of John Piersoll, about three miles east of Watkinsville; that of Wm. Hays, a mile north-west from Piersoll's; those of John S. Smart, near Piersoll's, and that of Daniel Long, in the north-east corner of the angle of the county, are all in the Corniferous, and near the horizon of Thompson & Brown's.

Oriskany Conglomerate.—The only proof that this, usually a sandy limestone or a clean quartz grit, has the character of a conglomerate in Union county, consists in the appearance of that character near the county line, in Mill Creek, as already mentioned in the report on Delaware county. It there contains water-worn pebbles of the underlying Waterlime, which are sometimes two or three inches in diameter. The whole thickness is not more than two feet.

The Waterlime.—This limestone is so named from its known hydraulic qualities, in other States as well as in some places in Ohio. It appears in outcrop in widely separated parts of the county, and probably is the surface bed-rock throughout the most of the county. The quarry of Wm. Ramsey, in the bed of Mill Creek, in Mill Creek township, although not now in operation, is sufficiently developed to show the Waterlime characters. Aaron Sewell burns a little lime here. The foundation for the old court-house at Marysville was taken out here. The stone is in beds of about four inches, but is wavy. Some of it is brecciated. The creek has excavated about ten feet in this limestone along here, the overlying Corniferous receding from the stream on both sides. This narrow belt of Waterlime extends northward and makes, probably, an isolated outlier of Corniferous which occupies part of Dover township, and crosses Scioto, in Delaware county, from near Millville, south-westerly. The Waterlime also is exposed on Ingham Wood's land, one mile north-west of Pharisburg, in Boggs's Creek; also on John Grandy's, near Wood's, as well as on the next farm above, Peter Jolliff's. It occurs again on John Gray's and Alfred Davis's land, half a mile north of Byhalia, in the bed of Little Rush Creek. At York Center it appears on Aaron Shirk's and Hiram Watts's land, on the north side of Boggs's Creek. On the south side of the creek it also affords good exposures on the land of Montreville Henry, John Timons, John Shirk, and Finley Davis, where it has been burned some for lime by Mr. Shirk; but it is not now wrought. It is mainly a surface exposure in the bed and low banks of the creek.

At Unionville the Waterlime appears in Big Darby Creek. It was recently opened for lime by F. J. Sager and J. C. Robinson. The beds are from four to eight inches thick, and fine-grained. This is said to be underlain by a blue clay which is four feet thick. It also occurs two miles above Unionville, on James Martin's land; and a mile further down, on land of Elijah Mitchell. It was formerly wrought a little on the land of Mr. Sager, three-fourths of a mile below the village, where the beds were from four to eight inches. It also is seen on H. Pennington's land, just below Mr. Sager's.

The Drift.—This deposit in Union county shows evidence of more recent date than it does generally in Delaware county. It appears very similar to the Drift in the north-west corner of Delaware county, the characters of which are sufficiently discussed in the report on the geology of that county. This evidence is of two kinds: (1st) that which pertains to the rock; (2d) that which pertains to the Drift itself.

(1) The streams of the county have not excavated channels in the rock, and but very rarely expose it in their beds. This is not strictly true in the south-eastern part, in the area of the Corniferous, where there is some erosion in the rock, like that seen throughout the most of Delaware county. This indicates that in the south-eastern corner the erosion by streams has been longest continued, although that part of the county has at the same time less elevation above Lake Erie. In other words, that the overspread of Drift in the south-eastern part of the county was earlier than in the rest of the county.

The rock, where exposed in the south-eastern part of the county, has the same long-weathered appearance, even when freshly uncovered by the removal of the Drift, that is observable in Delaware county. The marks of glacial action are dim. The natural jointing and planes of separation between the bedding are loosely filled in with the effects of oxydation and decomposition to a greater depth than in the rest of the county.

(2) If we revert to the appearance of the Drift itself, the most striking contrast is presented in the general smoothness of the surface throughout the county, compared to the surface of Delaware county. This is partly due to the effect of less erosion on the Drift by the streams, and partly to the evenness of the rock surface. With a single exception, the Drift seems to have been very uniformly and gently deposited in Union county. The uniform direction of, and the regular intervals between the main streams, may all have been at first determined by slight differences in the thickness of the Drift deposited, but such differences are now so obscured that they can not be detected by the eye, except in the interval between the Big Darby and Mill Creeks.

Besides this general flatness of surface, the yellowish color, caused by the formation and infiltration of hydrated oxides from above, does not extend so far downward in Union county as in Delaware. In the latter county the light colored clay extends downward to the depth of fifteen or twenty feet, and sometimes as much as twenty-five feet. In the former the blue clay is usually met within ten feet. It sometimes rises within eight feet of the surface, and occasionally the yellowish color extends to twelve or fifteen feet. The depth of such superficial coloring seems to vary not only with the length of time the Drift may have been exposed to the air and surface water, but also with the ease with which these agents find access below. A sandy or gravelly knoll is generally weathered deeper than one of clay, and a rolling surface is apt to be more deeply oxydated than a flat one.

The Drift ridge which separates Big Darby and Mill Creeks has already been alluded to under the head of *Surface Features*. Its exact form, limits, and location, even within the county, have not been fully made out. The time given to the county would not allow a careful survey of this ridge in detail. It is well known to the inhabitants of the county. It forms a belt of high and rolling clay land which shows bowlders and gravel somewhat more abundantly than the surface of the rest of the county. It is believed to be of the nature of a glacial moraine, and was probably thrown down by the ice at a period when the retreating ice-foot was nearly stationary for a long time at about that place. It is very similar to those other very extended Drift moraines that cross north-western Ohio, but is somewhat more clayey than they. Its connection with them is not known, but it was doubtless cotemporaneous in origin with one of them. The elevated region in Logan county, where there is an island of Devonian rock which withstood the ice-period, was a disturbing element in the otherwise very regular contour of the foot of the glacier. Union county seems to have been in the pathway of a spur or branch of the ice-sheet, and to have suffered very extensive erosion thereby. After the actual withdrawal of the ice from the county, the drainage of a large tract of ice-covered surface would have passed principally through the same pathway. This pathway is bounded on either side by a persistent barrier of Corniferous limestone. It is probable, also, that the Waverly overlay this area, at least in the Logan county island, since fragments of the Berea grit are found in the Drift in the south-western part of Union county. The effect of this drainage over the county is probably seen in the near approach to the surface of heavy gravel beds in the Drift over wide tracts, although the level of the county in the same tracts is now that of the general country, and is perfectly flat. This may be seen in the frequent gravel pits about Richwood and Essex, where the surface is outwardly comparable to that of the Black Swamp of north-western Ohio, but is so closely underlain with gravel that almost every cellar encounters it within three or four feet. This gravel belt runs southward toward Pharisburg, and is also penetrated on the farm of Mr. Josiah Westlake, a mile and a half north of Marysville, who avers that small "shiner fish" appear late in the summer, or in the fall of nearly every year, in a shallow well curbed by a "gum," which is inserted in an excavation penetrating to the gravel, or to the water of a subterranean lake.*

The same phenomenon of gravel closely underlying the surface of a flat country occurs on the south side of the moraine ridge in Union township. There the "Darby plains," which constitute a fertile and fine agricultural tract, are based on a gravelly subsoil.

Wells and Springs.—The following observations on the common wells of the county are of interest. They give some idea of the accessibility of water for domestic purposes, and of the composition of the Drift, as well as of its thickness at various places:

Owner's name.	Location.	Feet above the rock.	Feet in the rock.	Total depth.	Through what.	Remarks.
J. H. Felkner	Dover	25	......	25	Yellow and blue clay	Good water.
Josiah Westlake	1½ mile north of Marysville	47	......	47	12 ft. yellow clay, 28 ft. blue clay, 7 ft. sand	Irony water.
J. R. Richey	Dover township	25	......	25	....	Good water.
"	"	15	......	15	....	"
John Robinson	"	20	......	20	....	"
Aaron Sewell	"	27	......	27	Clay and gravel	"
Widow Ligget	"	22	......	22	"	"
Rob't Thompson	Mill Creek	24	......	24	Blue clay and gravel	Sulphurous.
Joel Conklin	Pharisburg	12	......	12	Yel. and blue clay	Good water, in sand.
B. W. Welsh	"	20	......	20	"	"
Widow Scott	"	17	......	17	"	Slightly sulph'us.
John Elliott	1 mile N. W. of Pharisburg	20	......	20	Brown clay	Good water.
G. W. Merritt	Jackson town'p.	30	......	30	....	"
John Dixon	"	30	......	30	....	"
John McPeck	Washington tp.	17	......	17	....	"
William Moffitt	Byhalia	22	......	22	Brown and blue clay, and gravel	"
B. A. Martin	"	22	......	22	"	Struck the rock.
J. M. Darling	Summerville	22	......	22	"	Good water.
John Southard	"	25	......	25	"	"
Wm. T. Fulton	York township	31	......	31	Clay and gravel	"
J. T. Gates	Broadway	14	......	14	In gravel	"
Public pump	"	36	......	36	"	"
"	Newton	52	......	52	Brown and blue clay, and gravel	Bitter water.
E. Hammond	"	12	......	12	Brown clay	Good water.
—— Smith	Pottersburg	60	......	60	Blue clay	Little water.
"	"	55	......	55	"	Plenty of water.

* This circumstance would not be mentioned had it not been frequently reported by others in reference to certain wells in Defiance and Fulton counties. The facts are given with great circumstantiality and positiveness, and can not safely be denied.

WELLS AND SPRINGS.

Owner's name.	Location.	Feet above the rock.	Feet in the rock.	Total depth.	Through what.	Remarks.
?	2 miles east of Pottersburg.....	63	......	63	....	Good water.
Paschal Spain....	1 mile N. W. of Allen Center...	13	......	13	In gravel	"
"	"	11	......	11	"	"
Henry Poling.....	Allen Center.....	11	......	11	....	"
"	"	30	......	30	Brown and blue clay, and gravel..	Slightly bitter.
James Poling	1 mile south of Allen Center...	22	......	22	Brown clay and gravel	Good water.
Public pump......	Milford Center..	32	......	32	....	Poor water.
Wm. M. Winget..	" ..	26	......	26	Brown and blue clay, and gravel..	Good water.
James Guy	1¼ mile west of Pleasant Valley	33	......	33	"	Irony water.
"	"	23	......	23	"	"
E. W. Barlow.....	Pleasant Valley.	22	......	22	In gravel	Good water.
S. B. Woodburn.	New California..	54	......	54	Brown clay, 15 ft., blue clay, 39 ft...	Bitter water.
Widow Bain......	" ..	51	......	51	"	"

MATERIAL RESOURCES.

The most of the county is poorly supplied with building stone. This necessary article is imported from Logan county, where the Onondaga quarries at Middleburg afford a good stone, from the quarries in the Hamilton, at Marion, in Marion county, and from the same at Delaware. The quarries in the limestones of the Devonian, in the south-eastern part of the county, would probably be better patronized if better roads intersected that section, and if the quarries themselves were energetically developed. Not much lime is made in the county, the kiln of Thompson and Brown, in Mill Creek township, doing more than all others united. A kiln has recently been opened near Unionville, by Sager and Robinson, for burning the Waterlime, and at Plain City the beds of the Delhi stone are burned by William Lamb, the stone being hauled from Dublin, on the Scioto River. William Bales burns a little lime in the extreme western angle of Allen township, from loose pieces of limestone taken from gravel banks and from the bottom of Darby Creek.

The Drift clays, however, are freely used in the manufacture of red brick and tile. The following list embraces such brick and tile yards as were noticed in the survey of the county:

John Weaver, 1 mile south-east of Marysville	Brick.
Peter Daum, 1½ mile south of "	"
E. Weller, ¾ " "	Tile and Pottery.
Casper Scheiderer, 3½ miles south-east of Marysville	Tile.
Grandy and Parsons, Richwood	Brick and Tile.
Albert Merritt, "	Brick.
E. Philips (formerly), "	Pottery.
Franklin Bros., 2½ miles east of Pharisburg	Brick.
Jordan and Crary, Allen Center	Tile.
A. Moran, Irwin P. O.	"
Wm. Gillespie, "	"
Mitchell and Snodgrass, Unionville	Brick.
McCune and Bro., Plain City	"
Horn and Son, "	Tile.
Absalom Rudolf, 2 miles north-east of New California	Brick.

There is a great deal of standing timber yet in Union county. Extensive lumbering is carried on in the eastern part of Jackson township by Hazen and Sons.

The natural features and the geological structure of the county will forever preclude the development of any other element of material wealth that will rank with that of agriculture. The community is very largely one of farmers, with only such necessary professional men as they need.

CHAPTER XL.

REPORT ON THE GEOLOGY OF PAULDING COUNTY.

BY N. H. WINCHELL.

SITUATION AND AREA.

This county lies in the north-west corner of the State, and borders on Indiana. It occupies the angle between the Auglaize and Maumee Rivers before their union, extending a little beyond the limits of that angle on both streams. Its area is given by the State Board of Equalization at 259,235 acres, of which 21,443 acres are arable, or plow land; 7,552 acres meadow or pasture land; and 230,240 acres uncultivated or wood land.

NATURAL DRAINAGE.

The Maumee is the principal stream of the county. It cuts off the north-west corner of the county, running north-easterly. In a similar manner the Auglaize cuts off the north-east corner, running north-westerly. They unite a short distance north of the north line of the county, at the city of Defiance. The slope of the county is very gentle toward the north-east, and all the other streams flow in that direction, the most of them uniting with the Auglaize. The streams are all sluggish, and flow with a winding course through wooded land, which is also to a large extent very slowly drained of surface water in the spring.

SURFACE FEATURES.

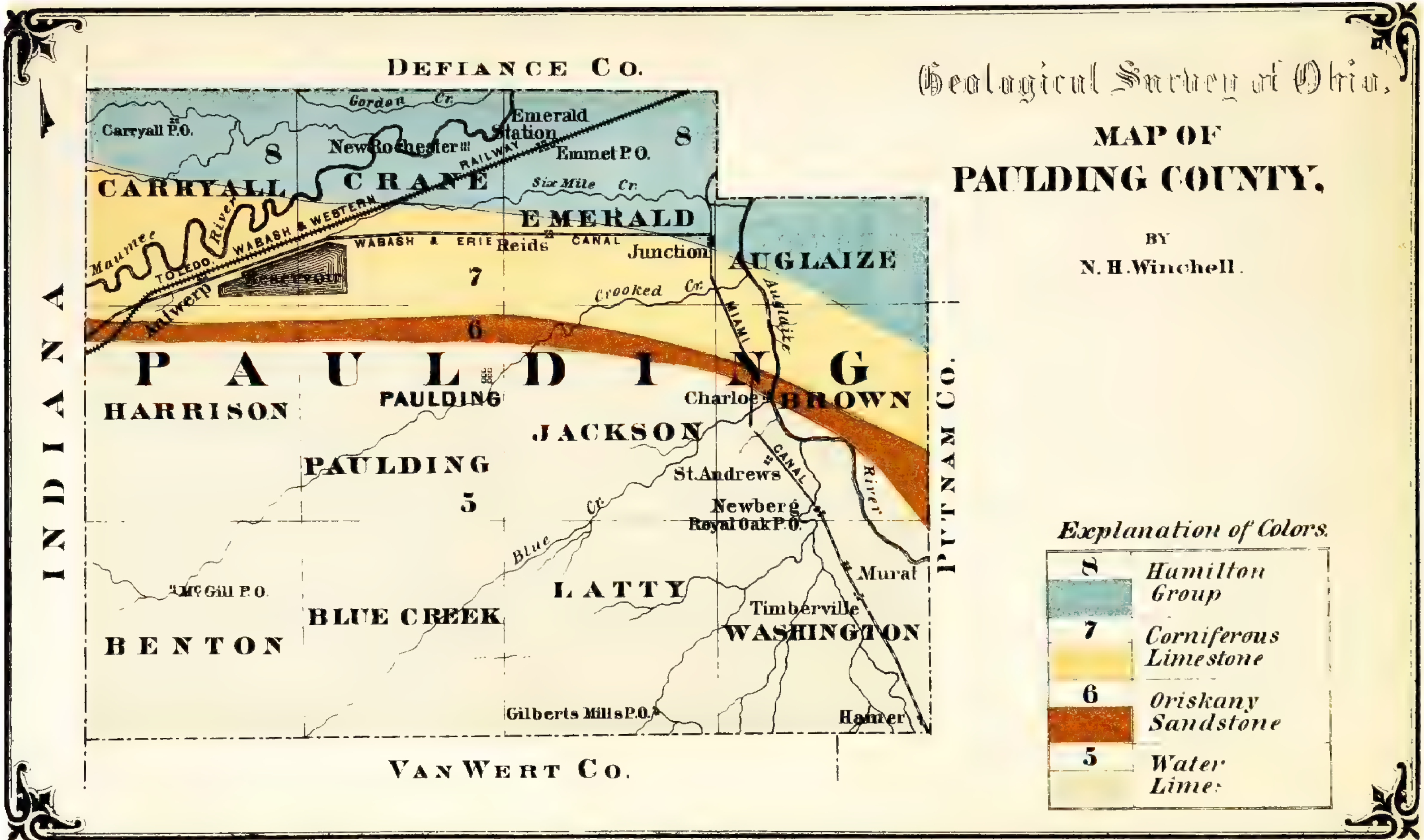
These are to a great extent hid by the existence of a heavy growth of forest timber. About eighty-nine per cent. of the acreage is classified as "uncultivated, or wood land." In general the county is an unbroken plain, the valleys of streams, eroded entirely in the loose Drift materials, constituting almost the only variations from a dead flat. On the north side of the Maumee there is a gentle descent of about forty feet between the county line and the north bank of the Maumee, at Antwerp, with a further descent of about fifty feet to the water level. This dense forest, which is but little intersected by roads, is the hunting ground for parties coming in the fall of the year from the central and southern parts of the

State, who capture the common deer, and an occasional black bear and wolf.

Soil and Timber.—The soil is that which is characteristic of the well-known "Black Swamp." The entire county is embraced in that tract. It is mainly clayey, if not clay. Bowlders and stones are not common on the surface. In the beds of the streams, though, there is no apparent diminution. The banks of the Maumee sometimes show a finely laminated clay, reaching, at some points in the county, ten feet in thickness, forming the top of the Drift, and giving character to the soil. At other places the laminated structure is wanting, and the soil embraces the usual amount of gravel stones, or even of bowlders, the latter, when concealed from the weather, almost uniformly showing the effect of glacial action, and in that particular differing from those seen in more southern counties.

The following list of trees embraces those noted in the survey of the county. It is doubtless not a complete list for the county:

Quercus alba—White Oak	L.
Fagus ferruginea—Beech	Ait.
Populus monilifera—Cottonwood	Ait.
Quercus rubra—Red Oak	L.
Ulmus Americana—Elm (pl. Clayt.)	Willd.
Fraxinus sambucifolia—Black Ash	Lam.
Fraxinus Americana—White Ash	L.
Fraxinus quadrangulata—Blue Ash	Michx.
Juglans nigra—Black Walnut	L.
Carya alba—Shagbark Hickory	Nutt.
Platanus occidentalis—Sycamore	L.
Salix nigra—Black Willow	Marsh.
Populus tremuloides—Trembling Aspen	Michx.
Tilia Americana—Basswood	L.
Quercus imbricaria—Shingle Oak	Michx.
Quercus castanea—Chestnut Oak	Willd.
Prunus serotina—Black Cherry	Ehr.
Morus rubra—Mulberry	L.
Ostrya Virginica—Ironwood	Willd.
Acer saccharinum—Sugar Maple	Wang.
Cornus florida—Flowering Dogwood	L.
Acer rubrum—Soft Maple	L.
Æsculus glabra—Buckeye	Willd.
Prunus Americana—Wild Plum	Marsh.
Populus grandidentata—Great-toothed Poplar	Michx.
Crataegus coccinea—Thorn	L.
Quercus palustris—Pin Oak	DuRoi.
Quercus macrocarpa—Burr Oak	Michx.



Strobridge & Co. lith. Cin. O.

Zanthoxylum Americanum—Prickly Ash	Mill.
Gleditschia triacanthos—Honey Locust	L.
Asimina triloba—Pawpaw	Dunal.
Euonymus atropurpureus—Wahoo	Jacq.
Carpinus Americana—Water Beech	Michx.
Ulmus fulva—Slippery Elm	Michx.
Celtis occidentalis—Hackberry	L.
Cercis Canadensis—Judas Tree	L.
Pyrus coronaria—Apple	L.
Amelanchier Canadensis—June Berry	Torr. and Gray.

GEOLOGICAL STRUCTURE.

The rocks that have been identified in Paulding county range from the Waterlime to the Hamilton, including both. The geographical limits of each formation, as represented on the accompanying map, are largely conjectural, owing to the very unfavorable surface features that preclude detailed examination, as well as to the uniformly undisturbed condition of the Drift sheet. There is some evidence of the occurrence of a large outlier of the Upper Corniferous, or Hamilton, in the central portion of the county, or, it may be, a long spur from the main strike of the formations. It is disregarded in the coloring on the map. The following arrangement represents the formations in the order of their superposition, according to the nomenclature of the Ohio Survey:

Corniferous,
Oriskany,
Waterlime.

Of these the New York equivalents are represented in the following list.* (See Geology of Delaware County.)

Tully limestone,
Hamilton shaly limestone, }
Corniferous limestone, } ....Devonian.
Onondaga limestone, }
Oriskany limestone, }
Waterlime (of the Lower Helderberg group).

The Ohio "Corniferous" is separable into four distinct and well-defined parts, the characters of which are persistent throughout the Fourth District. These four parts above represented, by New York equivalents, are believed to correspond with well-known members of the Devonian.

* I am compelled to say that for the classification adopted in the above schedule Prof. Winchell is alone responsible, as I cannot fully indorse it until it shall be sustained by further evidence than has yet been procured. The shale which he calls the "Olentangy shale" has as yet yielded no fossils, and I see no good reason for separating it from the Huron. The rock which he regards as the equivalent of the Tully limestone may be so, but it has as yet been identified by no fossils of the Tully limestone. It is unquestionably Hamilton, as I have found in it elsewhere *Pterinea flabella*, *Tropidoleptus carinatus*, and *Nyassa arguta*.

The "Hamiliton limestone"—No. 4, of Prof. Winchell's section—can hardly be re-

They are observable, though not yet with the same definite limitations, in Michigan and Illinois.

The Tully Limestone.—This has not yet been seen in Paulding county, but is visible in the Auglaize River, in N. E. ¼ section 9, Defiance, Defiance county. It constitutes the upper member of the Hamilton, and is marked in Delaware county by large lamellibranchiate fossils. (See also, Geology of Delaware County.)

The Hamilton Limestone.—This limestone is known to underlie the north-eastern portion of the county, and to present many indications of being *in situ* in the township of Paulding, near the center of the county. Its line of contact with the Corniferous limestone is plainly exhibited by the frequent exposures of rock in the bed of the Auglaize where it crosses that river in Auglaize township. The lowest outcropping rock overlying the Corniferous ("Delhi beds" of Delaware county) is seen at the quarry of Samuel Doyle, at the mouth of the Little Flatrock (N. E. ¼ section 30), which joins the Auglaize about three-quarters of a mile north of the Flatrock.* This quarry furnished the stone put in the aqueduct at Royal Oak (Newberg on the maps) fifteen years since. At the quarry the beds are firm and uniform, showing but little shaly tendency; with dip north and north-east. Some are taken out that have a thickness of twelve or eighteen inches. It is of a dark, blackish blue, and is, on weathering, found to be charged with Hamilton fossils. At the quarry but few could be identified, owing to the high stage of the water, but the following species were seen in the stone put in the aqueduct, where the long exposure has caused it to check into hundreds of thin beds, and, by the disappearance of the shaly parts, to disengage numerous well-preserved fossils. These beds are rarely or never crystalline, except that occasional calcite appears in the interior of the shells, but the massive abutments are crumbling away. *Atrypa reticularis*, *Cyrtia Hamiltonensis*, a handsome *Orthis*, *Spirifera mucronata*, *Spirifera* (large species, resembling

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garded as purely Hamilton, though it contains many fossils which are usually called Hamilton fossils, but all these, with perhaps the exception of *Spirifera mucronata*, are also found in the Corniferous of New York. And it also contains fossils which are regarded at the east exclusively Corniferous; such as *Spirifera gregaria*, *Pentamerus aratus*, *Strophodonta hemispherica*, *Tentaculites scalaris*, and others. It also contains many fossil fishes and mollusks, which are abundant and characteristic fossils of the Corniferous in Ohio.

I also regard the separation of the Lower Corniferous into two members, and their identification with the Corniferous and Onondaga limestones of New York, as premature, since it is as yet sustained by no palæontological evidence. This subject will be found more fully discussed in Vol. I., Part I., pp. 144 and 149 of this Report, and in the Report on Erie County. J. S. N.

* The Indians called the Flatrock *Crooked Creek*, and that name still prevails on the maps.

S. macrothyris, Hall), *Terebratula*, *Strophomena*, *Cyathophyllum*, *Aulopora*, *Calopora*, and various fine incrusting corals.

More enduring and persistent stone belonging to the Hamilton, overlying the beds at Mr. Doyle's, is seen S. E. ¼ section 19, Auglaize, with a dip north and north-east This is owned and quarried by Smith Mead. It is near the highway bridge, east of Junction. This place furnishes flux for the furnace near Cecil. The beds are hard, blue, and crystalline, and very similar to the limestone quarried at Sandusky and Delaware, yet it is almost unfossiliferous, although it contains one or two *Cyathophylloids* and a *Favosites*. It also holds considerable chert.

Thomas Columbia's quarry is in similar stone, but a few rods below Mr. Mead's. Still further north the same or similar beds are quarried on section 17, in Defiance, Defiance county, by Town Newton, for flux for the Paulding furnace. Dip still north and north-east.

In section 29, Paulding township, the bed of the Flatrock shows various indications of the Hamilton *in situ* in the bed of the stream, on land of Judge A. S. Latty and of P. W. Hardesty. Many large fragments and some pieces of black slate are seen along the bed of the stream, and there is a noticeable ripple in the current. The indications extend over the space of nearly a mile, yet the actual beds cannot be seen exposed.

The Corniferous Limestone.—This term in general is made to cover considerably more than is herein intended to be described, as already explained. It is here meant to apply specially to a separate and distinct member of the Corniferous group, as described in the Ohio reports by Dr. Newberry, viz., to the light-colored and very fossiliferous layers that are first below the blue limestone above described as Hamilton, and which in the report on Delaware county are mentioned as the "Delhi beds," but parallelized with the Corniferous limestone of New York. This limestone has been observed at two points only in the county. It makes a broad surface exposure—which gives name to the creek—at the mouth of the Flatrock, and there dips toward the north-east, passing below the Hamilton. At this place there has been but little artificial working. It is owned here by Judge A. S. Latty and Calvin L. Noble. The fossils seen are largely species of corals, with the usual associated brachiopods. The same beds are wrought for quicklime—N. W. ¼ section 32, Auglaize—by Wm. H. Mansfield.

At Antwerp, the Corniferous limestone appears in the Maumee, and is wrought for flux for the Antwerp furnace. About three feet only are shown by the operation of the quarrymen; but the same stone is said to extend downward three feet further, and to be succeeded then by a "rotten sandstone," that name being very often applied to a coarse granular magnesian limestone, like the Onondaga. The outcrop here causes a little rapid in the river, although the beds are not bare except where quarried, the water coming in contact with bowlders only. The most common fossils are *Favosites*, *Acervularia*, *Coenostroma*, and *Cyathophylloids*. There is also occasionally a distinct crinoidal structure. Some of the corals are blackened, and smell of petroleum. Oil also gathers on the surface of standing pools of water about the quarry.

The Onondaga Limestone.—This is the lowest member of the Corniferous group in Ohio. It outcrops further up the Auglaize than the last described, and is burned for lime by Frank McEvoy, S. E. ¼ sec. 5, in Brown township. The beds here are thinner than where exposed at a lower horizon. These heavier magnesian beds are quarried, in connection with the Oriskany, at Charloe, including also some of the upper layers of the Waterlime. The river here is thrown into a long series of rapids in passing these more persistent beds. This quarry is south of the mouth of Blue Creek, on the west side of the Auglaize, and shows, according to the statement of the proprietors, the following thickness for the several members:

SECTION AT CHARLOE.

No. 1.	Sandstone, having the appearance of that at Grand Rapids, in Wood county; hard; sawn off for flagging; suture-jointed upon No. 2; seen, only		6 in.
" 2.	Even-grained magnesian limestone, of a buff color, containing nodules of chert; sawn into handsome building blocks, and exported largely	4 ft.	
" 3.	Dark drab; soft; magnesian; with some cavities which often contain straw-colored calcite	1 "	10 "
" 4.	Rough; blue-drab; close-grained; heavy and hard, or brecciated and vesicular; with some pyrites; in one bed, of at least	3 "	6 "
	Total seen	9 "	10 "

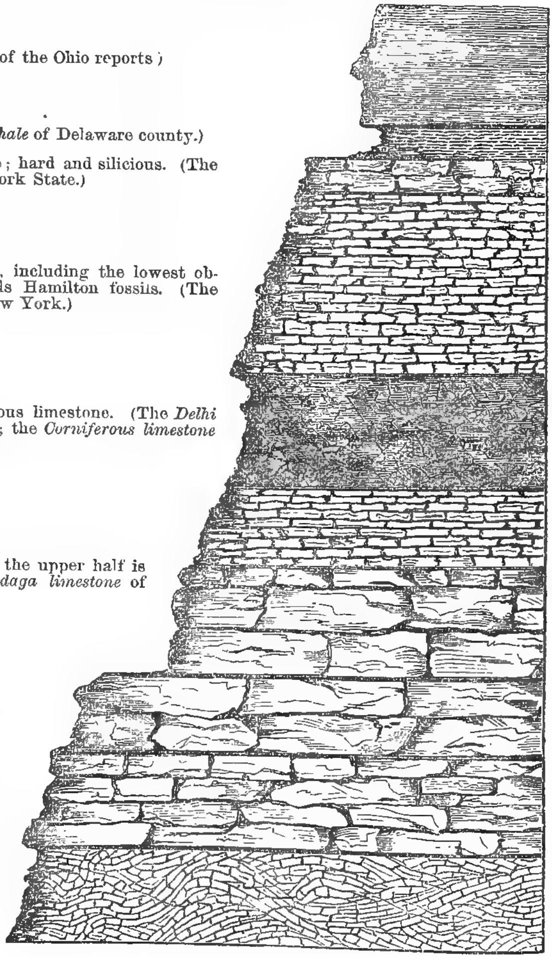
Of this section, No. 1 is the base of the Oriskany; No. 2 is a stone seen at other places embraced within the Onondaga limestone; Nos. 3 and 4 are the uppermost members of the Waterlime. (See Geology of Wood County.)

The Oriskany Sandstone.—In north-western Ohio the beds supposed to represent the Oriskany of New York play an important economical part in the geology of that district. They do not exceed an aggregate thickness of twenty feet, and are sometimes less than ten; but from the quarries that have been opened in them in different counties they have supplied stone for the most important structures. The horizon at which the sandy phase appears exhibits some variation, as has been mentioned in reports on Wood and Sandusky counties. The arenaceous character seems to be spread more largely through the overlying Onondaga in Wood county than in Sandusky or in Delaware county. In both of these counties, as well as in Paulding, the Oriskany merges into the Onondaga by insensible changes. In Paulding and in Sandusky there is a considerable thickness of a soft magnesian limestone in heavy beds, excellent for cut-stone, lying *below* the Oriskany, having no arenaceous tendency. These beds have very much the aspect of the recognized Onondaga, or Lower Corniferous, and have been regarded as belonging to that formation, but are somewhat more bituminous. Their actual place in the series throws them, however, into the Waterlime, and they have exactly the characters of that phase of the Waterlime which has been described as "Phase No. 2" in reports on Ottawa and Wood counties. The quarry at Charloe is in these beds, their thickness being about six feet.

The Waterlime.—This limestone affords many characteristic and valuable exposures in the bed of the Auglaize River above Charloe. It appears S. E. ¼ sec. 21, Brown, one-fourth of a mile above the mouth of the Little Auglaize, between the farms of Oliver Young and H. Harmon, on opposite sides of the river. It is here of a light blue or blue-drab color, in beds of four to eight inches; hard, yet porous, with *Leperditia*, and makes excellent lime. Some of this stone is crystalline, like the Van Wert county Waterlime, and some is dark drab and rough. The Waterlime also appears in the Auglaize at the mouth of the Little Auglaize, showing the characteristic fossil, *Leperditia alta;* beds thin, but finely crystalline. In the N. E. ¼ sec. 34, it is a fine-grained yet magnesian stone, which under the hammer emits a bituminous odor, and is soft, like the Onondaga beds of the Corniferous. It here shows in rather heavy beds, which in a cross section have a curly internal structure, with bituminous films. Yet these thick layers are intermingled variously with thinner, fine-grained drab layers, that show the characters of "Phase No. 3" of Ottawa county. In section 35 the bed of the Auglaize is on the fine-grained drab beds of the Waterlime, which have been a little worked for local use. Section 1, in Washington, shows Waterlime of the same kind. It is also exposed in section 29, same township, in the creek, where it is quarried.

General Section of the Rocks in Defiance and Paulding Counties.—In the progress of the survey of Delaware county some evidence was obtained of the Hamilton age of the whole of the blue limestone of that county, but not such as placed such an opinion beyond the limit of doubt. Hamilton fossils are found in it in various places. The same is true of its exposures in Marion and Seneca counties, and at Bellevue, in Sandusky county. But in Paulding county the closest attention was paid to the solution of the question, "Do Hamilton fossils extend through the whole of the blue limestone?"—a question propounded by the Director of the Survey for the purpose of testing the evidence. It is deemed best here to present a general section of the rocks of Paulding and Defiance counties, in order to express clearly the position of the beds that have furnished the writer the only Hamilton fossils found in north-western Ohio. This section agrees in all its details with that of Delaware county, except the attenuation here of the Olentangy shale of Delaware county. Indeed, this shale, which in the Report of Progress for 1869 is regarded as *Hamilton*, is seen to be entirely wanting in most places in Defiance county, the thin, tough black slate layers lying immediately on the hard beds of the Tully limestone:

General Section of the Rocks of Paulding and Defiance Counties.



No. 1. Black slate. (*Huron shale* of the Ohio reports.)

" 2. Bluish shale. (*Olentangy shale* of Delaware county.)

" 3. Blue and blackish limestone; hard and silicious. (The *Tully limestone* of New York State.)

" 4. Blue limestone; the whole, including the lowest observed part of this, holds Hamilton fossils. (The *Hamilton limestone* of New York.)

" 5. Saccharoidal, very fossiliferous limestone. (The *Delhi beds* of Delaware county; the *Corniferous limestone* of New York.)

" 6. Buff, magnesian limestone; the upper half is thin-bedded, (The *Onondaga limestone* of New York State.)

" 7. Quartzose sandstone; conglomeratic in Delaware county. (The *Oriskany* of New York State.)

" 8. Heavy-bedded magnesian limestone. (*Phase No.* 2 of the Waterlime of Ottawa county.)

9. Irregular and wavy-bedded, compact limestone. (*Phase No.* 3 of the Waterlime of Ottawa county.)

No. 1 of this section does not appear in Paulding county, except in the form of floating pieces transported with the Drift. It is fully described in reports on other counties.

No. 2 appears in the Tiffin River, at Brunersburg, where it embraces a shaly limestone which crumbles under the weather. Such limestone is in detached lumps and lenticular masses. It is washed out of the shale near Waldo, in Marion county, by the force of the water of the Olentangy, where it falls over a dam. It is entirely unfossiliferous, as well as the shale in which it lies. In north-western Ohio No. 2 is very much reduced from its observed thickness in Delaware county (30 feet), and is usually altogether wanting. It is evenly but very thin-bedded, and is closely related to the Huron shale (No. 1), with which it is interstratified in Delaware county.

No. 3. This holds the place and exhibits most of the characters of the Tully limestone of New York. Its identity is not established on palæontological evidence. It is quarried at Florida, on the Maumee, and by Mr. Dilz, near Defiance. At the former place it is immediately overlain by the black slate. Its thickness is six to ten feet.

No. 4 has a thickness in Delaware county of 35 feet, and probably it will not vary very much from that on the west side of the anticlinal. There are no exposures in these counties favorable for learning its aggregate thickness. In the season of 1871 a collection of fossils, characteristic of the Hamilton, was made in the N. E. ¼ section 30, Auglaize, in Paulding county. The species here gathered were those already enumerated in the description of the outcrop at that place. Time was not sufficient then for determining certainly the relation of this stone to the rest of the blue limestone. In the season of 1872 this point was made the subject of careful investigation. The result arrived at was the conclusion that the beds that hold these Hamilton fossils are very near the bottom of the blue limestone. The evidence is not that of actual, observed superposition, but that which is based on a series of observations along the Auglaize valley on the *dip* of the underlying rocks. It is a very observable fact that the limestones of north-western Ohio are very evenly and regularly laid down, and have not been disturbed by any force so as to introduce exceptional, or even extraordinary, dip in any direction or degree. In passing along the valley of any of the streams that expose the rock, this fact is very apparent. The formations succeed each other in perfect conformity with the known general dip. It is so in Paulding county. The Waterlime, the lowest in the series of rocks in the county, occupies the most southerly part of the county. Its upper horizon unites with the Oriskany at Charloe.

The dip is very slight, but to the north. In regular order, and a little further north, the Onondaga beds of the Corniferous group appear. Next the Corniferous proper appears at the mouth of the Flatrock, with dip north-east. About three-quarters of a mile still further occurs the outcrop which holds the abundant Hamilton fossils, there the dip being in the same direction and to the same amount. This is at the mouth of the Little Flatrock. A half mile still further north is Mr. Mead's quarry, in the blue limestone of Delaware, the dip being the same. A few rods still further north is Mr. Columbia's quarry, in the beds of the same, or nearly the same, horizon. About three-quarters of a mile still further north the blue limestone is again quarried, in section 17, Defiance, Defiance county, where the dip is still north or north-east. About a mile and a half still further the Tully limestone comes into view, and is wrought by Mr. Dilz for lime. A mile still further the black slate appears. Throughout the whole of this distance there is no return of the strata by an exceptional dip. The beds occur in exactly that order they should if laid regularly down like the shingles on a roof. The inference is inevitable that the lowest layers occur in outcrop furthest south. Now, as there is no blue limestone exposed to the south of the mouth of the Little Flatrock, but since there is, on the other hand, abundant exposure to the north, the dip being observed constantly to the north, the rock at the Little Flatrock containing the Hamilton fossils mentioned must lie below the rest of the blue limestone observed, and very near the bottom of that formation. There can be no other evidence except that of actual, observed superposition. The writer did not give strict attention to the subject of the downward limitation of well-known Hamilton fossils in the survey of any other county, having regarded the uniformity of lithological characters sufficient to establish the essential unity of the whole of the blue limestone, and never having noticed a lack of corresponding uniformity of palæontological characters. Those palæontological characters were sufficient to indicate the Hamilton age, and the perfect parallelism of the blue limestone with the Hamilton limestone of the adjoining State of Michigan.

No. 5 is that which is seen in the Auglaize River, near the mouth of the Flatrock. It is much different from the blue limestone in lithological characters. It is not so hard, nor so dark-colored. The beds are generally of about the same thickness as those of the blue limestone, but much less uniform. They are apt to taper toward the right or left, and appear as lenticular pieces. Their upper surfaces are also roughened by prominent corallites. It is much freer from argillaceous matter than the blue, and makes a whiter quicklime. It is sometimes crinoidal, and its mural faces in Delaware county present an apparent massive structure, with crumbling surfaces. the pieces falling out being an inch or two in diameter. Its thickness is about twenty-eight feet.

No. 6 has a thickness of about thirty feet. Its upper portion is thin-bedded, and fit only for quicklime. Its lower portion is in heavy beds of twelve or fifteen inches, and is in some places a prized building stone. It is of uniform grain and composition, being non-fossiliferous, and is susceptible of being cut or sawn into blocks of any desired dimensions. It often passes for a sandstone, and has a light cream color when weathered.

No. 7 is perhaps ten feet thick, but only six inches have been seen in Paulding county. It is sometimes conglomeratic. Several large bowlders derived from it were seen in the bed of the Maumee, near Emerald.

No. 8 is from six to ten feet in thickness. The quarry at Charloe is in No. 8.

No. 9 is in wavy, or at least in distorted, bedding, a common feature of that phase of the Waterlime.

The Drift.—This deposit throughout the county was laid down by the agency of the glacier, but the effect of standing water, which received the crude detritus from the ice, is seen in the occasional superficial, horizontal lamination of the upper six to ten feet. The bowlders contained in it are, almost without exception, marked by the well-known glacier scratches. It contains but little gravel. Sand in Paulding county is very scarce. That used at the Paulding furnace is from the Maumee bottoms, section 11, Crane township, land of H. B. Ferguson. Generally the Drift of the county is very clayey and impervious to water. The beds of all streams are in it, occasionally touching the rock, never excavated in it. Its average thickness is about 45 feet. The flood-plain of the Maumee rises about 12 feet above the stage of low water. The material of this plain is a sandy loam, containing a great many land shells. The face of the bank shows them in all parts, and the deposit has outwardly every aspect of the "Bluff formation" of the Mississippi River. It is difficult to resist the conviction that it has the same origin, its height there, as here, indicating simply the level at which the river has been able to transport the materials. The Drift-bank proper is generally at some distance from the immediate channel, and rises from 30 to 40 feet still higher.

Wells and Springs.—In Carryall township are a number of artesian wells. They prevail most along the North Creek, through the northern tier of sections. Many wells not artesian find water in a bed of sand and gravel from 10 to 18 feet below the surface, this sometimes affecting and destroying the flow of artesian wells. The water in these shallow wells sometimes rises nearly or quite to the surface, but the most of the artesian wells rise from a gravel bed that lies on the rock. They have a depth of 30 to 35 feet. This water-bearing stratum may also be the real source of the artesian flow of some of the shallow wells, since the first bed of sand containing water is known to not infrequently be connected with it so closely as to destroy the flow of the deeper wells. The general slope of the surface here is to the south-east. The hard-pan Drift-sheet is the confining stratum. The water finds access to the deep-seated gravel bed by passing through connected beds of water-bearing gravel and sand, in some region at a higher level, toward the north-west. The rock in Carryall township is generally 35 to 40 feet below the surface, yet it was positively asserted by Mr. McCormick that two wells about on the section line between 4 and 9 went down 70 to 80 feet without striking the rock. A deposit of yellow lake sand was met at Paulding Center, on Joseph Morrow's land. It does not rise much above the surface. There is considerable sand of the same kind on the land of L. Baldwin, north of Emerald, near the Maumee, and in Emerald township, between Six Mile Creek and the canal. Glacial marks were observed on the Corniferous, section 30, Auglaize, S., 40° W., and on section 31, Auglaize, S., 48° W.; on the Onondaga at Charloe, S., 35° W.

The following list of statistics, obtained in reference to wells in Paulding county, will be of importance in this connection:

Owner's name.	Location.	Feet above the rock.	Feet in the rock.	Total depth.	Through what.	Remarks.
?	Sec. 18, Benton	25	......	25	Blue clay	
Wm. Hany..........	N. E. ¼ sec. 21, Paulding	14	......	14	In gravel	Good water.
" "	"	18	......	18	In sand.........	" "
E. Blalock............	¼ mile S. E. of Paulding	10	......	10	Seeps from clay............	Little water.
Court House.........	Paulding.........	28	......	28	In bowlders...	Bitter water.
Judge A. S. Latty ..	"	25	......	25	....	Good water.
Mrs. Kate F. Cable.	"	25	......	25	....	" "
Elias Shafer	"	24	......	24	Blue clay	Good water in gravel
F.M.Rummel,Esq..	"	23	⅔	23⅔	Brown clay,10 ft.; blue clay, 13 ft...........	Water at 9 ft.; rises within 3 ft. of surface.
T. Emery, Esq.......	"	26	7½	33½	14 feet Brown clay; 12 feet blue clay	No water.
S. C. Dix	"	12	......	12	....	Water rises within 3 ft. of top.

Owner's name.	Location.	Feet above the rock.	Feet in the rock.	Total depth.	Through what.	Remarks.
Dr. D. M. Hixon....	1¼ mile N. of Paulding	15	......	15	Clay and sand	Soft water.
" "	"	16	......	16	" "	" "
Jehiel Seger	Paulding	30	......	30	Brown clay, 10 ft.; blue clay, 9 ft.; sand, 16 inches; blue clay, 7 ft......	Somewhat bitter.
Francis Ranish	Sec. 31, Emerald	14	......	14	In blue clay...	Good water.
Patrick Haly..........	Emerald Sta'n.	35	......	35	Through blue clay	" "
Mrs. E. McHamier	" "	35	......	35	"	Worthless water.
John Young..........	" "	35	......	35	"	Good water.
Patrick Haly	½ mile E. of Emerald Station..	41	......	41	Hard-pan clay	Good water at 31 ft.
Mr. Mooney	Sec. 15, Blue Creek	15	......	15	....	Artesian; good water
Henry Barkus	Sec. 6, Latty ...	35	......	35	....	Good water stands 4 ft. from surface.
Joshua Dikus........	Sec. 31, Auglaize	26	......	26	Clay only......	Good water broke out from the rock.
John Hilty	" "	30	......	30	Clay and gravel	Good water on the rock.
Isaac McCoy.........	" "	34	......	34	Clay and bowlders......	Bitter water.
Mrs. J. Mason	Sec. 25, Auglaize	38	......	38	....	" "
L. Baldwin	Sec. 5, Emerald	13	......	13	Lake sand, 4 ft.; blue clay, 9 ft..............	Good water.
W. H. Robertson ..	Cecil	39½	......	39½	Blue clay and bowlders	Bitter water.
M. M. Utley..........	"	25	......	25	Clay, 21 feet; sand, 18 in.; clay, 4 feet...	Good water.
E. C. Durfee..........	"	40	......	40	On the rock	Water at 17 ft.; rises within 10 in. of top.
Jos. Doda	"	13	......	13	Clay, 10 feet; sand, 2 in.; clay, 3 feet...	Water in sand.
A. H. Rogers	"	24	......	24	Clay, 12 feet; sand, 2 in.; clay, 12 feet..	" "
Paulding Furnace ..	Sec. 23, Crane..	36	......	36	Clay and gravel	Good water rises within 8 ft. of top.
" "	Sec. 27, " ..	45	......	45	Clay............	No water.
" "	Sec. 23, " ..	30	......	30	....	Good water.
John Gordon........	Sec. 16, " ..	30	......	30	Clay, hard-pan, sand......	" "
Public Pump	Antwerp.........	40	......	40	On the rock...	Sulphur water.
Antwerp Furn. Co..	"	40	......	40	Brown and blue clay; on the rock.	No water.
" "	"	40	......	40	" "	" "
" "	"	40	......	40	" "	" "

Owner's name.	Location.	Feet above the rock.	Feet in the rock.	Total depth	Through what.	Remarks.
Antwerp Furn.Co..	Antwerp.........	24	......	24	Clay, and 18 in. in sand...	Water rises within 1 ft. of the top.
P. N Harrington ..	Sec. 9, Carryall	9½	......	9½	Clay, 7 feet; gravel, 2½ ft.	Good water.
Harriet Liddell	" "	45	......	45	....	Artesian; good water
" "	" "	50	......	50	To the rock...	No water.
Fred. Barchard	" "	40	......	40	" "	" "
Mr. Lynd	" "	45	......	45	" "	" "
Peter Derrick........	" "	40	......	40	" "	" "
" "	" "	45	......	45	" "	" "
Josh. McCormick ..	" "	32	......	32	In gravel	Artesian.
" "	" "	29	......	29	Clay, 18 feet; sand, 11 feet.	Formerly artesian.
Jos. Clark.............	S. E. ¼ sec. 4, Carryall......	30 to 35 ft.	......	30 to 35 ft.	Eight other neighbors adjoining have artesian wells.	Good water; artesian
Zera Goff.............	"		......			" "
O. F. Wentworth ..	S. W. ¼ sec. 3, Carryall......		......			" "
John Banks..........	"		......			" "
Caroline Banks......	S. E. ¼ sec. 3, Carryall......		......			" "
Noah Ely.............	"		......			" "
Jedediah Banks.....	N.W.¼ sec.10, Carryall......		......			" "
Henry Oswaldt	N.W.¼ sec.11, Carryall......		......			" "
Perry Van Meter ..	"		......			" "
Jos. Lybarger........	S. E. ¼ sec. 10, Carryall......		......			" "
Chester Lybarger ..	S. E. ¼ sec. 3, Carryall......		......			" "
Lafayette Fruchey	Sec. 2, Carryall.............		......			" "
M. W. Brush	Sec. 5, Carryall.............		......			" "
Conrad Slough.......	Sec 23,Carryall	47	......	47	To the rock....	Sulphur water.
" "	Sec.14, "	5	......	5	Gravel, clay, and quicksand	Good water in abundance.
P. W. Hardesty	S. E. ¼ sec. 20, Paulding	18½	......	18½	In gravel and bowlders	Slightly sulphur.
" "	S. W. ¼ sec. 20, Paulding	24	......	24	Clay and gravel	Good water; formerly artesian.
Henry Barkus	Sec. 5, Latty ...	32	......	32	"	Good water rises within 9 ft. of top.
Deliv'rance Brown	Sec.26,Jackson	28	......	28	In bowlders....	Good water.
James Holtzbury ..	Sec.27, "	28	......	28	....	Good water; artesian
Adam Wymer	Sec. 12, Latty ..	30?	......	30?	....	Artesian.
J. H. Shirley	Royal Oak (Brown)	38	......	38	....	Bitter water.
" "	"	38	......	38	....	" "

Owner's name.	Location.	Feet above the rock.	Feet in the rock.	Total depth.	Through what.	Remarks.
A. Hoot	Royal Oak (Br.)	38	8	46	....	Bitter water at 38 ft.; sulphur water in the rock.
Wm. Black	Sec. 35, Brown	35	......	35	On the rock....	No water.
Mrs. Nancy Lutz....	Sec. 5, "	36	......	36	In gravel	Good water stands within 15 ft. of top.
Lewis Keefer	Sec. 8, "	40?	......	40?	....	Worthless bitter water.
Jacob Bennett	S. W. ¼ sec. 33, Auglaize	38	38	76	....	Sulphur water.

In Caryall township there is a strip of land a little higher than the river bank, running about a mile north of the Maumee, the surface of which is more gravelly or sandy, in which wells obtain water at about six or eight feet in compact gravel. They pass through fine, impervious clay, the bottom of which is more gravelly. The water is good. This strip is known and spoken of as a *ridge.*

At Paulding Mr. Jehiel Seger, a practical well-digger, gives the following as the general section of the Drift at that place:

General Section of the Drift at Paulding.

No.	1.	Soil and brown clay	10 ft.
"	2.	Blue clay	10 "
"	3.	Sand	12–18 in.
"	4.	Blue clay	10 ft.
"	5.	"Rock" (cemented gravel probably—N. H. W.)	18 in.
"	6.	Sand and gravel, with water.	

It is a current belief at Paulding that wells that go through the "hard-pan," or the layer of cemented gravel near the bottom of the Drift, are "through the rock." The rock at Paulding is about thirty feet below the surface. Mr. Emery's well there reached the Waterlime at twenty-six feet; at least drillings brought up were of that limestone.

MATERIAL RESOURCES.

Stone and Brick.—But very little has been done in Paulding county toward developing its natural resources; indeed, it is yet but very sparsely settled. The county will never be noted for its mineral products. The limestones that underlie the county are not known to contain anything of marked economical value. They are very little exposed, so far as now known, and the people in some parts of the county are greatly inconvenienced by the total lack of stone suitable for common foundations. It is to be presumed, however, that as the forest is cleared off, and the inspection of the county by settlers is carried to greater detail, many other outcrops of rock will be discovered. The limestones of the Devonian, in the northern part of the county, are those most abundantly quarried for building stone, if not for quicklime, in north-western Ohio; and the exposures in the Auglaize River are destined to become important in the future occupancy of the county, inasmuch as they are the only known outcrops of the blue limestone, west of the great anticlinal, that afford favorable opportunities for working. They are the same as the Sandusky blue limestone, and ought to have supplied the city of Defiance with the foundation stone for the court-house, instead of its being brought from that distant city. Had quarries been fairly and fully developed at any points in Paulding or in Defiance county, doubtless the expense of importing stone that could have been obtained at so convenient a place near home would not have been incurred.

In the survey of the county but two establishments for the manufacture of brick were met with. One is owned by Jasper N. Hughes, section 24, Caryall township, and the other by R. S. Murphy, Antwerp.

The Furnaces of Paulding County.—The heavy growth of timber in Paulding county has invited the establishment of furnaces for smelting the iron ores of Lake Superior. There are two such in full operation. One is known as the Antwerp Furnace, located at Antwerp, on the Maumee River, and the other as the Paulding Furnace, located at Cecil, section 23, Crane township. The ore is transported from Toledo by canal. The subjoined statistics, obtained of the proprietors in reference to these furnaces, will give the best exemplification of their size and products.

THE ANTWERP FURNACE, ANTWERP, OHIO.—Proprietors, Antwerp Furnace Company; President, A. Cobb; Superintendent, William Sayles.

Number of Furnaces—One; built by this company in 1865. Height of stack, 42 feet height of boshes, 7 feet; height of hearth, 6 feet; height of tuyeres, 40 inches; diameter at throat, 3 feet 6 inches; diameter in boshes, 8 feet 10 inches; diameter at tuyeres, 3 feet; diameter of hearth, 3 feet; diameter of tuyeres, $3\frac{1}{4}$ inches; number of tuyeres, 3; temperature of blast, not known; pressure of blast, not known.

Ores.—Kind and percentage, Lake Superior ores, 65 per cent. Location of mine, near Marquette, Michigan. Cost of ores, $10 at the furnace. Not roasted.

Fuel.—Kind and cost, charcoal, $7\frac{1}{2}$ cents per bushel. Obtained at the furnace. Fuel per ton of iron, 130 bushels. Ore per ton of iron, $1\frac{1}{2}$ (about).

Flux.—Kind and cost, limestone (Delhi beds of Corniferous), $8 per cord of 128 solid feet. Obtained from the river at Antwerp.

Charge.—Ore, 600 pounds; flux, 30 pounds; fuel, 20 bushels of charcoal. Charges in twenty-four hours, 70; production in twenty-four hours, 13 tons. Kind of iron: white, 1-12 of all is white; mottled, $\frac{1}{4}$ of all is mottled; gray, $\frac{2}{3}$ of all is gray.

Blast.—Kind of engine, upright; size of steam cylinder, 26 inches in diameter; size of blast cylinder, 40 inches in diameter, 26 feet long; stroke of piston per minute, about 30; pressure of steam, 40 to 50 pounds; blast ovens used, Pollock's.

Remarks.—Closed or open top: open, but will be closed. How waste gases are utilized: in heating blast and making steam. Kind of fire-brick used: Rochester, Pa. (Samuel Barnes, maker). Average length of campaign, eight months.

THE PAULDING FURNACE, CECIL, OHIO.—Proprietors, Evans, Rodgers & Co.; Superintendent, N. Evans, Cecil, Ohio.

Dimensions of the Furnace.—Height of stack, 40 feet; height of boshes, 8 feet; height of hearth, 6 feet; height of tuyeres, 32 inches; diameter of tuyeres, 3½ inches; diameter at throat, 38 inches; diameter at boshes, 9½ feet; diameter at tuyeres, about 40 inches; number of tuyeres, 3; diameter at nozzle of tuyeres, 3½ inches; temperature of blast, 900 degrees; pressure of blast, 1½ pounds per square inch.

Ores.—Kind, Lake Superior; per cent., 66; cost, $10. Location of mine, near Marquette, Michigan. Not roasted.

Fuel.—Charcoal; obtained at the furnace; cost, 7½ cents per bushel.

Flux.—Limestone, Upper Corniferous. Obtained section 17, Defiance, Defiance county. Cost, $1.50 per perch at the furnace.

Charge.—Ore, 500 pounds; coal, 22 bushels; limestone, 40 pounds. Amount in twenty-four hours, about 80 charges.

Product.—Amount in twenty-four hours, 11 tons. Kind of iron, all kinds. About five-sixths of all is gray iron.

Blast.—Kind of blast engine used, horizontal; size of steam cylinder, 18 inches; pressure of steam, about 60 pounds; blast oven used, old plan of cylinders and pipes, enlarged; piston-strokes per minute, 25.

Remarks.—Furnace built by the company in 1864–5. Length of time in blast, 7½ months. Average length of campaign, 8 months. Waste gases used in heating blast and generating steam. Kind of fire-brick used, Chenango. Cost, including freight, $80 per thousand. Annual production: 1869, 2,788 tons; 1870, 2,494 tons; 1871, 2,725 tons. Price of iron: in 1869, about $44; in 1870, about $38; in 1871, $40. Markets, Cleveland and Fort Wayne. Amount of fuel per ton of iron, 140 bushels. Close or open top, open.

CHAPTER XLI.

REPORT ON THE GEOLOGY OF HARDIN COUNTY.

BY N. H. WINCHELL.

SITUATION AND AREA.

Hardin county, like Marion, is situated on the watershed between Lake Erie and the Ohio River. It lies directly west from Marion, bounded south by Union and Logan, west by Auglaize and Allen, and north by Hancock. It has an area of a little more than twelve towns.

NATURAL DRAINAGE.

In this county are some of the sources both of the Sandusky and the Maumee, which flow northward to Lake Erie, and of the Scioto and Great Miami, which empty into the Ohio. The Scioto, the chief river of the county, first flows north, entering the Scioto Marsh, where its channel is said to become lost in lateral expansion as in a lake. It leaves this marsh in an easterly direction, and, receiving tributaries only from the south, it may be said to drain only the southern half of the county. In a similar manner streams flow northward into Hog Creek Marsh, in the northern part of the county, and are thence turned westerly along the channel of Hog Creek, which drains that marsh, and finally reach the Maumee River. The Blanchard, which rises within a mile of the Scioto at Kenton, also has a general northerly course. In the township of Goshen there are several small streams, which find their way into the Tymochtee Creek, in a north-easterly direction. The North Branch of the Great Miami drains southward a small, narrow valley in the south-western corner of the county. With this exception the general slope of the whole county is toward the north. Two natural divides, or ridges, cross the county. The most southerly is that which prevents the northward drainage of the Scioto Marsh, deflecting the Scioto River easterly across the county, instead of permitting it to follow the natural slope. Were it not for this ridge it would probably contribute its waters to the valley of the Blanchard, or through the Hog

Creek Marsh into the Hog Creek valley. The second divide in the same way prevents the northward drainage of the Hog Creek Marsh. Streams rise immediately on the northern slope of this ridge in Hancock county, and pursue their course uninterruptedly to the Blanchard, in a due northern direction. The northern line of the county runs about on the summit of this ridge. It is a low, gentle swell in the surface, hardly observable in passing over the country. The more southerly divide may be more properly termed a ridge. By reference to another chapter it will be seen that these divides have been traced westward through Allen and Mercer counties, and that they are regarded as glacial moraines.

SURFACE FEATURES.

The surface features of Hardin county are dependent on the condition in which the original Drift was left by the glacier. The southern part of the county, especially in the townships of Buck, Roundhead, and Taylor Creek, is occupied with a rolling surface. The northern portions of McDonald and Lynn townships are flat, with a clay soil. The southeastern part of the county may be denominated flat, or gently undulating. Along the north side of the Scioto and the Scioto Marsh, crossing the entire county, there is a tract of more elevated land, sometimes broken by long undulations, and not infrequently rolling or hilly. This strip has a width of from one to three miles. North of it the surface becomes nearly or quite flat, with only isolated and unimportant exceptions. Three extensive marshes are embraced within Hardin county. Their aggregate area is about forty thousand acres. Some efforts have been made to render them cultivable by artificial drainage, and with a good degree of success. Formerly water covered them the greater part of the year, but now in summer-time a team can be driven across them in various directions with entire safety. It is evident that the valley of the Scioto is the proper, if not the only, channel through which to drain the Scioto Marsh. By lowering its outlet, and constructing a system of tributary ditches, the whole area could could be given a dry and arable soil. Another low valley spreads northward in Cessna township, which might be utilized for the same purpose; yet its outlet is so near the outlet by way of the Scioto that not much would be gained. There are some indications that formerly a portion of the surplus water of the marsh found escape through this valley into Hog Creek Marsh. The Cranberry Marsh is drained westward into the Blanchard. The Hog Creek Marsh is drained northward into Eagle Creek, and westward by deepening Hog Creek channel, its natural outlet.

The frequent occurrence of such marshes on the broad watershed between the Ohio River and Lake Erie, or near the sources of the streams which flow in opposite directions from its summit, is a feature in the general physiography of north-western Ohio which deserves special mention. There seems no doubt that they were once shallow lakes. The occurrence of shell-marl below the peaty surface, and of sandy deposits about their margins, indicates not only that there was a time when they were receiving the annual freshet washings of calcareous matter from the adjacent Drift surface, but were also agitated by the wind into little waves which broke upon a sandy beach. Other similar undrained places in the old Drift surface, situated further down the slopes of the great watershed, were sooner filled by the greater accumulation of alluvium, or were drained by the more rapid excavation of their outlets by the increased volumes of the streams. There is reason to believe that the extensive prairies of Marion and Wyandot counties are analogous to the marshes of Hardin county, but were sooner brought into an arable state through the action of the Sandusky and the Tymochtee Creek.

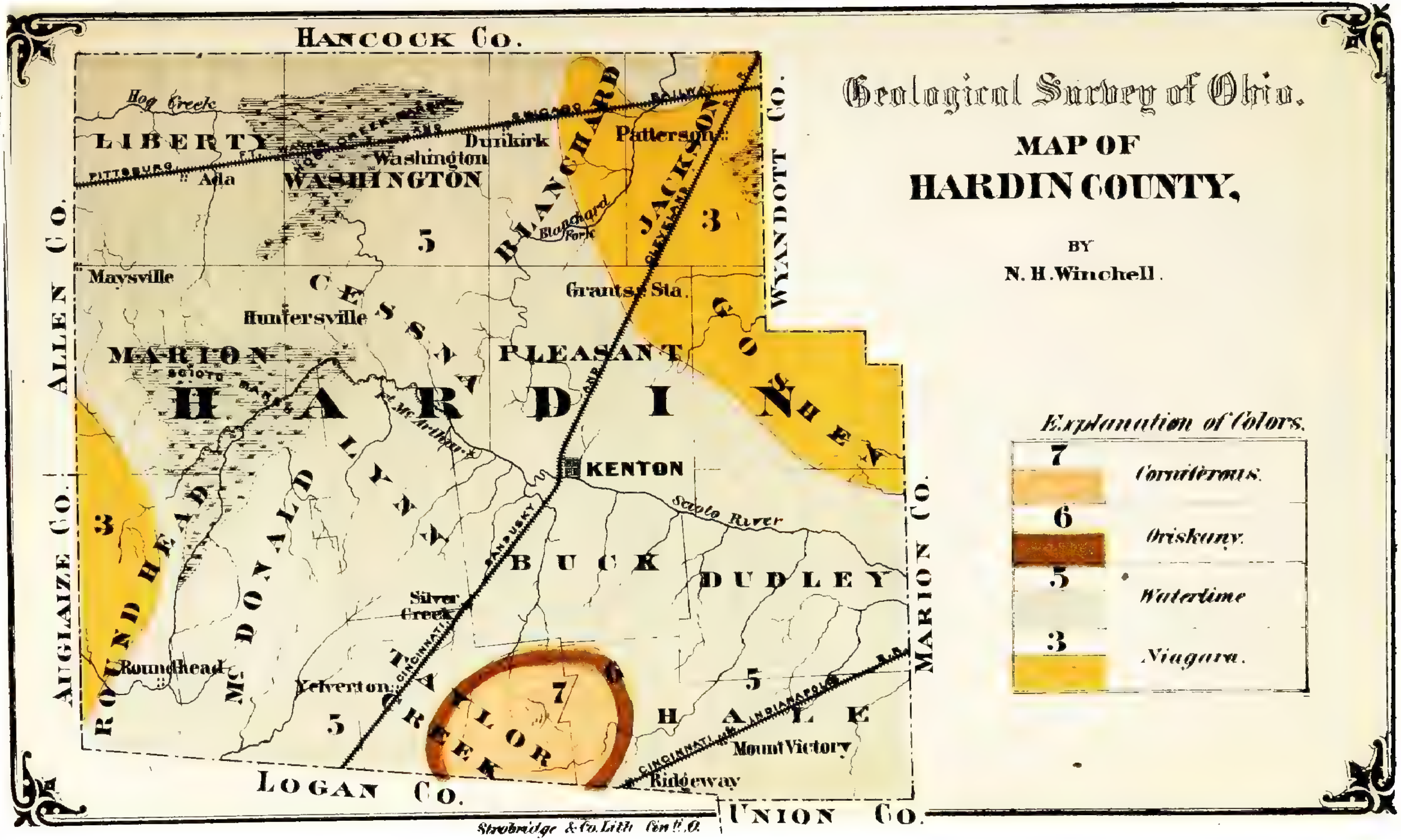
GEOLOGICAL STRUCTURE.

The old Drift surface has been so little disturbed that the underlying rock is very rarely exposed. Hence the details of the geological structure are unknown. The boundaries of the formations are drawn in accordance with such outcrops as actually occur, but governed, in the absence of positive knowledge, by the indications of the surface features.

The Niagara limestone is known to underlie portions of Blanchard, Jackson, Pleasant, and Goshen townships, and is also believed to occur in Roundhead township, west of the Scioto River. Thus Hardin county not only occupies the watershed between Lake Erie and the Ohio River, but also holds the separating ground between that belt of Niagara area which stretches northward to Lake Erie, and that larger area of the same great formation which extends south to the Ohio River and west into Indiana. What influence this formation may have exerted in locating the divide between the two great valleys can only be conjectured. Considering, however, its thickness—stated by Prof. Orton to be two hundred and seventy-five feet—and its great persistency in withstanding the forces of degradation, it certainly could not have been small.

In Goshen township it is exposed in the bed of Paw Paw Creek, S. E. ¼ section 36, where it has been a little worked for quicklime, on the land of Mr. Stephen Otis; also, on section 5, north, land of Hezekiah Hemp, worked for quicklime.

In Jackson township it has been slightly opened near the Cranberry Marsh, on the land of J. P. Pence, N. E. ¼ seetion 30.


Geological Survey of Ohio.
MAP OF
HARDIN COUNTY,
BY
N. H. Winchell.
Explanation of Colors.
7 Corniferous.
6 Oriskany.
5 Waterlime
3 Niagara.
HANCOCK CO.
ALLEN CO.
AUGLAIZE CO.
LOGAN CO.
UNION CO.
MARION CO.
WYANDOTT CO.
HARDIN
LIBERTY
WASHINGTON
BLANCHARD
JACKSON
GONEY
PLEASANT
CESSNA
MARION
LYNN
McDONALD
ROUNDHEAD
TAYLOR CREEK
BUCK
DUDLEY
HALE
Hog Creek
Ada
Dunkirk
Washington
Patterson
Blanchard Fork
Maysville
Huntersville
Grants Sta.
KENTON
Scioto River
Silver Creek
Roundhead
Yelverton
Mount Victory
Ridgeway
Ft. McArthur
Scioto Marsh
Pittsburg
Chicago Railway
Cleveland
Sandusky
Cincinnati
Indianapolis
3
5
7
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Near Patterson it is seen in the following section on the land of Dr. A. F. Stanley:

No. 1. Dark drab, slightly porous, with spots of blue and purple; no fossils visible; beds three to four inches; exposed.............. 8 in.
" 2. Surface exposure of somewhat vesicular, even-bedded, and crystalline Niagara, of a buff color.

The stone is used here for rough walls and for lime.

Section 11. In the Blanchard, and in a little ravine running east through the section; land of Thomas Huston and of Jeremiah Higgins; rapid dip N. E.

About half a mile west of Forest, almost within the limits of the corporation, the Niagara is exposed along a little ravine on the land of John Campbell.

The Niagara is also said to appear on the land of Mr. B. Jackson, S. W. ¼ section 24, and of Mr. S. A. Bower, S. W. ¼ section 14, in the same township.

The *Waterlime* underlies the greater portion of Hardin county. Wherever it appears it is in thin beds, which are sometimes blue, and at others drab, always separated by conspicuous bituminous films. It furnishes a building stone of ordinary quality by making selection of the thickest beds, and is considerably burned into quicklime.

Two and a half miles south-east of Kenton Mr. Erhardt Blum met the Waterlime in sinking a well at the depth of twelve feet. In the same vicinity a number of other wells terminated in the same way, without a supply of water.

About two miles south-west of Kenton the Waterlime is in outcrop near the railroad, on the land of Mr. Alonzo Teeter. It is a fine-grained, blue-drab stone, in beds of three to four inches, lying nearly horizontal.

Two and a half miles east of Kenton, on the land of Mr. Nicholson Rarey, the Waterlime appears in the Scioto in beds of two to four inches. It has been somewhat used for lime. There are surface indications of the near approach of the Waterlime to the surface on the land of Dr. William Chessney, two miles east of Kenton, along a stream known as Allen's Run.

On the land of Mr. T. W. Bridge, in Buck township, five miles south of Kenton, the Waterlime appears in thin, slaty beds, and has been burned into lime.

At Dunkirk there are several quarries in the Waterlime. Mr. Hugh Miller's is situated a quarter of a mile east of the village; Mr. Charles N. Hill's is a mile south. At the former it lies in blue-drab, slaty beds, which are torn up by picks and crow-bars, and used for road-making;

exposed eight feet; dip east and west. In the latter the stone is of the same quality, but is less exposed. The quarry of the Pittsburgh, Fort Wayne and Chicago Railroad Company, near the village, shows about six feet of the same or similar beds.

North of Ada the Waterlime, in thin beds, is exposed along Hog Creek. It was also encountered in ditching for the outlet of the marsh. It is here made into quicklime by Samuel Coon. Near the county line quarries in Hog Creek are owned by Isham Kendall and John Trussell. The former burns quicklime.

In Pleasant township the Waterlime may be seen in the Blanchard, at the "Camp Ground," and in its tributaries in sections 6 and 7; also on the land of John Osborn and of Jacob Kirtz, S. W. ¼ section 6.

In Blanchard township, section 31, Michael Zigler, John Sargon, and Mrs. Hedrick have small openings in the same stone.

Mr. Roland Park has a quarry in the thin blue beds of the Waterlime on the S. E. ¼ section 12, in Jackson township. Mr. Park's quarry is believed to be in some of the lowest layers of the formation. The Niagara probably occupies the base of his section as exposed, but could not be certainly ascertained.

The Lower Corniferous.—In the southern portion of the county, including portions of Taylor Creek and Hale townships, the area colored on the county map to represent the Corniferous limestone is so marked on the evidence of surface characters. These characters consist in a more rolling and gravelly surface, with occasional northern bowlders, and seem to extend northward from Logan county, where this formation has introduced, as in Sandusky and Seneca counties, already noted, a marked change in the general topography.

The Drift.—The mass of the Drift in Hardin county is an unstratified glacial deposit. It is divided into the two usual colors: the *brown*, which forms the soil where it has not been covered with alluvial or paludine accumulations, and has a thickness of ten or twelve feet; and the *blue*, which has an unknown thickness, but in some cases is known to exceed fifty feet. South of the "dividing ridge," which divides the county into nearly equal parts, the Drift contains much more assorted gravel and sand than it does north of the same ridge. Knolls and ridges, known as "hog's-backs" and "devil's-backs," are met with in Taylor Creek and Buck townships. The township of Roundhead and the southern part of McDonald afford abundance of gravel, which may be taken from many of the numerous knolls with which the country is diversified. The immediate surface of these knolls, as well as of the whole county, consists of the brown hard-pan, the stratified parts rarely rising to the top of the deposit. Yet the stratified parts of the Drift are nearer the surface south of the Scioto than they are on the north of that river. Wells at Kenton, on the south side of the river, pass through sixteen to twenty-four feet of hard-pan clay, finding water in gravel and sand. At the same place, on the north side of the Scioto, they are dug from thirty-five to sixty feet, entirely in hard-pan, sometimes without finding a supply of water.

Near Fort McArthur the remains of a mastodon have been obtained from the surface of the Drift. They were considerably scattered from the place of original deposit, and but part of the skeleton could be obtained.

MATERIAL RESOURCES.

Hardin county is poorly supplied with building stone, even for the rougher kinds of walls and foundations. Considerable stone, of the best quality, is brought from the Lower Corniferous quarries at Marblehead, near Sandusky, and from those at Bellefontaine. Considerable is also brought into the northern portion of the county from the blue Waterlime quarries at Lima. The Waterlime quarries at Belle Center, in Logan county, supply the Kenton market with quicklime, as well as furnishing stone for a great many foundations. In the northern part of Marion township bowlders have been gathered from the surface, and from channels worn in the Drift by streams, and used for foundations and walls. There are favorable opportunities for the development of the Niagara in the vicinity of Forest, and in the valley of the Blanchard, in Jackson township, which certainly cannot remain long unimproved. The Niagara limestone, owing to the thinness of the beds of the Waterlime, will prove the more valuable formation, both for building stone and for quicklime. It can also be more cheaply burned than the Waterlime. The latter, however, excels for flagging.

Clay, sand, and gravel from the Drift deposits, in the absence of convenient stone, have been more frequently resorted to for building material than in neighboring counties. Establishments for the manufacture of brick are common throughout the county. A number of farmers sometimes combine for the purchase of the machinery necessary to manufacture enough for themselves, and for sale, to make up for all outlays. Brick are made at Kenton by Henry Loeffert, Henry Kreihnbeihul, William Richards, and by Conrad Kahler. Tiling is made at the same place by Dean and Rarey and by Thomas Clemens and Son. The latter firm also burn considerable red pottery.

A commendable spirit of enterprise prevails in Hardin county in the construction of gravel roads. A series of such are being built across the county, chiefly radiating from Kenton, the county seat.

New Roundhead village is a deposit of bog ore, which is disturbed by the plow in the cultivation of the field; land of Thompson Irving.

CHAPTER XLII.

REPORT ON THE GEOLOGY OF HANCOCK COUNTY.

BY N. H. WINCHELL.

SITUATION AND AREA.

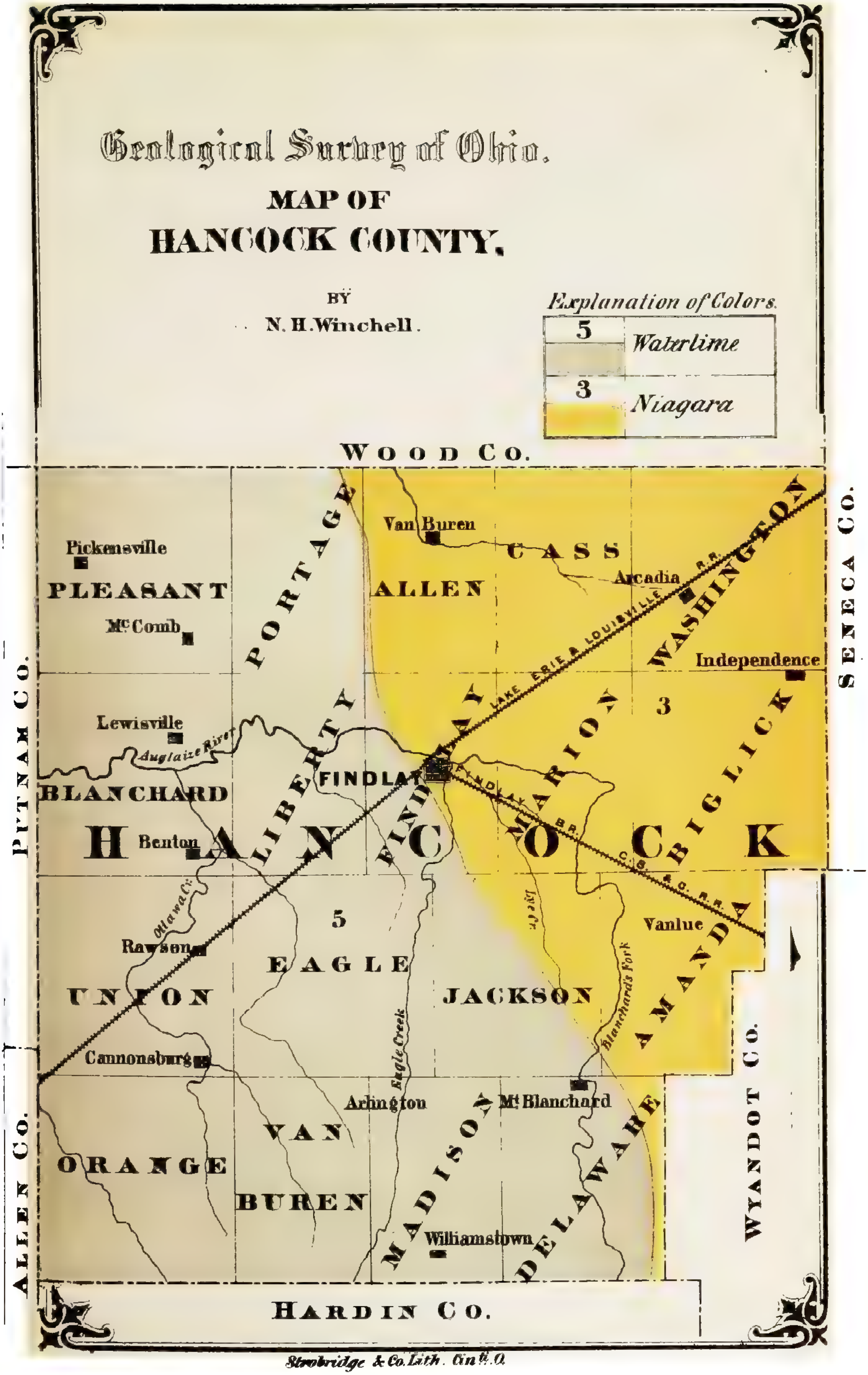
Hancock county is situated within the Lake Erie valley. Its county seat, Findlay, is forty-two miles almost due south from Toledo. It is bounded north by Wood county, east by Seneca and Wyandot, south by Hardin, and west by Allen and Putnam. It contains nearly fifteen towns.

NATURAL DRAINAGE.

The Blanchard is the principal stream of the county. Entering it from the south, after flowing fifteen miles in a northward direction it turns at a right angle westward, and continues in that direction till it passes into Putnam county, receiving tributaries only from the south. Among these may be named Lye Creek, Eagle Creek, and Ottawa Creek. In the northern part of the county different branches of the Portage also take rise, flowing first toward the west and then toward the north. These are all small streams, although the Blanchard, which is subject to sudden and sometimes devastating increase of waters, was declared by the early surveys navigable as far as Fort Findlay.

SURFACE FEATURES.

The country in general may be denominated flat. This is particularly the fact in the townships of Delaware, Madison, Eagle (except the southern portion), Jackson, Amanda, Big Lick, and Marion. These townships also contain vast tracts of the ancient forest. They are poorly drained, both naturally and artificially, and in many extensive areas the surface is under water for several months in spring and early summer. While the remainder of the county is diversified with a little undulation of surface, it also contains some very flat tracts. Rarely, however, are these flat tracts, even in the townships specified, covered with a black or peaty



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soil. On the contrary, it is a tough clay, with very little or no gravel, and almost no noticeable bowlders. The latter may be seen only along the eroded channels of the streams, as at Mt. Blanchard and at Findlay, or on the ridges which cross the county, as on the Van Wert ridge, west of Findlay. In general, that portion of the county north of the Blanchard is more undulating than that south. Between the Leipsic and Belmore ridges is a low and often marshy belt, known as a *swale*, while north of the latter ridge the country is altogether low, and often wet with standing water for a number of miles. The ridges which cross the county are simply strips of rolling, gravelly land, somewhat elevated above the adjacent flat on either side, in which stratified gravel and sand may often be found within a few feet of the surface. They are separately described in a former chapter.

The streams of the county are accompanied, as in other counties in north-western Ohio, with a sandy flood-plain rising from three to ten feet above the summer stage of the water, and sometimes coinciding with the general level of the country, as in some parts of Jackson and Marion townships; and with a higher terrace, consisting of the exposed section of the Drift as left by the action of the river, and inclosing the river valley. The latter is sometimes thirty or forty rods from the bed of the stream, its height depending on the contour of the original Drift surface and the depth to which the river may have worn its channel.

The soil of the county is clay, with very little intermixture of gravel, except on the ridges, where it is not infrequently gravelly, or even stony. Between McComb and Lewisville there are one or two strips of black and peaty soil.

GEOLOGICAL STRUCTURE.

The rocks which underlie the county belong to the Niagara and the Waterlime, the former underlying the latter. The Niagara is found in the eastern part of the county, and the Waterlime in the western, the dip of both being toward the west. The line which separates them crosses Delaware township in a northerly direction, east of the Blanchard; enters Jackson township in section 26, and leaves it in section 5; runs one-half mile west of Findlay, whence it follows a course nearly due north out of the county.

The *Niagara* has its principal exposures in the Blanchard, at Findlay, and in the township of Marion. It is frequently seen in the bed of Lye Creek, and also in Eagle Creek, near Findlay. The quarry of Messrs. Pressnel and Shirden, at Findlay, which has been in operation nearly eighteen years, still furnishes a great deal of stone, both for foundations, for flagging, and for lime. It lies in courses of three to six inches, is of a dark drab color, with darker mottlings of blue and purple, and slightly porous. It weathers a buff. The surfaces are very often roughened by small angular prominences which fit into corresponding depressions in the superimposed layer, forming the peculiar structure known as *suture-jointed.* The beds here lie nearly horizontal, although at other places near they show a slight dip both south, south-east, and south-west. Descending the creek from Pressnell and Shirden's quarry, the same characters are seen in the rock, which shows constant surface exposure to its junction with the Blanchard. Two or three short anticlinals occur in the bedding within that interval, and the beds are often glacier-scratched in a direction south 40° west. The bed of the creek lies on the surface of the rock, without having made any sensible excavation. Further up the creek are the quarries of Mr. Chris. Neucer, on land of Dr. B. Rawson, which also supplies stone for all the uses to which the Niagara is adapted, and of Mr. E. P. Philips, the latter on the N. W. ¼, S. E. ¼ section 30, of Findlay township, and embracing also a few beds of the overlying Waterlime.

S. E. ¼ section 18, Findlay township. In the bed of Lye Creek the Niagara appears in thick beds, and has been burned for quicklime by Mr. Isaac Harshy. Along this creek the Niagara may be seen on section 10, Jackson township, where it is in porous beds of three inches, rusty and shattered from exposure; and on S. E. ¼ section 38, Marion township, where the bedding is the same, showing some blue and gray on fracture, and frequently to the junction of the creek with the Blanchard. It also was observed on S. W. ¼ section 27, Marion township, on land of Samuel Essex, in the bottom of a ditch, and in the S. W. ¼ section 33, in a ditch by the side of the road.

In the Blanchard it is quarried in sections 12 and 1, Amanda township, where it is gray and vesicular. After it has been weathered a short time it acquires a greenish tinge, and also becomes firmer. A species of *Illænus* was met with here. On section 21, Marion township, it lies in massive gray beds. Mr. Allen Wiseley has opened it in the Blanchard on N. W. ¼ section 23, and it is abundantly exposed on section 16, both of the same township. Near Findlay it is quarried by Mr. Squire Carlin and by Mr. William Pilcher. Under the highway over the Blanchard at Findlay it has a characteristic surface exposure, where the current of the river has washed away the left bank so as to uncover a beautiful exhibition of glacial marks.

In the township of Cass the Niagara is wrought for lime and for foundations by Mr. John Frank, on the S. W. ¼ section 4. Beds have here a thickness of three to six inches; loose and vesicular.

In Allen township, N. E. ¼ section 8, on land of Mr. Joshua Workman, the Niagara furnishes heavy stone for bridge abutments, some of the beds being a foot or more in thickness, yet somewhat vesicular.

The exposures of the *Waterlime* are very frequent in Hancock county. Not only is it frequently bare in the bed of the Blanchard, where it flows over that formation, but the small creeks which enter that stream from the south are very often running immediately on the rock. It also causes occasional mounds or ridges above the general level. These rise and fall again to the surrounding level with a gentle inclination, and are, no doubt, dependent on the undulations of the strata. They are only found in the southern part of the county, at least only south of the Van Wert Ridge.

In Delaware township the following exposures were noted:

N. W. ¼ section 2. In the bed of the Blanchard Mr. Solomon Shafer takes out thin blue flags. Some beds are only a quarter of an inch. It has every feature of the *Tymochtee slate* of Wyandot county.

N. W. ¼ section 35. Mr. Solomon Ripley has a slight opening in thin-bedded, fine-grained drab stone.

N. ½ of section 1. Mr. Henry Greer has a quarry, or a slight excavation, in thicker drab beds. Further south, along Potato Creek, more irregular, fine-grained, but blue and compact, layers may be seen. Mr. Greer's quarry is situated on the line of geographical limits of the formation, and affords a very slight exposure of the Niagara.

Mr. John A. Rose has a quarry in the *Tymochtee slate*, in the southern part of section 14, as follows, from above:

No. 1.	Fissile, slaty beds, about one-half inch thick; dark drab, with bituminous partings		6 in.
" 2.	Bluish-drab or ashen; fine-grained and compact; beds three to four inches. The interior is a bright blue, which on weathering, even in the quarry, becomes ashen	1 ft.	6 "

Mr. Josiah Fail has a quarry in similar beds on section 11.

N. W. ¼ section 23. At the junction of a little creek with the Blanchard the beds appear one to two inches thick, and very perceptibly tinged with blue. Thicker beds are slightly vesicular and of a drab color.

N. W. ¼ section 4. A limestone ridge which covers portions of four contiguous sections, cornering near the quarry, is wrought by Abdiel Gobrecht, mainly for lime-burning. This ridge is a little over a mile in length north and south, about half a mile in width east and west, and rises perhaps thirty feet. The beds, where uncovered, which is on the summit of the ridge, are from a half inch to four inches in thickness, of the usual drab color and fine grain. The quarry exposes six feet of horizontal bedding.

The following outcrops of the Waterlime were noted in Madison township:

S. ½ section 30. Worked for lime and for stone, on land of Ulrich Thomas and of Jacob Bower. It also appears on land of John Wilson, half a mile south, on section 31.

S. E. ¼ section 24. On Abram Roderbauch's farm.

N. E. ¼ section 23. On Michael Simms's land.

Section 11. Slightly quarried in the creek, on the land of Nicholas Price.

N. E. ¼ section 11. At the highway bridge, and at other places near, where a little stone has been taken out for common foundations.

In Jackson township, about the center of section 8, Mr. William Bishop burns quicklime from Waterlime beds of about two inches. The bedding here, as at Mr. Gobrecht's quarry, shows some disturbance, which has displaced the layers.

In Findlay township the Waterlime was seen at the following exposures:

S. W. ¼ section 30. Here are the adjoining quarries of S. R. McCahan and George Woodley. They are located near the southern end of a ridge of Waterlime which is nearly three miles in length, running north and south, and reaching into section 14. The following descending section was taken at this place, dip west and south-west:

No. 1.	Thin-bedded, drab; used only for macadamizing roads...	5 ft.	
" 2.	Drab flags, in even beds two inches thick..................		4 in.
" 3.	Coarse-grained; porous, and in some places carious; rough; dark drab or brown	1 "	3 "
" 4.	Hard, thin, irregular or lenticular beds, sometimes appearing massive, with cavities; exposed....................	2 "	
	Total exposed....................................	8 "	7 "

No. 3 of this section has every appearance of being the equivalent of No. 1 of the section at Anderson's quarry, on section 22, Pitt township, Wyandot county, and of No. 10 of the section near Cary's quarry, sections 27 and 34, Crawford, in the same county.

Near Findlay, on section 24, Mr. Elijah Barnes has opened a quarry in the same ridge, and exposed about six feet of beds undistinguishable from those of No. 1 of the foregoing section. The beds are here shattered, and part in quarrying into angular pieces of a few inches across; dip, ten degrees west south-west. About twenty degrees south-west of Mr. Barnes's quarry Mr. A. P. Byall has made an opening in similar beds, which must lie twenty feet at least above, and have the same degree and direction of dip.

S. W. ¼ section 33. Mr. Jacob Feller burns lime from an exposure along a little ravine; beds, four to six inches; dip, east.

The Waterlime is also exposed in Eagle township as follows:

N. E. ¼ section 35. In Eagle Creek, land of J. C. Bickett; used for walls and foundations.

N. W. ¼ section 24. In Eagle creek, land of J. D. Bishop.

N. W. ¼ section 28. Land of J. L. and Joseph D. Keller.

S. W. ¼ section 33. On George Rheinhardt's farm.

S. W. ¼ section 24. In Eagle Creek, land of Coonrod Line.

Five miles from Findlay, along the Lima road, may be seen one of the peculiar undulations in the surface caused directly by the underlying rock, so common in the southern half of the county. They would often not be noticed were the surface not otherwise monotonously flat. This rises perhaps twenty feet, and is a half mile over. The approach of the Waterlime is only revealed by a few weathered fragments that may be seen in traveling over the ridge, the country in either direction being stoneless.

In Liberty township the only known outcrops are in the bed of the Blanchard. One is on S.E. ¼ section 8, at Croninger's Mill, where that stone is in thick beds of twelve to fifteen inches, and answers very well for abutments for bridges. It is very rough and irregular, with a mixture of loose and close-grained patches, the latter predominating. It is the equivalent of No. 4 of the section at McCahan and Woodley's, in Findlay township. The same bed, owing to irregularities of dip, is seen on Mr. C. Byall's land, in the Blanchard, S. E. ¼ section 10, where it is also quarried.

In Blanchard township the Waterlime was seen in the S. E. ¼ section 14, in the bed of the Blanchard River, where it lies in even, fine-grained, blue layers of about four inches; useful for a building material. The opportunities for obtaining the stone are so unfavorable that but little working has been done. It is also said to occur in the same stream at other points further west, particularly on section 19, near the county line.

In Ottawa Creek it appears S. W. ¼ section 36, on land of S. Fogelsong.

In Union township, south of the Van Wert Ridge, the bed of the Ottawa Creek very often discloses the Waterlime. At most of these places the formation is wrought for stone for foundations; and, occasionally, small quantities of lime are made for the convenience of the neighborhood about. The following points may be mentioned: S. W. ¼ section 25, by Mr. Amos Yeagley; center of section 36, by Mr. William Hannah;

section 26, on land of William C. Needle and of Daniel Cornwall; N. E. ¼ section 36, on Abram Spangler's land; S. E. ¼ section 25, on Peter Helpman's land; S. W. ¼ section 25, on George Rheter's land; section 2, quarry of Philip Powell; S. W. ¼ section 1, quarry of D. Powell; N. E. ¼ section 11, land of James Teatsworth, Sen.

In Orange township there are quarries in the Waterlime N. E. ¼ section 20, by Mr. A. H. Thompson, and N. W. ¼ section 7, in the bed of Reilly Creek, by William H. Ewing.

In the township of Portage, section 15, are the quarries of Mr. Jacob Kempfer and of Mr. Samuel Kalb. These are located along the north slope of the Leipsic Ridge, and probably owe their existence to the denuding action of the waves of Lake Erie, of the former presence of which in the northern portion of the county there are some indications, as already remarked in the chapter on *the Drift in North-western Ohio.* These quarries supply a wide range of country with quicklime and stone for foundations and bridge abutments. The beds are thin and often bituminous, with frequent films, their average thickness being between two and three inches; exposure six to ten feet; dip west.

The Drift consists of brown and blue hard-pan, the former furnishing the soil, except where it is covered with later alluvial or paludine accumulations, and extending downward from ten to twelve feet. The thickness of this deposit cannot be certainly stated. It is noticeably thinner in the southern part of the county than in the northern. South of the Van Wert Ridge its thickness would probably not exceed twenty-five feet. It lies very evenly, shows no denudation except such as may be due to the present streams, and in some cases does not conceal the irregularities in the rocky surface below. Such irregularities, when figured in the form of ridges disclosing the rock, immediately recall the "limestone ridges" of the "Lacustrine region," so common in counties further north. The similarity of the two extends no further than the name. In external aspects the Drift phenomena here are the same as already described in connection with the ridges near Carey, in Wyandot county, excepting the feebler scale on which they are here exhibited. The ridges are much smaller, and the ascents are more gradual. The rock is rarely seen laid bare by the washing off of the Drift deposits. Quarries in these ridges are almost invariably located along some small ravine which has been excavated by the wash of the hill-side, and are usually near the base of the ridge or on the slope, the whole being evenly covered with Drift. No sand banks are accumulated on these ridges, however high they rise, and no bowlders are scattered in bands about their bases, or bestrew their surfaces. They are not noticeably more frequent than in any rolling country where the finer materials of the Drift have been partially washed out by the rains. North of the Van Wert Ridge—at least north of the Blanchard River—the Drift deposits reach a greater thickness. At McComb, a point on the Leipsic Ridge, wells are said not to reach the rock at a depth of eighty feet. At Arcadia, also in the northern part of the county, water is obtained, without reaching the rock, at forty-seven feet. On the other hand, the average thickness of the Drift south of the Blanchard, judging from the height of the river banks, and the very frequent exposure of the rock in the streams, cannot exceed thirty feet. This moraine-like thickening of the Drift must have been the cause of the westward drainage of the southern portion of the county through the valley of the Blanchard, instead of northward through the valley of the Portage.

MATERIAL RESOURCES.

The underlying formations are not known to possess any minerals of special economical value. The only uses to which they can be put is the manufacture of lime, and stone-quarrying for building purposes and for paving. For both of these purposes they are admirably adapted, and some of their outcrops afford unusual facilities for acquiring the stone in the necessary form and abundance. The lack of railroads has a discouraging effect on these enterprises, and at the present time but little more is effected than the supply of the home markets.

The Drift affords every where in the county abundant materials for the brick-maker and the potter. The lack of sufficient sand for mixing with the surface of the hard-pan clay in the manufacture of brick is the principal difficulty in that branch of industry; yet the brick made are some of them of superior quality. Tile-making is also extensively carried on at Findlay, and at other points in the county. The following establishments of this kind may be enumerated:

Martin Hirsher, Findlay	Tiling and pottery.
Louis Bruner, "	Brick.
Gates O'Hara, "	"
John Karst, half mile west of Findlay	Tiling.
Robert Dorney, Arlington	Brick.
William McKinley, S. W. ¼ section 1, Orange township	"
Elias Wilson, section 4, Delaware township	"
Frank Brown, section 36, Pleasant "	Brick and tiling.
Davis Pendleton, " " "	Brick.
Andrew Powell, N. E. ¼ section 34, Liberty township	"
Matthias Markley, section 28, Union township	"
James Kelly, section 1, Washington "	"

Mr. Hirsher, at Findlay, not only manufactures the common red pottery from clay found in the Drift at that place, but he makes also a superior pottery from fire-clay imported from Portage and Summit counties. The average product of his establishment is sixteen to eighteen hundred gallons per week the year round. The clay in its natural condition is subjected to a pug-mill process with a little water, molded by hand, and burned with a regular heat for about two days. A glazing is produced by pouring over the articles before placing them in the kiln a fine clay reduced by water to the consistency of cream, and passing through the kiln, while burning, the fumes of common salt. The glazing consists of a *silicate of sodium*, formed by the chemical union of the soda fumes from the salt with the silicic acid of the clay, which can only be effected at a red heat.

A single deposit of bog ore was noted in Hancock county. It occurs on the land of Mr. Charles Van Horn, Jr., N. W. ¼ section 7, in the township of Amanda. It has been cut by a ditch ten inches below a peat of about ten inches. It covers ten acres, more or less. An impure bog ore, or an iron ochre, may be often met with along the north slope of the ridges which cross the northern portion of the county, and in some places a bog ore of average quality could probably be taken out. These ochres could be made useful in the manufacture of an umber-colored mineral paint.

Wells and Springs.—Wells on the gravel ridges reach water from eight to twenty feet below the surface. In the Drift immediately adjoining the ridges they pass through hard-pan a depth of forty to eighty feet before obtaining water. Sometimes a shallow artesian well is met with along the north slope of the ridges, depending for a supply on the reservoir of water in the gravel of the ridge, and confined by the overlapping of the hard pan upon the gravel of the ridge. When the well descends to the rock the water is apt to show mineral impurities, as at Findlay, where nearly every well is affected with a sulphurous taste. Many of these, however, are drilled from ten to fifty feet into the Niagara limestone underlying. At the same place an inflammable gas which escapes from such wells is utilized for purposes of illumination. The residence of Dr. Jacob Carr is thus lighted.

The following extract from a letter from Dr. Carr, dated February 4, 1872, covers the various points of interest connected with his well:

" * * * * I have lighted my house during the last nine or ten years from an adjoining well, which at first was dug to the rock, seven feet from the surface of the ground, for the purpose of procuring water for house use. The gas comes through crevices in the rock, and spoils the water for kitchen use. Three such wells are on my lot, which is fifty by two hundred feet. I have never been able to go down to the rock without encountering this gas, and have filled up a number of wells. The distance to the rock two hundred feet south is fourteen feet; one hundred feet north, twelve feet; thence to the river, one-fourth mile north, the average depth to the rock is fourteen feet, but it is very undulating. South one-half mile limestone crops out through the surface, rising about twenty feet above the level of my lot. In 1865 a company leased the privilege of drilling on my lot. They drilled one hundred and thirty-five feet in limestone, when the augur got fast, and they gave up the enterprise. I now use gas from that well, the supply being more abundant than from those where no drilling was done. In drilling this well, at a depth of seventy-one feet from the surface of the rock the drill dropped six inches through a vein of water that kept the hole clear from drillings for three days after, so that the sand-pump could not be sunk down without weights, and it brought up no chippings and sand during the three days after this vein of water was struck, the well being one hundred and thirty-five feet from the surface of the rock.

"Gas has been struck in small quantities in various parts of the town, but unless they strike crevices there is not a sufficient supply to light a dwelling-house.

"The surface of the rock in other parts than where I live is more solid. On my lot it seems to be turned up edgewise, its surface being covered with a mixture of pebbles, sand, bowlders, and blue clay. Whenever you dig through this mixture gas is invariably found. There seems to be a prominence in the rock, and a cracking and breaking up of the mass, so that the gas is concentrated on my lot in much greater quantities than in any other part of the town as yet developed. One hundred and twenty-five feet east of my well another was dug eleven feet deep, from which, in extreme dry weather only, gas issues: in wet weather it is entirely cut off. The wells on my lot are the only ones not intermittent in their action. In digging the sewers through the main street, they being an average of eight feet from the surface, a vein of sulphureted hydrogen gas was developed which has an extremely offensive smell, like rotten eggs, and which becomes oppressive when a wind from the north blowing up the mouths of the sewers, which are almost always exposed, forces the gas into the streets, near the sidewalks, through the catch-basins. The wells that give sulphureted water are all from the rock. There was a well dug thirteen feet deep to the rock, striking a crevice from which issues an inexhaustible supply of highly impregnated sulphur water. It is on the west side of Main street, three hundred feet north and one hundred and sixty feet west of my well. A very small quantity, say a drachm, of sugar of lead in a bucketful of this water colors it an intense black. There is only one other well drilled in the rock. It is four hundred feet north and a thousand east of my well. It is forty feet in the rock: no gas or sulphur. There is a well dug on the fair ground, forty feet in the rock, one-half mile south and west of my well: no gas or sulphur.

"The gas which I use was analyzed in 1865 by Prof. Chilton, of New York City, and pronounced by him to be light carbureted hydrogen, and to come from petroleum. It smells like benzole or gasoline. It makes a very bright light. Near the burner, in the flame, are small explosions or scintillations, which, I suppose, are the particles of carbon burning."

CHAPTER XLIII.

REPORT ON THE GEOLOGY OF WOOD COUNTY.

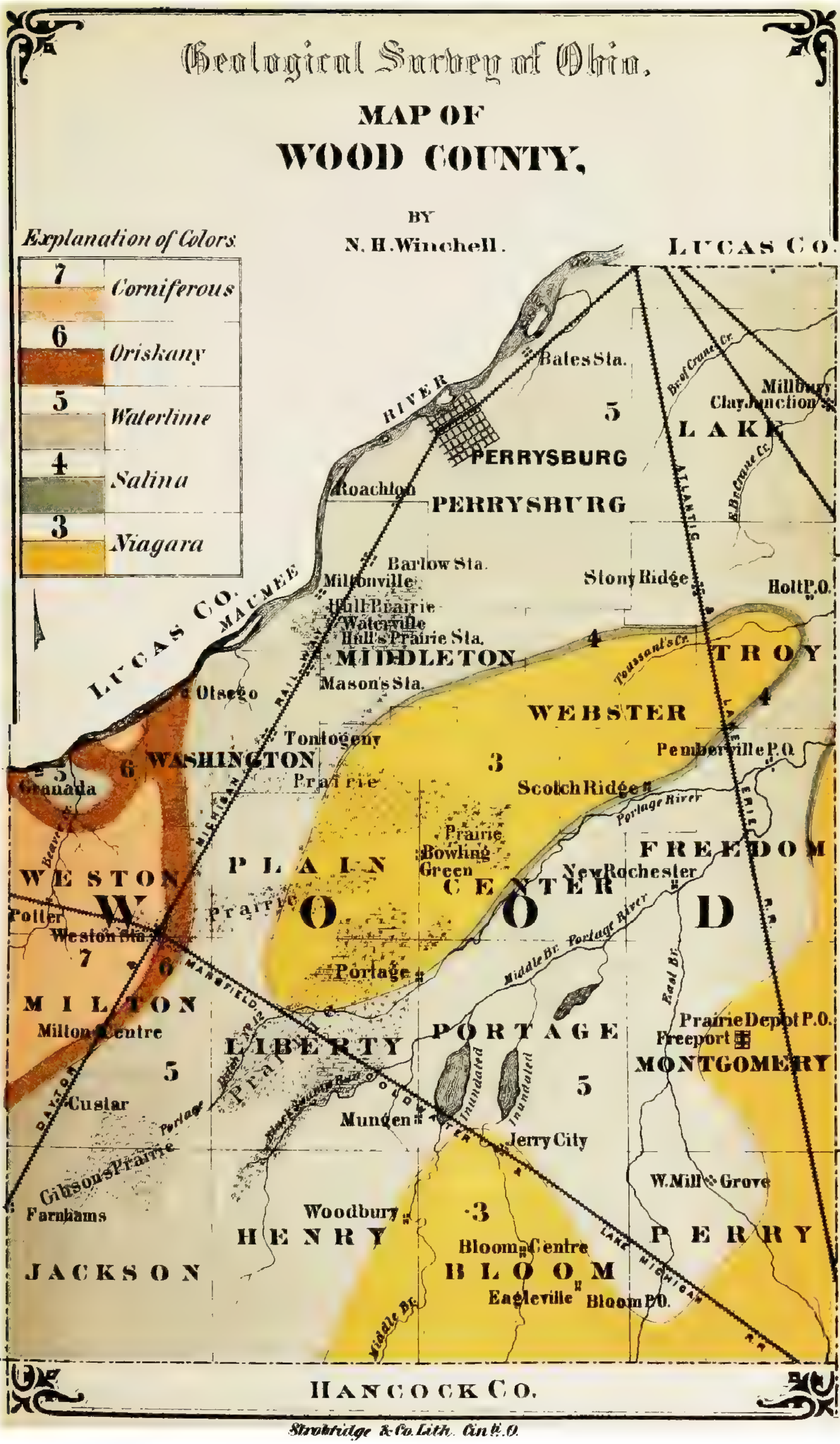
BY N. H. WINCHELL.

SITUATION AND AREA.

Wood county is situated just south of the west end of Lake Erie, its area reaching within five miles of the lake shore. The Maumee River separates it from Lucas county. It is bounded north by Lucas county, east by Ottowa, Sandusky, and Seneca, south by Hancock, and west by Henry and Lucas. With the exception of the north-western corner, which is cut off by the Maumee River, its form is that of a rectangular parallelogram, with an area of about seventeen towns, or six hundred and twelve square miles.

NATURAL DRAINAGE.

The Maumee River, which forms its north-western boundary, has but little effect on the drainage of the county. Beaver Creek, which enters it within the limits of the county, receives its waters from Putnam and Henry counties. With this exception, the Maumee receives no mentionable tributaries from Wood county. The Portage, with its tributaries from the south, forms the principal drainage system of the county. It has its source in springs from the Leipsic Ridge, in Putnam county. Its tributaries from the south also take their rise in other counties, and bear a similar relation to the Belmore and Leipsic ridges. The northern and central portions of the county, between the Portage and the Maumee, are poorly drained. In this area are several extensive tracts known as prairies, which, before artificial drainage was resorted to, were covered most of the year with standing water, and are clothed only with a growth of grasses and sedges. This area occupies the most elevated parts of the county. It is in the form of a plateau, or table-land, which extends nearly across the county from Farnham's Station, in the south-western corner, to the Maumee and Western Reserve Road, in the north-east. The northern portion of this plateau is drained north-eastward through



Strobridge & Co. Lith. Cin. O.

Crane Creek and its branches and the Toussaint Creek, and the southern supplies some of the sources of the Portage. While this plateau has a general slope toward the north-east, there are occasional slopes in other and almost opposite directions, and in all parts it blends with the surrounding country by almost imperceptible descents. Its eastern border, however, descends uniformly, and somewhat abruptly, into the valley of the Portage in a south-easterly direction. This is noticeable in traveling from Portage village to Bowling Green, the latter place being perhaps fifty feet above the former, yet in a direction due north. The valley of the Portage has a very slow descent, and when the waters are swollen they inundate considerable land adjoining. This renders the streams generally of little use for water-power. Some of the best water-powers in the county are furnished by the smaller streams in the southern part of the county, where the fall is greater than in the main valley. At Grand Rapids the water-power afforded by the Maumee has been improved by the State, although the dam was originally constructed for deepening the water of the Maumee for the use of the Wabash and Erie Canal. The Maumee is navigable to Perrysburg, between which place and Toledo steamers make regular trips. Above Perrysburg it soon becomes rapid, flowing immediately on the Waterlime formation.

SURFACE FEATURES AND SOIL.

In general, the whole county may properly be designated *flat*, and the soil a *heavy clay*. To this general statement must be made the usual exceptions of the sandy alluvium along the water-courses, which, in Wood county, is unusually abundant; the black, prairie-like soil of those parts of the plateau already described, which are destitute of trees, and require artificial drainage to become arable, consisting of a large proportion of vegetable matter, and the sandy deposits which are scattered abundantly over the whole country. These last are not infrequently spread over extensive areas of several thousand acres. They are, also, in the form of "sand ridges," which intersect the county in different directions, and of isolated knolls. With the exception of those broad undulations caused by the underlying rock—which, however, in Wood county are not sufficiently manifest to change the character of the surface from that of a broad plain—and these sandy knolls and ridges, the county presents no diversity of surface; and were it not for the dense forest with which the most of it is still covered, it would be comparable to the vast prairies of the states further west. Indeed, it seems to differ from them in no respect except in the presence of an abundant forest.

The river valleys are excavated in the Drift, although the Maumee

River has made occasional sections of the rock where local circumstances are favorable for rapid erosion. Its Drift banks are sometimes a mile separated, and bound it on either side with a height which sometimes reaches fifty or sixty feet. No succession of terraces, rising one above the other, is visible. There is sometimes an irregular descent from the general surface to the flood-plain, or even to the water-level; but these changes of descent are not constant, and are referable only to irregularities in the rate of erosion, or changes in the current from one side of the valley to the other. They are generally altogether wanting, the Drift banks descending suddenly to the flood-plain.

GEOLOGICAL STRUCTURE.

The rocks which underlie Wood county belong to the Devonian and Upper Silurian ages, and are named, in descending order:

Upper Corniferous limestone, Lower Corniferous limestone, Oriskany sandstone,	Devonian.
Waterlime (Low. Held.), Salina shale, Niagara limestone,	Upper Silurian.

The *Niagara limestone* occupies two areas of superficial outcrop, separated by a belt of overlying Waterlime. The first is of an irregular shape, in the south-east corner of the county, and belongs to the great anticlinal area which runs southward from Lake Erie to Marion county. Its line of separation from the Waterlime area lying to the west enters the county in section 1, Freedom township, south of the Portage River; runs south in the most eastern tier of sections in that township to the town line, where it takes a south-westerly course to a point a mile west of Freeport, where it changes to south-easterly, leaving Montgomery township in section 34. It then curves southward and westward, leaving Perry township, in section 30, in a north-westerly direction, which it holds as far north as section 33, Portage township. It then sweeps westward and southward again, leaving the county S. W. $\frac{1}{4}$ section 34, Henry township. The second area of Niagara is in the center of the county, and underlies and probably gave origin to the flat plateau on which the prairies are mostly situated. The south-western line of boundary of this area is not certainly known, owing to the prevalence of forest and of wet land in that part of the county. There are some reasons for believing it to run as far south as Jackson township, but it is not known further south than the north-eastern portion of Liberty township. Beginning at Portage village, where it lies between the river and the village, it runs north-easterly to Scotch Ridge village, probably without receding more than a quarter of a mile from the bank of the river. It continues in about the same direction to section 23, Troy township, where it forms an acute angle, and returns nearly due west to section 22, in Webster township, where it is diverted a little more southward to a point about two miles east of Tontogany. It here turns still more south to section 8, Liberty township, where it forms another acute angle, and runs to Portage village.

The most northern exposure of the first-described area of Niagara is on the county line, section 1, Freedom township. It is known as "Caler's Ridge," and has the characters of the *Guelph.* It is a buff, vesicular stone, in beds usually of four to eight inches, or rougher and more massive in beds of a foot thick, nearly destitute of fossils, weathering a light buff, and crumbling sometimes like chalk. It holds a deposit of lake sand. The next point south within the county is in the southern part of section 1, Montgomery township, where the ridge it forms is also capped with sand. This sandy tract runs south-west, in the form of a soft, beach-like ridge, on which a road is located, into section 29. It is probably on the line of outcrop of Niagara. In the south-eastern part of the township of Montgomery there is considerable wet and prairie land which is closely underlain by the Niagara. The rock may be seen in frequent outcrops in sections 25, 26, 35, and 36. This stony region extends also into Sandusky county, and is locally known as *Stony Barter.* In some places the Drift has been so washed away, leaving the bowlders, that piles of stones in the fields from which they have been gathered have the frequency and very much the appearance of hay-cocks in a harvest-field. The fence corners are also filled with them. About two-thirds of these loose pieces are fragments of Niagara, probably from the underlying rock not far away. The remainder are bowlders of northern origin. They are all rounded and water-worn. In Perry township the Niagara forms a ridge on the land of John Norris and of Justus Stearns, in S. W. ¼ section 14. It may also be seen in sections 25 and 24. On Judge Ash's land it is opened for macadamizing roads, and shows the features and fossils of the Guelph phase.

In Bloom township there are several hundreds of acres of land in which the Niagara is either quite bare or the soil is so thin that no attempt is made to plow it. Mr. John Frank owns such a stony tract in S. E. ¼ section 31. East and north from this place, along the north side of the Belmore Ridge, the Niagara may frequently be seen. Large fragments are gathered from the fields, and piled, with northern bowlders, in the streets. Different individuals burn lime from these loose pieces. On the N. W. ¼ section 19, at the "Rocky Ford," the Niagara appears in the Middle Branch of the Portage. It is of a dark drab or dirty gray color, in thick, crystalline beds, showing a roughened, water-worn surface. It is pitted with innumerable dish-shaped depressions, or "thimble-holes," apparently excavated by sand agitated by water. Bare surface rock is exposed on N. W. ¼ section 16, land of David Wyrick, Thomas McCuen, and of Solomon Smith; also N. W. ¼ section 7, in the form of a ridge, and in the creek, land of Joshua Yeaman; also S. W. ¼ section 23, land of George and Samuel Schlotterbeck, of Peter Zigler, and David Hays. This rocky patch extends westward three or four miles, visible especially along the north side of the ridge. On the N. W. ¼ section 5 is a Niagara ridge, partly owned by George Gorton and John Low. On the southern part of the same section it is exposed on the land of Mr. Stackhouse and of Reason Whittaker. Near Bloom Center, on sections 15 and 22, it outcrops on land of Rheinhardt and Alfred Simons, of Marvel Dennison, and of James Frey. It also is exposed on land of Robert McKay, S. W. ¼ section 7. It also occurs bare over several acres in section 6. At Shiloh village (section 4) there is a considerable deposit of sand, evenly spread over many acres.

The exposures of the second area of Niagara, which occupies the plateau in the center of the county, are of a similar character to those already enumerated of the area in the south-eastern part of the county, but are generally less denuded of the Drift, and more extensively covered or accompanied by lake sand.

In Liberty township it appears in outcrop in the vicinity of Portage, and in N. E. ¼ section 1, where it was encountered at a short depth below the surface in ditching by the side of the road. It is here a firm, thick-bedded, crystalline, gray rock, which can be obtained in large blocks. Through sections 12, 11, 10, and 9 its strike is indicated by the rapidly rising ascent from the valley of the Portage north-westward, although there is no known outcrop of the rock. This elevation is more or less constantly surmounted by a sandy deposit, which also is said to extend some miles further south into Milton township. It runs also, with interruptions, along the left bank of the Portage north-westward to Scotch Ridge, where there is one of the most remarkable deposits of beach sand.

In Plain township the Niagara is laid bare in S. E. ¼ section 25 by ditching along the road; dip, south-east. On sections 1 and 2, east of Tontogany, are sudden ridges of Niagara limestone, that on the former holding a deposit of sand. That on section 2 is on the farm of Jerome and Silas Thomas; that on section 1 is opened and burned for lime by Clarendon Nye, the product being about three thousand bushels per year.

In the township of Middleton there is a low ridge of Niagara on section 32. Its northern end is on Mr. John Davis's land, and holds no sand; its southern is on the land of Mr. O. B. Brown. South of Mr. Brown's farm, in section 5, there are several acres covered with about two feet of sand. A few stone have been obtained also in the S. W. ¼ section 24.

In Webster township the Niagara limestone is laid bare on N. E. ¼ section 12, land of Robert Stewart. On Mr. Stewart's farm there is a remarkable knoll of lake sand, which rises suddenly from a generally flat country to the height of about thirty feet, sinking away again toward the north-east within a quarter of a mile. Toward the south-west more or less sand is met with for several miles, but spread evenly over a flat surface, the knoll itself falling away almost as quickly in that direction as toward the north-east. This area of exposed Niagara extends across the McCutchenville pike into section 7. Water-worn fragments on the surface contain species of *Pentamerus* and *Atrypa*, and broken stems and calyces of crinoids. A mile and a half further north-east, on sections 31 and 32, the surface is closely underlain by the Niagara. It shows occasionally above the surface, but not in bluffs or sudden ridges. The land is generally tillable, and only poor by reason of numerous bowlders and limestone fragments. Some portions of the farm of Orrin Burgess are remarkably stony.

In Troy township there is considerable surface exposure of the Niagara in sections 27, 28, 33 and 34, making very rough and stony ground.

In Center township Sylvester Abbot's farm of two hundred acres, in S. W. ¼ section 32, is closely underlain by the Niagara. In some places plowing is prevented by the underlying rock. Much of the surface is sandy. In the same section this description may be applied to portions of the farms of Henry Sundy and George Klophenstein. On the S. W. ¼ section 29 Peter Van Ett burns lime from the Niagara. This kiln has been in operation more than fifteen years, more than half that time on surface fragments. The quarry now opened supplies stone for this kiln and for foundations. It is light buff and vesicular, with some purplish spots. The surface is bestrewn with bowlders of northern origin. On the S. E. ¼ section 30 Peter Klophenstein also burns lime from surface fragments. His quarry supplies stone for walls and bridge abutments. Bowlders are very common here also. The Niagara is also exposed in the street just south of Bowling Green. This village is situated on a rolling and bluffy patch of sand, which is spread over many acres adjoining, the soil being so sandy as to be injured for farming. The sand is soft, and impedes the traveler. Wells are said to strike the rock in a few feet. At a point one mile east the well of Mr. Lawrence Sader, situated at his brick and tile establishment, met the Niagara after passing through fourteen feet of brown and blue clay.

In Portage township the Niagara may be seen in section 6, on Mr. Fuet's land, and at Portage, N. W. ¼ section 7. At the latter place it is slightly quarried near the public school-house. A well dug at Portage, on Mr. Louis Dinest's land, happened to strike a crevice in the rock two feet in width. The overlying Drift was eighteen inches. This crevice, upon removing the Drift, furnished water at the depth of six and a half feet from the surface.

The Salina.—On the eastern slope of the Niagara anticlinal, in Ottawa and Sandusky counties, the Salina is met with, but in a very reduced condition. It is represented by a green shale, which is not more than a foot in thickness, and is altogether wanting south of Sandusky county. In the north-eastern part of Ottawa county it has a thickness of at least thirty feet, and contains the white gypsum exported from Sandusky. In Wood county the junction of the Niagara and Waterlime has not been observed, and nothing is known concerning the existence of the Salina west of the Niagara anticlinal.

The *Waterlime* in Wood county has the three lithological phases described in giving the geology of Ottawa county.

1st. It is a coarse, brecciated limestone, without distinct bedding or stratification; often massive; sometimes vesiculated, even cavernous; of a dull gray or drab-gray color, and almost destitute of fossils. In this condition of the Waterlime there are small, irregular patches of fine, hard, and close-grained rock, with thin laminations of alternating light and dark drab, running in wavy lines sometimes quite perpendicularly, but often at angles constantly changing. Such rock is heterogeneously mingled with loose-grained, vesicular rock, of a lighter color, which, by crumbling under the influence of the weather, gives the whole mass a cavernous appearance.

2d. It is a coarse but even-grained, thick-bedded, and magnesian limestone, of a dirty buff color, soft and easily wrought; a very useful stone for building where it can be found in sufficient quantities.

3d. It appears very frequently as a thin-bedded, drab, close-grained limestone, the layers of which are uniformly separated by bituminous films. This character of the Waterlime is subject to sudden and inexplicable changes of dip. The beds, which are usually about three inches thick, are sometimes not more than half an inch. It most frequently shows the characteristic fossil *Leperditia alta*, although it has also been found in No. 1. No. 2 has as yet afforded no fossils, so far as known.

Owing to the abundance of the Drift deposits and the monotony of topographical features in Wood county, there is no opportunity afforded for ascertaining the stratigraphical relations of these three phases of the Waterlime; yet it is certain that phases Nos. 1 and 2 disappear from the formation toward the south, and phase No. 3 is more largely developed, and seems to acquire more bituminous matter, becoming a thin-bedded but tough slate. Its characteristic outcrop in Wyandot county has received the name of the *Tymochtee slate.* Phase No. 1 is believed to occur at different but not constant horizons in the formation, but seems to prevail especially in the upper portions. Phase No. 2 has been seen in Wood county only in such positions as would place it in the lowest portion of the Waterlime.*

The Maumee River lies almost constantly on the Waterlime from the west line of the county to Perrysburg. It traverses, however, in that distance, the Oriskany sandstone three times. Throughout this distance the Waterlime shows the lithological characters of phases No. 1 and No. 3, those of the latter being far more frequent than the former. No. 1 was noticed especially at a point about half a mile above Miltonville. At a point a mile below Miltonville the following section was taken:

SECTION OF THE WATERLIME, RIGHT BANK OF THE MAUMEE, NEAR MILTONVILLE, WOOD COUNTY, FROM ABOVE.

No. 1.	Slaty beds, but so tortuous as not to separate; almost appearing massive, with irregular cavities, which are often lined with calcite crystals, and also sometimes contain "tarry oil," or asphaltum; dark drab, or almost black; hard	10 ft.	
" 2.	Thin, but mostly even beds of two to four inches; very hard and close-grained; sometimes tortuous	3 "	
" 3.	One bed; close-grained; crystalline and very hard; a bluish-gray, variegated with drab and blue; silicious, appearing like flint	1 "	3 in.
" 4.	An irregular exposure of beds like those of No. 1, which also occupy the bed of the river, exposed	2 "	
	Total exposure	16 "	3 "

The bituminous appearance of the rock for a mile both above and below Miltonville is so conspicuous, in the form of gummy asphaltum contained in the numerous cavities, and not infrequently staining and making fetid the rock itself, as to induce considerable expense in drilling for petroleum. One well, which descended about eight hundred feet,

* See, however, the section at Bellevue, in Sandusky county, where the top of the Waterlime contains similar beds; also quarry No. 3, at Tiffin, in Seneca county.

obtained a small flow of oil at about two hundred and seventy feet, though not enough to pay for working. This was said to rise from a "white sandstone," the rock both above and below being a "brown limestone," without showing much variation. About two miles above Perrysburg the layers are from two to eight inches in thickness, of an even grain and drab color, and are quarried from the river, adjoining Mr. Shawler's land. Mr. Michael Hayes owns a quarry a little below Mr. Shawler's, in similar beds, and another about a mile above Perrysburg. About a mile above Mr. Shawler's, Mr. Joseph Barnes has taken stone from the bank of the Maumee for the construction of his residence. It is a close-grained, blue-drab, crystalline stone, and in the structure makes a very fine appearance. About three miles east of Perrysburg the brecciated Waterlime appears at the surface over an area of several sections, causing a very rough and untillable tract, occupying several hundred acres. Beginning at the N. W. ¼ section 2, Perrysburg township, it spreads irregularly over sections 2, 3, 10, 11, and 15, reaching as far south as sections 21 and 22, where it was formerly burned into lime on the land of Henry Spilker. Throughout this area it has been more or less worked by different persons for quicklime, of which it makes a superior quality. At George McMulligan's quarry, on the Maumee and Western Reserve Road (section 10), the beds are opened to the depth of about fourteen feet. The brecciated structure occupies the uppermost two feet. Below it about twelve feet of rather even-bedded, drab courses are seen, having a thickness of two to six inches. These beds are the source of most of the stone burned by Mr. McMulligan, who ships over ten thousand barrels of lime per year. At this place bowlders are numerous.

In Lake township the Waterlime appears in S. W. ¼ section 33. A ridge here crosses the road east and west. Matlock's mill, N. W. ¼ section 22, stands on a low ridge. Another ridge occurs in S. E. ¼ section 28.

In Troy township the Waterlime was observed in the following places:

Section 5. The Empire House, on the Maumee and Western Reserve Road, stands on the summit of a prominent ridge of Waterlime. The stone is rough, massive, and of a dark color. This ridge may be traced almost without interruption north-east across the northern portion of section 4. The road encounters the rock again on the N. W. ¼ section 10. Between sections 8 and 9 the road passes over a low ridge of Waterlime. In this township Mr. Briggs, of the Geological Survey of 1838, reports outcrops of rock on sections 11, 12, 25, and 14, on the authority of the county surveyor. They are believed to be of the Waterlime, although they were not seen in 1871. On Mr. Fred. Whitker's land, S. W. ¼ section 36, large blocks of dark drab Waterlime are obtained from the surface of a low ridge. The internal structure shows a wavy and curling lamination, or variegations of dark and light drab. The texture, however, is usually not close. Such stone would be useful for ornamental work, owing to the thickness of the blocks, the ease of cutting, and the beauty of the surface. It would also probably resist sufficient pressure to warrant its use in large structures, though it should be first carefully tested. There is abundant exposure of this phase of the Waterlime in the bed of the Portage, about a mile south of Mr. Whitker's.

In Freedom township the Portage and its branches often disclose the Waterlime. In section 2 and N. W. ¼ section 12 the thick, soft beds of phase No. 2 are uncovered by the current of the river, showing remarkable glacial grooves. The same or similar beds are occasionally met with in ascending the Middle Branch of the Portage as far as New Rochester, where they have been used in the abutments of the highway bridge. These were quarried near the bridge, in blocks twelve to sixteen inches thick, and are mingled in the bridge with stone belonging to phase No. 3. It is again quarried, S. E. ¼ section 30, on the land of Sidney Calkins. It here affords large, even-grained blocks of eighteen to twenty-four inches thick. In sections 16, 17, 19, and 20 are very extensive deposits of lake sand, on ridges of Waterlime. These sometimes show the brecciated condition, but are also sometimes even-bedded. Mr. William Fish has a quarry in regularly laminated beds on section 20, at the base of a bluff of brecciated rock. The rock, however, of these ridges is usually hid by sand, which rises in some places to the height of forty feet. At Pemberville (N. E. ¼ section 10) the bed of the river is specially rocky. Not only are there detached masses of coarse, brecciated Waterlime, some as large as five feet by six feet by eight feet, covered with black lichen, lodged along the banks, but the bed of the river shows the various lithological features and changes of dip through which the rock is liable to pass in short intervals. A peculiarity of the Waterlime to become suddenly concretionary or massive is strikingly illustrated near Pemberville. In the midst of even and fine-grained beds are seen a number of rough and massive patches which swell above the surrounding surface. They are sometimes but two or three feet across, and may be ten or even thirty. The same peculiarity was observed in Ottawa county, and is believed to illustrate the manner of occurrence of the brecciated condition, or phase No. 1, of the Waterlime. There is a heavy sand deposit on a Waterlime ridge, N. W. ¼ section 33, land owned by Thomas S. Carman, known generally as the "Clay Farm."

In Portage township the bed of the river, N. W. ¼ section 7, exhibits very much the same kind of exposure as at Pemberville, and the stratigraphical horizon must be nearly or quite the same. At this place it can also be profitably worked for a building stone when the settlement of the county shall have progressed so far as to demand a cut-stone of such quality. At the present time it is used somewhat for foundations; but the abundance of stone generally throughout the county retards the special development of superior qualities. The following section was taken at this place, a portion of it being from the N. E. ¼ section 12, Liberty township:

DOWNWARD SECTION OF THE WATERLIME AT PORTAGE, WOOD COUNTY.

No. 1.	Soft, drab, somewhat vesicular, weathering a buff color; beds, six to sixteen inches; texture generally homogeneous, similar to the magnesian and harsh, thick beds of the Lower Corniferous	2 ft.	4 in.
" 2	Harder, crystalline, with a darker color, showing some bituminous films, which, on fracture, appear as black, horizontal streaks. In this member there is a tendency to an oölitic structure, seen sometimes in patches, or in beds horizontally continuous, with a thickness of a quarter of an inch to three inches; beds three to eight inches	2 "	
	Total exposed	4 "	4 "

This section is displayed on the land of William Sargent. The dip is toward the south and south-east. At the crossing of the road between the two townships it is ten to fifteen degrees south-east. The land rises toward the north and north west, caused by the appearance of the Niagara. East of the bridge about forty rods, thin and slaty beds are seen in the river, some of which are so bituminous as to burn like coal. Twenty rods further down, on land of Mrs. J. L. Roland, the rock appears hard, crystalline, dark drab, almost brecciated, yet in regular beds of sixteen to twenty inches; dip, south-west. This probably overlies the layers of the foregoing section, since, the dip continuing the same, the soft, magnesian, drab beds (No. 1 of the section) appear with a thickness of fourteen to twenty inches, affording opportunities for a profitable quarry.

Near Mill Grove, in Perry township, the Waterlime in loose pieces has been burned for quicklime on the farm of Winfield DeWitt. It also appears in regular beds of two to four inches in the East Branch of the Portage, at the village, and again in the McCutchenville road, N. E. ¼ section 9, in similar layers; also further south, in the same section, in thick beds. In the S. W. ¼ section 17, Mr. Daniel Pelton obtains good flagging stone from the Waterlime, one to three inches in thickness. On the N. E. ¼ section 19, land of Henry Baker, it appears in thick beds of an even texture, somewhat used formerly in Fostoria for building. This may be the equivalent of the stone quarried at New Rochester and at Pemberville, belonging to phase No. 2 of the Waterlime, as already described, although the opportunities for examination were not sufficient to determine certainly.

In Middleton township, N. E. ¼ fractional section 16, the "Belleville Ridge" rises, including the sand with which it is surmounted, to a height of about forty feet. The surface of the sand has a rolling outline, and a thickness on the summit of at least six feet. The ridge is a mile long north and south, and half a mile in width east and west. Round the base, especially toward the south, there is considerable rocky surface, and bowlders are very numerous. Loose fragments are burned for lime by Andrew Jennison.

In Liberty township the Waterlime appears in a low ridge, N. W. ¼ section 32, owned by Mr. John Edgar and Isaac Rusch. On S. W ¼ section 24 it lies in thick beds of eighteen to twenty-four inches; irregular, porous, dark drab, opened in a ditch by the roadside. Thinner but more compact and even beds have been cut in the same way in N. E. ¼ section 25.

In Henry township it is exposed and slightly quarried in thin layers on S. E. ¼ section 10. It closely underlies considerable land owned by Jacob Nier, William Hammond, and Michael Anverter. The "Callahan Ridge," S. W. ¼ section 9, and the "Howard Ridge," S. W ¼ section 21, are both of the Waterlime. It is rough and cavernous. The latter is quarried by William Norris.

The Oriskany Sandstone.—At Grand Rapids, on the Maumee, near the western border of the county, the base of the Lower Corniferous is exposed. What can here be seen is a buff, arenaceous limestone, in thick beds of six to thirty-six inches, having a thickness of ten to twelve feet. This holds the place of the *Oriskany sandstone* in states further east, and may be the equivalent of that formation. Yet the identification is not free from doubt. The section here seen is as follows, from above:

No. 1.	Sandstone, or arenaceous limestone, of a gray or lead color, varying to cream color and white; in thick beds, without visible fossils; texture uniform	10 to 12 ft.
" 2.	Fossiliferous, porous, harsh, arenaceous limestone, of a lead color, weathering buff	1 "
" 3.	Waterlime; hard and flinty; beds thin and lenticular, or massive, of a bluish-drab color; exposed	5 "

No. 1 is exposed furthest up the river, the dam being built on it. It is said also to have produced rapids in the river some distance above the site of the dam, but it is now hid by deep water. At the dam, and in the recent excavation for the enlargement of the mill-race, half a mile below, this stone is opened, and found to produce even-grained blocks and pieces of irregular shape, but which with care could be obtained of almost any desired dimensions. It is seen in the bed of the river for the distance of half a mile below the dam. It is not easily separable from No. 2, into which it graduates.

The fossils found in No. 2 are in a very fragmentary condition. There are numerous pieces of crinoidal stems, and traces of a bivalve, apparently a *Spirifer*. A fractured trilobite was also seen. The workmen report finding "turtles'-backs" as large as a man's hand, which may be *Macropetalichthys*.

The junction of No. 2 with No. 3 is jagged with lignilitic prominences, or suture-shaped roughness. The lignilitic crystals are often two inches long, and covered with black films, while in the depressions an arenaceous limestone is deposited. Sometimes in quarrying, these suture-joints are so firm as to tear up the first layer of No. 3 rather than separate.

No 3 swells gently upward, bringing itself into contact with the current of the river for a distance of half a mile below the "Purdy Mills." It first shows a dip west, but changes to east, so as to permit the return of the sandstone (No. 1) at the mouth of the Beaver Creek, a mile below the village of Grand Rapids.

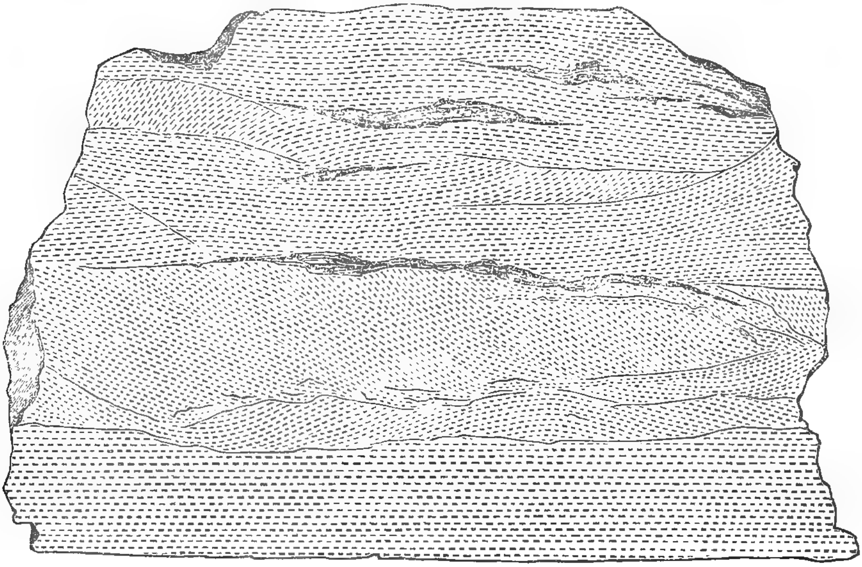
About four miles still further down the river, opposite the village of Otsego, the Oriskany is again intersected by the Maumee. It is seen here in beds of eight to twenty-eight inches. The grains are fine and white, although there are some places which show an apparent quartzitic structure, the silica grains being apparently crystallized into a solid mass, losing their forms, while some of it is more properly an arenaceous, magnesian limestone. Within, this stone is of a light-blue color, or gray, with spots of blue. The blue sometimes prevails near the junction of the beds; indeed, the bedding-planes are very often separated by a very blue or purple lamination, which is also sandy. These laminations, which are sometimes an inch thick, are so split not infrequently as to include lenticular patches of lighter rock like the mass of the thicker beds. The whole weathers a buff or almost white. The following section was taken at this place, in descending order:

No. 1. Limestone; close-grained; crystalline, light drab, or dark drab, and porous; in one bed. The dark and porous parts have the forms of inverted kettles, and show traces of fossils.. 2 ft.

No. 2.	The same, except the dark and porous parts are less definite in form; in one bed	2 ft. 6 in.
" 3.	Limestone; irregular; rather soft, drab, streaked with tortuous bituminous films; sometimes fine-grained and hard; when quarried, comes out in blocks a foot thick; beds eight to twelve inches	3 "
" 4.	Sandstone; banded with blue, gray, and black streaks, owing to changes in sedimentation; in three beds	1 "
" 5.	Limestone; even; drab, with bands of light and dark; beds four to six inches	2 "
" 6.	Irregular; hard and close-grained; crystalline; of a light drab, or yellowish-drab color; surface inverted kettle-shaped	2 "
" 7.	Irregular; dark drab or brown; slightly fossiliferous; arenaceous; vesicular	1 "
" 8.	Sandstone; in one bed; firm; grains white, rounded, and distinct. This bed contains occasional small masses or pebbles of silicious rock, much larger than the ordinary grains, due either to the chemical confluence of smaller grains or to the existence of pebbles of that size in the materials which at first formed the rock. So far as observed, they do not show the rounded condition seen in the grains of the general mass	3 " 8 "
" 9.	Sandstone; light blue or lead color; its fine grains deposited in irregular, lenticular beds, and separated by divisional planes in all directions. This is below the falls caused by the last (No. 8), and the water runs straggling over it. Thickness unknown. Exposed	1 "
	Total exposed	18 " 2 "

The principal bed of the Oriskany here is No. 8, which is so persistent as to run continuously across the river bed, causing, in a low stage of water, a marked change in the river landscape. The unequal erosion of the current on the materials composing this member of the section reveals the effect of currents of water operating in the act of deposition. There are distinct lines of bedding, or oblique stratification, seen crossing the main bed, the water having removed the softer parts, the whole being rounded grains of sand. The following sketch will illustrate this arrangement of the sand grains. It recalls very forcibly the oblique stratification seen in the sand and gravel of the Drift of the present day.

SEDIMENTATION OF THE ORISKANY SANDSTONE.



The section exposed at the quarry of the Delphos Stone and Stave Company, half a mile south of Charloe, in Paulding county, is as follows, in descending order. It covers the lower part of the Oriskany phase, embracing also the top of the Waterlime:

No. 1.	Sandstone, having the appearance of that at Grand Rapids, in Wood county; hard; suture-jointed upon No. 2; sawn off for flagging; seen only		6 in.
" 2.	Even-grained, magnesian limestone of a buff color; containing nodules of chert; sawn into handsome building blocks, and exported largely	4 ft.	
" 3.	Dark drab; soft; magnesian, with some cavities, which contain orange-colored calcite	1 "	10 "
" 4.	Rough; blue drab; close-grained, heavy, and hard, or brecciated and vesicular; with some pyrites; in one bed of at least	3 "	6 "
		9 "	10 "

No. 1 of this section is the base of the Oriskany; No. 2 is a stone seen at other places embraced within the Lower Corniferous; Nos. 3 and 4 are the uppermost members of the Waterlime.

On the eastern slope of the Niagara, at Bellevue, in Sandusky county, the sandy beds supposed to represent the Oriskany of New York are embraced within the Waterlime, about six feet of that formation overlying them. At Grand Rapids, in Wood county, only a foot of a fossiliferous limestone, referable to the Lower Corniferous, intervenes between the Oriskany and the Waterlime; while at Charloe, in Paulding county, that intervening bed has increased to four feet, showing a vertical change of ten feet in passing westward a distance of about eighty-five miles.

The *Lower Corniferous* underlies the western portions of Weston and Milton townships. The only outcrop which is known to occur south of Grand Rapids is at the quarry of Mr. Luther Pue, S. W. ¼ section 6, Milton township. The following section was here taken, and is believed to show the junction between the Upper and Lower Corniferous:

No. 1.	Very fossiliferous beds of one to two inches; shattered and water-washed; very slight exposure. This is thrown out in quarrying. An *Orthis* can here be distinguished, two or three corals, and a Brachiopod, like a long-beaked, small *Pentamerus*, with fragments of numerous other fossils	1 ft.
" 2.	Harsh, magnesian limestone, without fossils; apparently in thick beds, having much the outward aspect of a sandstone; some flags of two inches thick have been taken out; exposed......	3 "
	Total exposed	4 "

The Drift in Wood county shows the usual characters of a glacial hard pan. The upper six or eight feet are of a light brown color. The remainder is known as "blue clay." The whole contains, disseminated through the mass irregularly, more or less sand, pebble-stones, and bowlders. The average thickness of the whole would be not far from seventy-five feet. It shows locally, but very rarely, an indistinct assortment, or at least an arrangement of its materials in tortuous bands, as if the mass itself had been compressed or folded, or had been denuded and again covered with the same materials. There is also more or less superficial lamination of the upper part seen in the banks of the Maumee near its mouth. These strata, which contain, so far as seen, nothing coarser than fine sand, and usually consist largely of clay, seem to be confined to the larger water-courses. They are by no means constant. On the contrary, the banks even of the Maumee generally contain nothing but the typical hard-pan, or glacial clay, which rises to the surface and forms the soil. These laminations below pass into coarser materials, containing, with a gradual loss of their distinct arrangement into layers, gravel and bowlders. The beds, although not infrequently oblique and wavy, are usually nearly horizontal. They become more oblique near their junction with the unstratified Drift, into which they merge and become lost. They are believed to be due to the action of water from the glacier on the unmodified Drift along its foot when in the act of retiring. They, however, may be attributed to the action of the water of the Maumee, instead, upon the glacial Drift at the time of its deposition by the glacier. Its action, however, would be more likely to be seen throughout the whole thickness of the Drift, and would not be overlapped by the hard-pan deposits as these laminations are seen to be near their junction with the glacial clay.

The surface of the Drift in various parts of the county has suffered considerable denudation since the retirement of the glacier. The waters of Lake Erie formerly covered the whole county, rising about 180 feet above their present level. Their prevalence at that height is indicated by the following phenomena:

1st. The rock is laid bare in a great many places, and is wrought into fantastic shapes, similar to the surface of rock now undergoing the constant beating of the waves. Such water-worn rock is seen nowhere in north-western Ohio except along the present lake shore, and at various heights above it up to about 180 feet.

2d. In the vicinity of these rocky outcrops, known as "limestone ridges" in the Black Swamp, there are great numbers of bowlders of all sizes, and usually of metamorphic rocks. They are thought to be the remains of the hard-pan which at first covered uniformly the underlying rock, the clay and sand having been washed out by the waves. They usually lie immediately on the bare rock, and are most abundant round the bases of the ridges. They are water-worn and rounded.

3d. Deposits of fine sand, similar to the subaqueous bars and beaches now forming about the shores of Lake Erie, are scattered over the whole county, and seem to occupy all heights up to about 180 feet above the Lake. They are seen on the elevated portions, that is, on those portions which rise somewhat suddenly above the surrounding level. Thus they follow, and almost mark out, the eastern border of the Niagara area in the center of the county. These sandy deposits are not only in the form of isolated knolls, having nuclei of the persistent breccia of the Waterlime formation, but are sometimes so continuous and regular as to have the name of ridges. Such ridges are met with in all parts of the county, running in all directions; and sometimes roads have been located on them. The continuous ridge which passes through the townships of Bloom and Perry, in the south-eastern part of the county, is not one of lacustrine origin, but is believed to be of the same nature as those long gravel ridges seen at higher altitudes in north-western Ohio having the nature of terminal glacial moraines. Yet it must have been submerged by the waters of the Lake in some parts of its course, as in Wood county, and its original height and peculiar character greatly modified, or perhaps destroyed, by the action of the lake waters. It is noticeable in the cases of isolated knolls, that the sand prevails most on the southerly or south-westerly side of the limestone ridge, as if the resultant action of the waters was in that direction. The limestone uniformly has most exposure on the north or northeastern sides.

At a point two miles below Otsego the right bank of the Maumee is fifty feet above the summer stage of the river, consisting entirely of hard-pan. No stratification can be seen. The materials are perhaps a little finer and more sandy at the bottom. At another point, about a mile below Perrysburg, the same bank is forty-eight feet. Its contents, exposed by the entrance of a ravine, are seen to consist of hard-pan from the top to the bottom. Near the base of the exposure the materials are finer, but contain occasional stones. The whole acts under the hammer, especially in a moist state, like putty. Mr. Briggs, of the Survey of 1838, reports a laminated condition of the upper portion of the Drift exposed along the excavation for the canal near Perrysburg, on the left bank of the Maumee. The layers were of fine sand and clay, alternating in thin, nearly or quite horizontal, laminations, like those already described at Toledo.

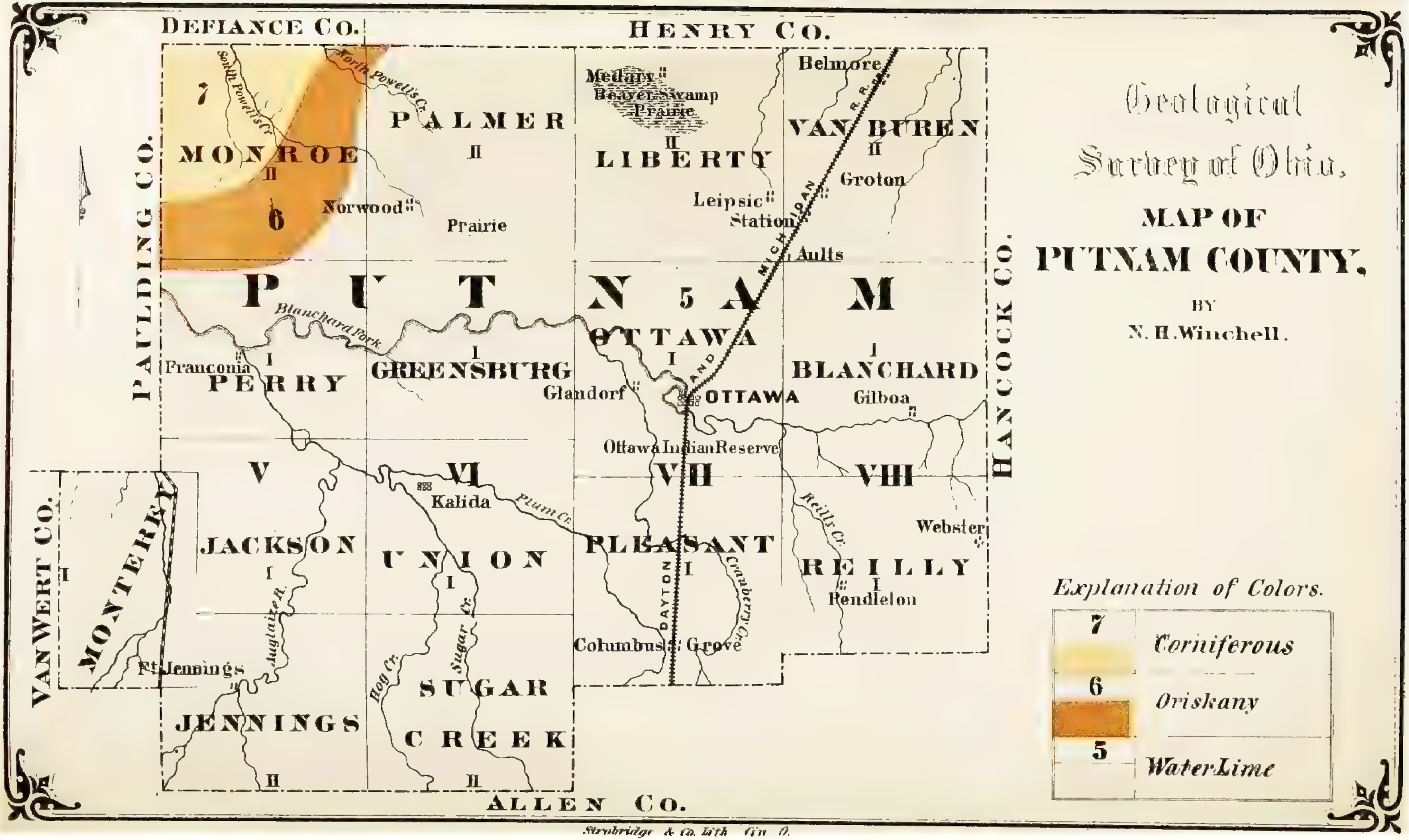
The material resources of the county consist first in the soil, which is destined to make Wood county one of the first in agricultural wealth and importance in the north-western part of the State. Its favorable location for reaching market at Toledo, and for obtaining an outlet for its products by lake transportation east, will make it a favorite resort for enterprising farmers, while its nearness to the Lake will enable them to command the best prices for their farm products. The full development of these resources can only be brought about by carrying to completion the plan of artificial drainage that has been wisely adopted, and by the construction of railroads to facilitate communication and transportation. At the present time the public roads are not in good condition, and there is a lack of railroads. While gravel is not common in the county for roads, there is abundance of stone, which can easily be rendered of great service in macadamizing the public roads.

Next to the wealth which lies buried in an undeveloped and undrained soil, may perhaps be mentioned the heavy forest with which the largest portion of the county is yet covered. Various species of oak, hickory, maple, ash, elm, with some cottonwood, sycamore, black walnut, chestnut, and beech, make up the principal forest trees. The chestnut was seen only at one point. Large fruiting trees of that kind occur near

Freeport, in Montgomery township (sections 15 and 11), growing in a sandy soil.

The county is well supplied with stone of good quality for building and for lime. One of the most valuable varieties of stone for building purposes seen in the county is the thick but soft drab beds of the Waterlime, constituting what has been described as phase No. 2 of that formation. Opportunities for working it are afforded at a number of places, which have been enumerated in the description of that formation. When the facilities for transportation are improved, and the exigencies of development demand a useful or ornamental cut-stone, this part of the Waterlime in Wood county will prove of great value. The Oriskany sandstone quarried at Grand Rapids is exported largely to neighboring counties. It is extensively if not exclusively used in the locks and aqueducts of the Wabash and Erie Canal as far south as the city of Defiance. Blocks of almost any required size can be obtained, which may be wrought into ornamental forms. It answers for all purposes, except for flagging stone, as well as the Waverly sandstone. The Niagara is not very much quarried at any point within the county. Wherever it is used it is for lime-burning. It seems not to afford a building stone of superior quality, although it supplies the local demand in many places for foundations and common walls.

The clays of Wood county are well suited for the manufacture of brick. The surface of the Drift is usually so free from limestone fragments, except in the vicinity of the "limestone ridges," that it can be profitably employed for this purpose. The location of brick-yards on the river bottoms will generally prove less successful than those on the surface of the Drift. The ice which lodges on the flood-plains in spring-time holds numerous fragments brought down from the rapids caused by the Waterlime formation. These are dropped upon the flood-plain, and when the brick burned from the materials of the river bottoms are exposed to the weather, the lime slacks, so as to destroy them for use in buildings. The greatest difficulty met with in the use of the surface Drift at points removed from the river valleys will be the lack of sand. This can be supplied, however, from the sand ridges and knolls so common in the county.


Geological Survey of Ohio,
MAP OF PUTNAM COUNTY,
BY
N. H. Winchell.
DEFIANCE CO.
HENRY CO.
HANCOCK CO.
ALLEN CO.
PAULDING CO.
VANWERT CO.
PUTNAM
MONROE
PALMER
LIBERTY
VAN BUREN
PERRY
GREENSBURG
OTTAWA
BLANCHARD
JACKSON
UNION
PLEASANT
REILLY
JENNINGS
SUGAR CREEK
MONTEREY
Norwood
Prairie
Medary
Beaver Swamp Prairie
Leipsic Station
Belmore
Groton
Aults
Franconia
Glandorf
OTTAWA
Gilboa
Ottawa Indian Reserve
Kalida
Webster
Pendleton
Columbus Grove
Ft. Jennings
North Powell's Cr.
South Powell's Cr.
Blanchard Fork
Plum Cr.
Reilly's Cr.
Cranberry Cr.
Auglaize R.
Hog Cr.
Sugar Cr.
MICHIGAN AND DAYTON R. R.
Explanation of Colors.
7 Corniferous
6 Oriskany
5 Water Lime
Strobridge & Co. Lith. Cin. O.

CHAPTER XLIV.

REPORT ON THE GEOLOGY OF PUTNAM COUNTY.

BY N. H. WINCHELL.

SITUATION AND AREA.

Putnam county is bounded north by Defiance and Henry, east by Hancock, south by Allen, and west by Van Wert and Paulding. Ottawa, its county seat, is forty-eight miles south of the Michigan State boundary line and thirty-nine miles east of the Indiana State boundary line. It contains nine square miles more than thirteen towns.

NATURAL DRAINAGE.

The principal river valley is that of the Blanchard, which crosses the county midway in a direction a little north of west, receiving tributaries only from the south, the direction of all of which is nearly due north. These streams, which afford frequent exposures of the rock over which they pass, are Reilly Creek, Cranberry Creek, Plum Creek, Sugar Creek, which unites with Hog Creek in Union township; the Auglaize, which receives Hog Creek in Jackson township, and the Little Auglaize. In the northern portion of the county are the sources of the Portage, which, intersecting Henry, Wood, Sandusky, and Ottawa counties, enters Lake Erie at Port Clinton, having a course nearly north-east; of the Beaver Creek, which joins the Maumee in Wood county, and of South Turkey Foot and Powell's Creeks. Thus it appears the general slope of the county is toward the north, the Blanchard only having a westerly direction. With the exception of the Blanchard, the Auglaize, Hog Creek, and the Little Auglaize, the streams of the county are not reliable for water-power through the summer season. These have been extensively improved for flour-mills and saw-mills.

SURFACE FEATURES AND SOIL.

The surface of Putnam county is flat, the only diversity being in the sand and gravel ridges which cross it, and the sandy, undulating tract underlain by the Corniferous limestone in the township of Monroe. South of the Van Wert Ridge, in Reilly and Pleasant townships, the surface is also more gravelly and broken. These ridges consist of strips of rolling land, in which gravel and sand in oblique stratification may be found a few feet below the surface. They prevail in the north-eastern part of the county, crossing it obliquely from north-west to south-east. They have been fully described in the chapter on the Drift in north-western Ohio. With the exception of the Medary Swamp and another small area in Palmer township, the whole county was originally covered with forest. The soil is that peculiar to the Black Swamp, and consists largely of a close, tough clay, with but little intermixture of vegetable matter. It is remarkably free from bowlders and stones, not one being seen sometimes in a day's travel. In the vicinity of the ridges and knolls in the northern part of the county it is often gravelly or sandy, and hence much more easily drained. In general, the whole county will require thorough artificial drainage.

GEOLOGICAL STRUCTURE.

The only rock seen in outcrop within the county is the Waterlime; yet it is believed that the lower part of the Corniferous, including the Oriskany sandstone, underlies the most of the township of Monroe.

The most important exposures of the Waterlime are either in the bed of the Blanchard, or in the streams tributary to it from the south. It here shows itself at numerous points, and is wrought for general building purposes and for quicklime. The thick-bedded, soft, drab stone which occurs in Wood county, and which will prove valuable for a cut-stone, has not been observed within the county; neither has that character described as phase No. 1. Phase No. 3, however, is commonly seen in Putnam county. Besides this condition of the Waterlime (see Geology of Wood County), there are occasionally seen thick, hard beds of fine-grained rock, with cavities, and bands of softer or vesicular rock disseminated through the mass. Such rock was seen at Croninger's mill, near Findlay, in Hancock county (S. E. ¼ section 8, Liberty township), and is regarded as the equivalent of the breccia of phase No. 1, reduced in its dimensions and modified by the weakening of that force, whatever it be, which occasioned the brecciated masses developed conspicuously in the islands at the west end of Lake Erie, and in the island of Mackinac, at the head of Lake Huron. The gradual change southward in the lithological characters of the Waterlime has been already noted. In Putnam county its condition is usually an intermediate stage between that seen in Ottawa and Wood counties and that described under the Geology of

Wyandot County, and styled the *Tymochtee slate*, although the characters of the latter, especially its thin beds, are not entirely wanting in Putnam county. Some of the principal quarries within the county are in the bed of Reilly Creek, among which the following may be mentioned:

S. W. ¼ section 30, Blanchard township; quarry of James Wade.

N. W. ¼ section 6, Reilly township; quarry of F. N. Climer.

N. E. ¼ section 36, Ottawa township; quarry of Judge J. Y. Sackett, affording some thick, even-bedded stone, the blocks of which are sometimes ten to sixteen inches and four feet long.

Section 6, Reilly township; quarry of William Blodgett.

N. E. ¼ section 7, Reilly township; quarry of Michael Bridenbauch. This quarry affords stone resembling that seen in the Scioto River a couple of miles below Middletown, in Marion county, being blotched and variously mottled with blue and drab, in beds ten to twelve inches thick.

Section 8, Reilly township; land of George W. Alkire.

N. W. ¼ section 18, Reilly township; quarry on the land of M. S. Rice.

Good stone from the Waterlime is also obtained at Pendleton.

In the bed of Cranberry Creek are the following quarries:

Section 23, Pleasant township; the quarry of James McComb supplies the village of Columbus Grove.

N. W. ¼ section 26, Pleasant township; quarry of Joseph McComb.

S. E. ¼ section 23, Pleasant township; quarry of J. Postleweight.

In the bed of Hog Creek the Waterlime is very often exposed, and is usually slightly worked for common stone for foundations. On the N. W. ¼ section 16, township of Union, land of A. C. Syfert, it shows very sudden and remarkable changes of dip. The beds are twelve to sixteen inches in thickness, and have been apparently upheaved superficially and fractured, the opened crack being eighteen inches across, running north and south. This opening of the rock is not confined to those parts of the river valley which have been entirely denuded to the rock, but one such upheaval was seen several rods from the immediate channel. At this place the disturbance of the overlying Drift has admitted a small creek in time of freshet, which so washed away the clay as to reveal the condition of the beds. A singular phenomenon, probably ascribable to the same cause, was witnessed a few years ago on the land of William Turner, S. E. ¼ section 32, in Pleasant township. It is generally known as "the earthquake" in the immediate neighborhood, and is said to have occurred during a thunder storm. Across the bottom land of Sugar Creek a singular and sudden upheaval of the surface took place, creating a bank running in a north-west and south-east direction, crossing the creek and entering or abutting on the Drift banks on either side (which have a height of about five feet) in such a manner as to set back the water of the creek. The surface rose three or four feet. On excavating this bank for the purpose of releasing the water, nothing was encountered but the ordinary alluvium. This account is given on the authority of Judge Skinner, of Kalida. In Sugar Creek township the Waterlime is quarried from the bed of Hog Creek, on section 17, land of William Guffy and of Jacob Rhodes. Here it shows a dip north; beds two to four inches. On the same section, land of John W. Thomas and E. C. Ford, on opposite sides of the creek, it is also worked to a limited extent. On section 8 it is in beds of four inches on the land of Joseph Sherick, and shows a veritable dip. On section 7 beds eighteen to twenty-three inches thick are taken from the creek on the land of James Rhodes. Jonathan Ford's quarry is adjoining. On the same section heavy stone is also obtained by James Thomas and William Rhodes, on opposite sides of the creek. William Evans also has a quarry on section 6, in the same township. It is also quarried by J. E. Dicus on the N. E. ¼ section 1, Jackson township. On the N. E. ¼ section 8, Union township, the Waterlime is shown on the land of John Eyer, in the bed of Hog Creek. It is here burned for lime by James Foley. The stone is very bituminous, and almost black, with a strong fetid odor under the hammer. The beds are three to four inches. A gummy, shining asphaltum is found in the rock here, in small deposits, filling cavities, and lying between the beds. It is jetty black, fractures like sealing-wax, and is slightly brittle. It is not known to be escaping from the formation, but is met with in quarrying.

The Auglaize, in like manner, lies frequently on the Waterlime. Below its union with the Blanchard the rock can be seen in N. W. ¼ section 7, Perry township, on land of Josiah R. Merritt. On the S. E. ¼ section 21, in Perry township, it is worked for common foundation stone, in the bed of the river, by John Myers; also, on the N. W. ¼ section 27, by Mrs. Samuel Myers. The beds are two to four inches in thickness at the latter place, or adherent so as to come out in blocks of a foot or fourteen inches, of a light drab color; gentle dip south. J. Hetrick has a quarry, S. E. ¼ section 15, Jackson township, in the bed of the stream. At the ford of the Auglaize, S. W. ¼ section 27, Jackson township, there is a fine surface exposure of the Waterlime in beds of two to eight inches, somewhat quarried. At Fort Jennings the quarry of Louis Bœhmer furnishes stone ten to sixteen inches in thickness, extensively used in the surrounding country for many miles. It is taken from the bed of the river. It appears also in the Auglaize, on the land of Amos Bœhmer, section 4, Jennings township.

At Ottoville, in the Little Auglaize, S. E. ¼ section 24, Monterey township, the Waterlime presents a surface exposure.

In the Blanchard River the rock often shows in Blanchard township. It was noted particularly at a point three miles west of Gilboa, on land of Mr. George Harding; also, S. E. ¼ section 29, on Samuel Kline's land. It also appears on sections 27 and 28, land of O. W. Crawfis.

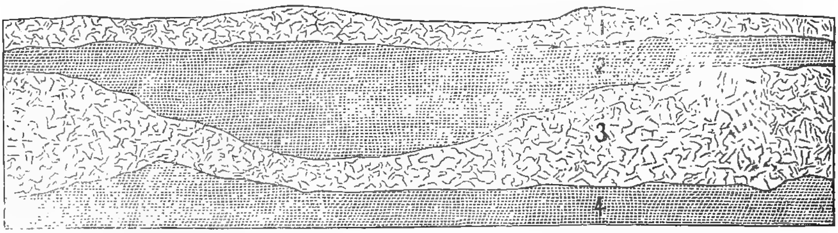
Occasionally, in the southern portion of the county, the Waterlime rises in gentle undulations, which are observable through the Drift. In such cases the rock is sometimes visible, and has been quarried. These undulations are not conspicuous enough to be known as "limestone ridges." Indeed, the rock is sometimes encountered in ditching in low, flat ground, where no change in the general level is observable. The rock is exposed in this manner on the land of N. W. Ogan, section 35, Pleasant township; also, S. W. ¼ section 36, on the land of D. Strow, in the same township; also, in sections 8, 17, and 16, Sugar Creek township, land of Jacob Rhodes.

The Drift in Putnam county, as in Hancock, seems to be thicker north of the Blanchard than south of it. The frequent exposure of the rock along the streams flowing northward in the southern portion of the county indicates that their channels are eroded as deeply in the Drift deposit as the inequalities in the rocky surface will permit. The average height of their banks will not exceed twenty feet; and twenty-five feet will probably exceed rather than fall short of the average thickness of the Drift. North of the Blanchard the average depth in the Drift of thirty wells reported by the County Surveyor, L. E. Holtz, of Ottawa, many of which did not strike the rock, is sixty-four feet. He gives but two south of the Blanchard, both of which are twenty-two feet, one being artesian.

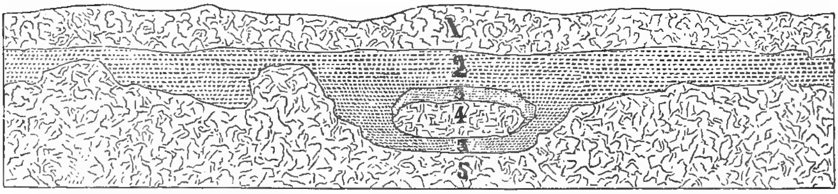
The materials of the Drift are rarely assorted or stratified, the great mass of it being a typical glacial hard-pan. Bowlders of all sizes are disseminated promiscuously through it. It is generally quite impervious to water, and sometimes artesian wells rise from the bed of sand and gravel which usually intervenes between it and the rock. Although the mass is unassorted, the ridges and knolls which occur in the northeastern part of the county, as well as the Van Wert Ridge, which crosses the south-eastern corner, passing through Webster, Pendleton, Columbus Grove, and Vaughansville, consist largely of assorted materials, usually of gravel and sand, in oblique stratification. Bowlders are very rarely seen in the county, except in the drainage valleys, where they have been washed out of the Drift. On the S. E. ¼ section 21, Jackson township, a large Corniferous bowlder lies in the channel of the river, having a height exposed of fifteen feet. A bowlder of granular quartzite lies on the land of William Evans, section 36, of the same township. It rises over three feet, and measures twenty-eight feet in circumference at the surface of the ground. On section 14, Monterey township, the land of Sebastian Bendley is very stony with bowlders over an area of about five acres, with few fragments of limestone. The surface rises about three feet.

The hard-pan itself sometimes embraces lenticular beds of stratified materials. The following were observed in the right bank of the Blanchard at Ottawa:

SECTIONS OF UPPER PART OF DRIFT AT OTTAWA, ON THE RIGHT BANK OF THE BLANCHARD.



No. 1.	Unassorted brown hard-pan	6 ft.
" 2.	Fine, yellow sand; stratified	4 ft. to 6 ft.
" 3.	Blue hard-pan	4 ft. to 6 ft.
" 4.	Clean, blue sand; stratified. Exposed	6 ft.



No. 1.	Brown hard-pan	10 ft.
" 2.	Stratified yellow sand	1 ft. to 6 ft.
" 3.	Fine blue sand	6 in. to 18 in.
" 4.	Isolated mass of blue hard-pan	1 ft.
" 5.	Blue hard pan	4 ft to 10 ft.

These beds of assorted materials cannot be traced far. They soon give place to the prevailing unassorted Drift, which may be seen near the highway bridge, N. E. ¼ section 28, Ottawa township. The river bank here is twenty-four feet from the surface downward, without showing any assortment. The brown color occupies the upper ten feet, and forms an ashen or light yellowish soil, with very little gravel. The right bank of the Blanchard, S. E. ¼ section 12, Greensburg township, exposes 29.8 feet in time of low water. The Drift here shows occasional patches of rude stratification, or a curly arrangement, but no distinct assortment.

In Liberty township fossil remains of the mastodon were discovered in ditching for the drainage of the Medary Swamp. At one point, forty rods south-east of the center of section 6, large bones, supposed to have belonged to that animal, were found in a sandy loam along the north side of the Leipsic Ridge. A large oak tree is said to have stood over the spot. In section 8 the remains exhumed consisted of fragments of a tusk about five inches in diameter, two teeth, and bones from the posterior extremities. They had the appearance of having been broken before being deposited in their present positions. The large bone belonging to the posterior extremities was removed twenty-three feet from the fragments of the tusk, and near it were no other remains. On its under side the natural surface had been fractured, and the cellular tissue exposed in large spots. With the exception of the teeth, nothing could be preserved entire. The whole lay about three feet below the surface. Throughout this swamp, so far as revealed by ditching, there is a deposit of six inches of black muck, underlain by two feet of nearly black clay, probably so stained by vegetable decomposition, and an unknown thickness of hard-pan, filled with gravel, on the original surface of which are occasional large bowlders. Large bones are also said to have been found near the surface of the Drift on Samuel Purkey's land, section 7, township of Ottawa.

MATERIAL RESOURCES.

The Waterlime in Putnam county is more than usually adapted to purposes of general building. While it is without that massive and rough condition so often seen in Wood and Ottawa counties, it still has not acquired the thin, laminated condition of the *Tymochtee slate* of Wyandot county. Hence the quarries of the county generally supply the demand for all stone, even the most massive, although the facilities of transportation by the Miami Canal are so ample that the "Dayton stone" of Prof. Orton, from the Niagara, is found in use in the western part of the county, as well as stone from the Lower Corniferous quarries at Charloe, in Paulding county. The surface of the Drift in Putnam county affords in many places a superior clay for tiling, brick, and red pottery. That used at Ottawa by Mr. Samuel Row and Mr. D. D. Mullet may be cited in illustration. It is almost entirely without stones and sand. The manufactured article is very firm and dense. A peculiarity was noticed at Mr. Row's tile-yard. Wherever they are touched by the hand, or bruised by contact with each other, or with the machinery, before burning, the pieces turn, in burning, to a light ash, or cream color, and come out of the kiln variously marked. Corners which had been trimmed with a knife are uniformly of this color, and very hard, almost glazed, the general color of the piece being brick red. Crevices within the clay contain small crystals, which are soft enough to be calcite, and have no taste. A bitter substance also oozes from the Drift, and forms incrustations on the surface along the banks of the Blanchard at Ottawa, which has the taste of Epsom salt. Water from many of the wells at the same place has, according to Dr. C. M. Godfrey, a cathartic effect, which is believed to be due to this substance. Samples were collected for analysis, but no opportunity has yet been afforded for making chemical determinations.*

Generally the county is well supplied with material for macadamized roads. The gravel from the ridges could be very advantageously used for the purpose of road-making, although it has been but very little developed.

Bog ore was encountered in a number of places within the county, as follows: Section 16, Liberty township, land of Adam Hammond; a small deposit so far as known. It is said also to occur about a mile north of Leipsic Station; also on section 26, Liberty township. On section 8, Perry township, land of E. Demick and Joseph Wollam, there are many indications of a deposit of bog ore. It occurs on section 16, Sugar Creek township, land of Cadwallader Jones.

Wells and Springs.—The following data, reported by L. E. Holtz, of Ottawa, the surveyor of the county, are of much interest in determining the depth of the Drift and the character of water usually obtained. Mr. Holtz has manifested an intelligent and active interest in all the objects of the Survey, and in many ways contributed to its prosecution:

WELLS OF PUTNAM COUNTY.

Owner's name.	Location.	Depth in the Drift.	Depth in the rock.	Total depth.	Remarks.
J. J. Smith	S. E. ¼ sec. 2, Ottawa tp.	70	......	70	
H. V. Watts	N. W. ¼ sec. 12, "	86	......	86	Good water; on the ridge 20 ft. sand, without water.
Wm. McCurdy	N. W. ¼ sec. 15, "	57	......	57	
M. Otto	N. E. cor. sec. 10, "	70	......	70	
Barney Loomis	S. E. ¼ sec. 1, "	58	......	58	
J. M. Elbert	N. W. ¼ sec. 14, "	69½	½	70	
A. Laubenthal	N. E. ¼ sec. 4, "	58	......	58	Good water; comes within 3 ft. of surface.
B. Leopold	N. E. ¼ sec. 22, "	58	15	73	Poor water.
George Skinner	N. E. ¼ sec. 27, "	57	......	57	Good water.
Putnam county fair ground	Near W. line sec. 26 "	47	......	47	Good water; north of the river but little water.

* This was chemically examined by Mr. O. C. Johnson, of the *Chemical Laboratory* of the University of Michigan, and was found to consist principally of Epsom salt.

WELLS OF PUTNAM COUNTY.

Owner's name.	Location.	Depth in the Drift.	Depth in the rock.	Total depth.	Remarks.
Catholic Brotherhood	S.E.¼ sec.12, Greensb'g tp.	47	......	47	Good water.
Timothy Downey	S.W. ¼ sec. 16, Pleasant tp.	22	......	22	" artesian.
Samuel Vanbuskirk	S. W. ¼ sec. 5, Reilly tp.	22	......	22	"
—— ——	Sec. 30, Van Buren tp.	80	......	80	At Leipsic Station.
C. Winegardner	N.W. ¼ sec. 31, "	85	18	103	Good water; but little.
William Nash	....	59	......	59	Good water.
A. Blanvelt	N. E. ¼ sec. 8, V. Buren tp.	60	5	65	Rises within 10 feet of the surface.
A. Mooney	Sec. 20, "	58	4	62	Good water.
F. Miley	N. E. ¼ sec. 21, "	76	......	76	Good water; mostly through blue clay; water on striking the rock.
S. Kitchen	S. E. ¼ sec. 6, Ottawa tp.	60	......	60	
Jacob Hardick	Sec. 1, Liberty tp.	58	......	58	Good water; stands within 7 feet of the surface.
William Krauss	Sec. 9, "	80	1	81	Good water.
George Hummond	S. E. ¼ sec. 16, "	93	14	107	Poor water; very little.
Adam Hummond	" "	94	1	95	Good water.
John Ruff	N. W. ¼ sec. 29, "	68	3	71	"
H. Monteith	S. E. ¼ sec. 15, "	81	4	85	"
Joseph Seifker	S. W. ¼ sec. 21, "	67	......	67	Good water; stands within 12 ft. of the surface.
John Kearns	N. E. ¼ sec. 24, Palmer tp.	62	......	62	Good water.
Aaron Donaldson	S. E. ¼ sec. 16, Monroe tp.	47	2	49	Irony; comes within 15 ft. of the surface.
A. C. Smith	N. W. ¼ sec. 22, "	50	......	50	Good water; comes within 12 ft. of the surface.
H. Wing	N. E. ¼ sec. 24, "	37	2	39	Good water; comes near the surface.
John Connett	N. E. ¼ sec. 15, "	......	......	......	Artesian; in the bottom land of Powell's Creek.
William Guy	Sec. 23, "	39	......	39	Good water.
Calvin and Breck	N.W. ¼ sec. 17, Richfield, Henry county	47	17	64	Good water; stands within 23 feet of the surface.
Charles Horning	Sec. 22, Pleasant tp., Henry county	86	......	86	

Mr. Holtz says there is a fine, black sand, varying from two to fourteen feet, next the rock. He very reasonably suggests that many of these wells, in which the water stands so near the surface, would prove to be artesian if properly tubed, the occurrence of seams of sand allowing the lateral escape of the water before it reaches the surface. It is also very likely that many of those wells supposed to penetrate the "bed-rock" have only been drilled into some of the bowlders which often form a deposit varying from three to fifteen feet near the bottom of the hard-pan.

A strong "sulphur spring," rising from the rock, occurs on the land of

Judge J. Y. Sackett, S. E. ¼ section 36, in Ottawa township. Although not so copious, it has probably the same origin and nearly the same chemical composition as the Green Spring mineral water of Sandusky county. Its taste and odor are undistinguishable from that, and the water precipitates similar substances over the surface of the ground where it spreads. Another spring of the same character is on Mr. U. Y. Rice's land, section 8, Reilly township.

CHAPTER XLV.

REPORT ON THE GEOLOGY OF ALLEN COUNTY.

BY N. H. WINCHELL.

SITUATION AND AREA.

Allen county lies south of Putnam, is bounded east by Hancock and Hardin, south by Auglaize, and west by Van Wert. It is separated from the Michigan boundary line by three intervening counties, and from the Indiana line by one. Its area is nine square miles more than eleven towns of thirty-six square miles each.

NATURAL DRAINAGE.

The streams which drain the county are small, and flow west and south-west in the eastern half of the county, but turn toward the north in the western half. This is true not only of Sugar Creek, the Ottawa (known also as Hog Creek), and the Little Ottawa, which form such angles within the county, but also of the Auglaize, which rises in the south-east corner of the county, leaves it in a south-westerly, then re-enters and crosses it in the western part in a northerly direction.

SURFACE FEATURES AND SOIL.

The western half of the county is flat, and presents the common features of the Black Swamp. The banks left by the erosion of the streams are from ten to fifteen feet in height above the summer stage of the water. The Auglaize below Cramersville (section 3, Marion) has frequent exposures of the rock. Also, in the township of Amanda, near the county line, the rock forms the bed of the river. In general, however, the bed of the river is on the Drift materials. The same is true of the Ottawa. The soil of this portion of the county is usually a close, heavy clay. There are places, however, where considerable alluvium is spread over the surface of the Drift, incident to the overflow of the streams. Occasionally, as in the Van Wert Ridge, which passes through the townships of Marion and Sugar Creek, gravelly soils appear in the midst of the prevailing clay. Such tracts are uniformly more elevated, and slightly rolling. The eastern portion of the county has a different general contour. It is separated from that already described by, and is co-extensive with, the westward course of the streams. It is undulating or gently rolling, and in the south-eastern corner of the county is characterized by prominent gravelly ridges and knolls. This undulating surface prevails over most of the township of Sugar Creek, but is more or less wanting in Richland and Monroe townships. There are likewise some flat and prairie-like tracts even in Auglaize and Perry townships. In the former, sections 11, 12, 13, and 14 have this character. In the latter there is much flat land in the vicinity of Amherst. The soil in the eastern portion of the county is generally the same as that of the western. Its chief element is clay, yet it contains much more gravel, and sometimes stones and bowlders. In the settlement of the county these elevated knolls and ridges were first selected. That tract of rolling land known as the "Dividing Ridge," in the south-eastern part of the county, is at the present time in marked contrast with much of the adjoining country. It is occupied by handsome, well-drained, and well-cultivated farms, the native timber having been nearly all removed, while on either side much of the country is still in its primeval state. Throughout this tract the rock is occasionally seen in the beds of the streams. The banks of the streams are usually higher than in the western part of the county. The banks of the Ottawa at Lima are about thirty feet, and continue of that height for two miles above the city, the water running on the surface of the rock.

GEOLOGICAL STRUCTURE.

With the exception of a small area in the south-eastern corner of the county, the underlying rock belongs to the Waterlime.

The Niagara is quarried by Mr. Alexander E. Kerr on section 30, Auglaize township. It presents the features of the Guelph phase, in vesicular beds of two to three inches, and lies horizontal or dips gently toward the north. It is of a bluish-gray color, and some portions of it are firm and crystalline. About eighty rods north-west from Mr. Kerr's quarry is that of Mr. Alexander Crepps, where the stone is slightly different from Mr. Kerr's. There was not sufficient exposure to indicate whether it be Niagara or Waterlime, although the evidence was, so far as seen, in favor of the latter. The Niagara is again seen in the bed of a small tributary to the Auglaize, on Mr. Hay's land, N. E. ¼ section 22, and in a similar situation on Mr. Harrison Clawson's land, N. E. ¼ section 21, both of the same township. Mr. Hay has not opened his for use, but Mr. Clawson has taken a few stone from his for ordinary foundations. So far as seen, this stone is the same as that in the quarry of Mr. Kerr, in section 30.

The Waterlime in Allen county shows almost every where only the features of the *Tymochtee slate.* The beds vary from an eighth of an inch to eight inches, but are usually not over two inches in thickness. Their color is either blue or a bluish drab, with black films of bituminous matter between the bedding. These films are themselves so largely developed in some places, and the more calcareous beds are so thin, that the aspect of the rock is that of a bituminous slate. By reference to the Geology of Wyandot County a more complete account of this phase of the Waterlime may be seen in the description of the section taken from the banks of the Tymochtee in Crawford township.

In Richland township the following persons work the Waterlime, exposed in the bed of Reilly Creek, near Bluffton, viz., Reese and Siddall, for common stone and for lime-burning; Barney Huttinger and J. H. Eaton. Mr. Eaton also burns lime. John Shoemaker has a working in the same stone three miles north-west from Bluffton, in the bed of the creek.

In Auglaize township the Waterlime appears, and has been somewhat used for general purposes and for lime, on the land of David Crall, section 17, taken from the bed of the stream. Beds here are about two inches in thickness.

In Bath township the quarry of Alexander Miller. S. W. ¼ section 29, supplies an even-bed, flat stone, of a blue color, about three inches in thickness, which is largely used at Lima and other places for flagging. The beds, however, occasionally become six inches thick, when they are valuable for walls, and command a good price for all uses. They are easily cut and broken, by the usual means, into such sizes and shapes as may be needed, the fracture being straight and running like the fracture of glass under a diamond. The best stone is delivered at Lima for $1.50 per perch. The amount of exposure here is about three feet perpendicular, the beds lying horizontal.

On the S. W. ¼ section 28 Dague & Brothers have a quarry in the Waterlime. Another occurs on the land of J. Fetter, N. W. ¼ section 26. That of J. Custer is on the S. W. ¼ section 24. It furnishes a rough, dark-drab stone, in beds of three to six inches, with more or less interstratification of thinner and more bituminous layers. One mile below Custer's is Samuel McClure's quarry. Daniel Miller's quarry is on section 8, in the bed of Sugar Creek, the stone supplied being a fair representation of the Tymochtee slate. It lies in thin, blue layers, with black, bituminous films separating the beds. The edges of the bedding are sometimes horizontally streaked with bluish drab. The best stone here is three inches thick. It brings $1 per perch for walls at the quarry. Second grade stone for walling is sold at the quarry for 62½ cents per perch; third grade for walls (½ inch to 1 inch), 37½ cents per perch. Three grades of stone for flagging are sold as follows:

First grade, delivered in Lima, per 100 square feet	$3 25
Second grade, " " " "	$2 25 to 2 50
Third grade, " " " "	1 75

At Lima, in Ottawa township, the quarries of Delzall and Overmeyer and of Wadhams and Bowers are situated in the Ottawa, and are principally occupied in lime-burning. At the former about four and a half feet are seen in beds of one to two inches. Some of it is rough and vesicular, but in beds not over six inches. Stone has also been taken from the bed of the Ottawa, at Lima, on T. K. Jacobs's land.

Near Gomer, in Sugar Creek township, the bed of the Ottawa is rocky. It may be seen on the land of Isaac H. Clevenger (section 20), where it lies in thin, horizontal beds; also on the land of David Roberts, near the county line, where the beds are three to four inches, and dip south. Formerly stone was taken from the same creek at Allentown, section 29, German township.

In the township of Marion the Waterlime shows in the bed of the river, N. E. ¼ section 28, and on David Robinson's land, S. E. ¼ section 21. Some has been taken out at the latter place in blocks six inches thick. The abutments of the highway bridge over the Auglaize at this place are of Waterlime blocks, twelve to sixteen inches thick, like the stone obtained from Bœhmer's quarry at Fort Jennings, in Putnam county. They are capped with sawn blocks of Lower Corniferous from Charloe, in Paulding county, and angled with blue Niagara from Piqua, in Miami county. The Waterlime has been slightly worked in the bed of the Auglaize at various points near Cramersville (section 3). Such quarries are owned by W. V. Scott and John Welsh. Mr. Welsh also burns some lime. John A. Seitz also runs a lime-kiln, S. E. ¼ section 35.

In Amanda township the chief exposures of the Waterlime are in the Auglaize, near the county line. It occurs in blue layers on the land of Samuel Stewart, N. E. ¼ section 9. On the N. E. ¼ section 15 it lies in thin, blue layers on the land of William Bice; and on the S. E. ¼ of the same section, between Mr. James Sunderland's and Mr. Samuel

Anderson's farms, the following section may be taken from the bed of the river:

No. 1.	Soft, porous, gray, and chalky in spots. In every respect similar to No. 1 of the section taken from Anderson's quarry, on section 22, Pitt, Wyandot county	8 inches.
" 2.	Hard, massive, or thin-bedded; dark drab; flinty; laminations irregular, sometimes coalescent. This is the equivalent of No. 2 of Anderson's, in Pitt, Wyandot county. Irregular surface exposure, showing a perpendicular section of perhaps	6 "

In Spencer township the Waterlime appears in the bed of Jennings's Creek, in section 14, where it is quarried for quicklime by C. C. Marshall. The beds are two to four inches thick.

The Drift.—The character and the materials of the Drift in Allen county are the same as already described in other counties in north-western Ohio. The peculiar features of this deposit, which may be seen in the south-eastern corner of the county, are fully described in a previous chapter. There is a more frequent occurrence of stratification and assortment of the Drift in the eastern half of the county, where the streams all flow toward the west or south-west, than in the western half. It seems also to be arranged in a series of broad north-east and south-west ridges, or swells, the intervening valleys being occupied by the streams, which necessarily conform to the direction of the main valleys. The average thickness of the Drift in the county can not be stated, but it is probably not over seventy-five feet. It seems thicker in the eastern than in the western half of the county. At Lima gravel beds are seen in the Drift, and in some instances near there the gravel rises to within three or four feet of the surface. It shows the usual tortuous, glacial stratification, and is embraced within the St. Mary's Ridge. It is utilized by Mr. Alexander Miller and Dr. E. Ashton for road-making, the finer parts being used for mortar.

MATERIAL RESOURCES.

Besides the strong and deep soil with which the county is every where covered, and in which consists its chief source of material wealth, the county has little to depend on in the products of its geological formations. Indeed, the most of the county is poorly supplied with stone for common foundations. The Niagara, in the south-eastern part of Auglaize township, is of the Guelph, or upper portion of that great member of the Silurian age, and is an inferior stone for building. For quicklime it is well adapted. It affords a strong, white lime, which acts quick, and is easily burned. The quarries which have been opened in it have not been systematically prosecuted, a fact which has served not only to reduce the derivable income, but also to discourage others from similar industry. Where the overlying Waterlime occurs in thick beds it could be profitably worked, but there are no considerable openings in such beds within the county. The formation is chiefly wrought in its thinner, blue layers, owing to the evenness of the stone, and the ease with which it can be obtained. Much of this kind of stone is used for flagging at Lima, Bluffton, and Delphos. Some of the best quarries are located at Lima, and afford also a handsome stone for walls and foundations. The quicklime made from the Waterlime at Lima not only supplies the local demand, but is used in the surrounding country. The product of a single firm, Delzall and Overmeyer, amounts to about twenty thousand bushels per year. Other kilns would increase the annual product of quicklime to at least thirty-five thousand bushels. In the summer of 1871 the retail price per bushel was twenty-five cents. In wholesale amounts the price of lime delivered on the cars was twenty-two cents per bushel. In the eastern part of the county gravel for roads and sand for mortar are not uncommon in the knolls and short ridges of the rolling tracts. Clay, also, suitable for red brick and pottery, is abundant in all parts of the county. There are, probably, but few square miles, if any, within the county from which good brick could not be manufactured—a statement which is equally applicable to most of the Fourth District of the State. Brick-yards are met with at the following points, the clay being taken from surface of Drift:

S. E. ¼ section 24, Marion township, Richard Evans; Beaver Dam, section 29, Richland township, Rich and Lewis; Bluffton, Dr. H. P. Eaton; Bluffton, Lewis and Baker; Lima, John P. Haller; Lima, Lewis Gottfried; Delphos, Joseph Fetter.

Wells and Springs.—Wells for domestic and farm-yard purposes usually find water in the Drift deposit. Such water most frequently springs from the gravel or sand reservoirs embraced within the Drift, or lying between the hard-pan and the rock. In the eastern portion of the county, in rolling or undulating areas, such gravel deposits are usually met before penetrating to the bottom of the Drift; but in the western part, where the country is flat, the only gravel bed which supplies water seems to be on or near the bed-rock. Wells, however, on the Van Wert Ridge, in the northern part of Marion township, reach good water at ten or twenty feet, in gravel which lies above the great mass of the Drift. A short distance either side of this ridge wells have to be dug much deeper.

Strong mineral springs issuing from the rock occur in various parts of the county. While they rise immediately from the Waterlime, their origin is believed to be in the Niagara. They are known as white sulphur springs. One occurs on section 7, Bath township, on the land of John B. Miller; several others on section 8, land of Daniel Miller; and another at Bluffton, which rises with an artesian overflow from a well drilled to the depth of one hundred and twenty-nine feet. The source of the water in the Bluffton well is said to be near the bottom, and must be in the Niagara. These springs deposit a white or creamy coating near the source, and where the current is rapid; but in still water, and at points more remote, every thing over which the water passes is of a purplish black. An offensive gas, like sulphureted hydrogen, escapes from the water, and can be perceived for some rods. It is only by a chemical examination of these springs that they can be distinguished from similar springs met with in Seneca, Sandusky, Ottawa, Hancock, and Putnam counties.

CHAPTER XLVI.

REPORT ON THE GEOLOGY OF AUGLAIZE COUNTY.

BY N. H. WINCHELL.

SITUATION AND AREA.

Auglaize county lies immediately south of Allen. It is bounded east by Hardin and Logan, south by Logan and Shelby, and west by Mercer. Its county seat, Wapakoneta, is situated on the Auglaize River, thirty-six miles from the Indiana State line, and seventy-nine from the Michigan State line. The area of the county is three hundred and ninety-eight square miles. It has an irregular general outline. Its length east and west is about thirty-nine miles. Its width varies from seven and a half to twenty-three.

NATURAL DRAINAGE.

Its situation is near the summit, but on the north side of the broad watershed between the Ohio and Lake Erie. Indeed, some portions of it are drained southward through the Muchinippic Creek into the Miami River. It necessarily contains no large streams. Those in the eastern part of the county present the same peculiarity of direction as already noted in the case of the streams of Allen county. They flow toward the south-west or west, turning at right angles toward the north-west or north. Some of those again which have acquired a northerly direction are diverted a second time from their most direct course, and are made to run diagonally across the general slope of the country. Thus the St. Mary's, after passing one such barrier at the village of St. Mary's, encounters a second near Kossuth, which it cannot pass, but maintains a diagonal instead of a direct descent to its junction with the St. Joseph, in Indiana. These streams are to a great extent dependent on springs from the gravelly reservoirs embraced within the Drift. The St. John's Ridge serves at once as a barrier to the Pusheta Creek, which flows along its upper or southern side, and as the reservoir from which flow northward a number of the tributaries of the Auglaize. Gravelly deposits in the same ridge give rise to springs in such numbers in the western part of the county that, by the action of the Wabash Ridge, they unite to form the St. Mary's River. Such streams are less influenced by seasons of drouth, and are more reliable for water-power. They are, however, so small in Auglaize county that, with the exception of the St. Mary's and some parts of the Auglaize, they cannot be extensively utilized in that way. The Miami Canal furnishes good water-power at its various locks, which is generally improved for flouring or manufacturing purposes. The aggregate descent in the grade of the Dayton and Michigan Railroad from Botkin's Station, near the southern boundary of the county, to Criderville, near the northern, is one hundred and twenty-seven feet.

SURFACE FEATURES AND SOIL.

Auglaize county, although showing many of the features of the Black Swamp, both in surface contour and soil, has many exceptional features that indicate its border situation. The townships of Salem, Noble, Moulton, and Logan may, perhaps, be strictly included within the scope of that term; but the most of the county is more undulating, and the Drift is more gravelly, and more frequently shows an assortment of its materials than the level tract usually embraced in that designation. The features of the Black Swamp fade out gradually toward the south, and the characters which prevail in the various moraine-like ridges which cross it are spread more generally over the whole country. These changes become very perceptible in crossing the ridges at right angles from the center outward. Auglaize county is affected by three of these ridges. The outer and older is characterized by a succession of gravelly knolls and short ridges, having often a very rolling surface. It has a width which varies from one-half mile to three miles. It crosses German township, the north-west corner of Shelby county, Pusheta, Clay, and Union townships. New Bremen, Botkins, and St. John's are situated on it. Owing to its remarkable development at the last-named place, it has been named the *St. John's Ridge.* Another gravelly ridge, called the *Wabash Ridge*, intersects the county in a similar way, passing through St. Mary's, Moulton, and Duchouquet townships. It is intersected by the Auglaize at Wapakoneta. The third passes through the northern part of Salem township. This is simply a broad, gentle undulation, or thickening of the Drift, and seems to consist of clay. If it contains gravel, it lies at considerable depth, as seen at Lima, where the Ottawa River makes through it. It has been fully described in a preceding chapter, under the name of the *St. Mary's Ridge.* Between these ridges the country is sometimes quite flat, but more frequently undulating in Auglaize county.

In the townships of Wayne and Goshen, on the summit of the great watershed, the drainage is so imperfect that considerable territory is in the condition of swamp or wet prairie, on which stand several inches, or feet, of water during the wet months of the year. These areas are mainly without forest, and have a peaty soil. They are in the eastern part of the county, and are drained southward into the Miami River.

The soil of the county is essentially clay. Various local circumstances have caused accidental qualities to greatly modify it. Along the river bottoms, the rich, sandy loam resulting from the annual wash of the streams upon the Drift banks adjoining, has always been prized for the quickness of its crops and the ease of tillage. In places poorly drained there is an accumulation of animal and vegetable debris which, undergoing slow decay, adds considerable ammonia and phosphorus to the original Drift soil The farms on the ridges, particularly the St. John's Ridge, are characterized by a gravelly clay soil. In short, wherever the drainage is rapid, so as to carry away the finer constituents of the Drift soil, there is found a greater amount of gravel. Stones and bowlders very rarely disturb the plow in Auglaize county. Wherever they occur they seem to have been washed from the materials of the Drift by rapid drainage.

The streams have a flood-plain, and a single bench, or terrace, worn out of the drift deposit. The height of these at any point depends on the swiftness of the current, the amount of set-back in the water, and the undulations in the original Drift surface. The flood-plain usually is from three to six feet above the summer stage of the water, but it sometimes rises to ten or twelve. The Drift banks of the Auglaize and the St. Mary's rivers are usually about twelve feet above the summer stage of the water. Where they cross the ridges the exposed section is much more, sometimes reaching twenty-five or thirty feet.

GEOLOGICAL STRUCTURE.

There is but a single exposure of the underlying rock within the county. Hence but little is known of the details of its geological structure. In general, however, judging from the known formation of surrounding counties, the Niagara limestone must underlie the townships of Wayne, Goshen, Clay, Pusheta, Washington, Jackson, German, and St. Mary's, the boundary line between it and the Waterlime passing south-westwardly through the township of Union, and north-westwardly through Noble, and about a mile south of Wapakoneta. The remainder of the county is underlain by the Waterlime formation. The only exposures of this stone within the limits of the county are in the bed of the

Auglaize River, section 22, township of Logan. It is worked for foundations and for walls, as well as for flagging; and being the only stone obtainable within a radius of many miles, particularly toward the south, east, or west, it obtains an extensive sale. The *Dayton stone* is, however, principally used for heavy walls and for abutments in all the western portion of the county. The most important opening in the Waterlime is that of Mr. George Lathrop, although it is also quarried by Mr. Russell Berryman, Mr. J. Pierson, and Mr. Benjamin Backus. The stone is generally thin-bedded and blue, with much bituminous matter, presenting the features of the *Tymochtee slate.* It is usually not well adapted to lime-burning, although some of the beds, particularly those which are thicker and irregular, or vesicular, could be profitably employed in that way.

The Drift.—The composition of this deposit in Auglaize county is not noticeably different from that already described in giving the geology of adjoining counties; yet the proportions of its constituent parts seem to undergo a gradual change toward the south. The clayey element is more frequently replaced by assorted sand and gravel. These materials seem to be embraced within the clayey hard-pan, and to be developed upward through it, from the gravel and sand bed which often lies on the rock, and which even in the Black Swamp forms the lowest part of the Drift deposit. They are, however, undoubtedly disseminated in detached beds, or pockets, through the whole thickness of the Drift. In the ridges which have been mentioned as crossing the county these coarse materials greatly predominate, always showing an arrangement in beds, and exhibiting most perfectly the oblique stratification which in a former chapter has been attributed to the effect of streams of water issuing from the melting ice of the glacier. Yet even here these beds are almost every where buried beneath a greater or less thickness of unassorted Drift, which has every appearance of that which covers them generally throughout the country, and which every where forms the soil, unless it has become covered with subsequent alluvium. Where the action of the glacial streams was intensified by the geological conformation of the surface, or by the occurrence of canons or crevasses in the ice, or was prolonged at a single point, this stratification and assortment of the Drift would be best developed. Such seems to have been the case in the vicinity of St. John's. Bowlders are not common in the county. They are usually altogether wanting in the level or gently undulating tracts lying between the ridges; but in the vicinity of the ridges, and on them, especially in the drainage valleys which sometimes intersect them, they are very often seen. Although the greater part of them are derivable from the Devonian and Silurian limestones of north-western Ohio, there are also many which must have had a more northern origin. In the absence of positive data, the thickness of the Drift deposit at any point in Auglaize county cannot be stated with certainty. Wells only penetrate to the water-bearing gravel or sand, which is generally less than fifty feet, although some have been known to go upward of seventy feet before striking gravel or sand in sufficient quantity to furnish a constant supply of water. The average thickness, however, is not believed to be much greater or less than in the eastern half of Allen county. The lack of rock exposure, while it indicates a greater accumulation of Drift, may be due to the absence of large streams capable of eroding the deposit to the rock.

MATERIAL RESOURCES.

It is evident that the material development of Auglaize county will not be from the geological stand-point, except so far as the materials of the Drift may be made to subserve the comfort and convenience of its inhabitants. These materials themselves have a geological origin, and give character to the soil. Thus geology antedates agriculture; and in that sense even the agricultural resources of the county may be said to be of a geological origin. Aside from this, however, the Drift of the county is rendered abundantly useful. It supplies an excellent clay every way suited for the manufacture of brick, tiling, and pottery. The gravel of the ridges which cross the county, wherever it is revealed, is made to subserve the purposes of road-making, though not to that extent that its proximity and the ease with which good roads can be made by its use would indicate and demand.

The following establishments for the manufacture of brick and tiling were met with in the survey of the county. There may be others:

Michael Stenger, Wapakoneta..........Brick.
John P. Fus, " .... "
Christ. Haeisler, " ....Tiling.
A. P. Rheinhardt, N. E. ¼ section 21, Union..........Brick and tiling.
William Lemon, section 12, " ....Brick.
David Gilmore, N. E. ¼ section 1, " .... "
Quincy Hufferd, two miles west of Roundhead, near the east county line..........Tiling.
Philip Knairr, Fryburg..........Brick.
Ernest Hilgeman, New Bremen .... "
William Langhorst, " ....Tiling.
William Barth, S. W. ¼ section 5, German ....Brick.
Barney Ortman, Minster .... "
Theodore Dickman, " .... "
Cook and Meckstroth, section 30, Washington..........Tiling and Brick.

The principal banks opened for gravel occur at St. Mary's and Wapakoneta, at both places in the Wabash Ridge. The St. John's Ridge is also opened for gravel a short distance north-east of New Bremen and at St. John's village.

A deposit of mineral paint, or ochre, in the S. E. ¼ section 34, Union township, was met with on the land of John Neal. The soil about is red as with iron peroxide, and indicates the proximity of a bed of bog ore. The ochreous deposit also spreads over the land of William Giberson. If this deposit of ochre, on examination, should prove to be extensive, it might be made of considerable economical value in the manufacture of a mineral paint.

CHAPTER XLVII.

REPORT ON THE GEOLOGY OF MERCER COUNTY.

BY N. H. WINCHELL.

SITUATION AND AREA.

Mercer county lies on the Indiana State line. Its form is that of a regular parallelogram, twenty-six miles in length north and south, and eighteen in width, embracing thirteen towns of thirty-six square miles each. It is bounded north by Van Wert county, east by Auglaize, and south by Darke.

NATURAL DRAINAGE.

The natural slope of the whole county is toward the north, and the small streams which take their rise between the ridges run uniformly in that direction. Encountering the ridges, they unite to form one main stream along the upper or outer side of each ridge, which then flows diagonally across the general slope toward the west or north-west, following the direction of these barriers. Thus the small streams which form the Wabash rise in Darke county or the extreme southern part of Mercer, and run north till they meet the St. John's Ridge, when they are diverted westward. Before the Wabash leaves the county it crosses this barrier near Fort Recovery, owing, probably, to the very gravelly character and the rolling surface of the Drift prevailing in that section, and then follows the natural, direct descent till it meets the Wabash Ridge. This it is not able to pass, but follows it into Indiana. It finally is carried in this way over the great watershed; or rather, the great watershed verges so far north as to appear on the other side of this ridge, allowing the Wabash to join the Ohio toward the south. A number of other streams of Mercer county are in the same way diverted westward by the Wabash Ridge. On the north of this ridge the streams have a northerly direction to their union with the St. Mary's, when, with it, they are carried along the southern side of the St. Mary's Ridge till, meeting the St. Joseph at Fort Wayne, Indiana, their united waters have succeeded in passing the ridge.

SURFACE FEATURES AND SOIL.

The surface of the whole county is a continuous plain, and the changes of level in general are due to the inclination of the rocky floor beneath. Gentle undulations and local changes of level are, however, due to the condition of the Drift deposit. In no county in north-western Ohio has that dependence been seen more perfectly exemplified. The whole county is underlain by the same member of the Silurian age, except a small area in the north-eastern corner, which does not offer such differences of character as to permit unequal erosion by the great glacier. Yet there may be seen crossing the county three successive ridges, or belts of thickening of the Drift deposit, which rise from ten to twenty-five or thirty feet above the general level. The location and character of these ridges have been sufficiently discussed in foregoing chapters. It is only necessary to say at this place that they are believed to be glacial moraines, marking periodical resting-places in the retreat of the glacier, which was prolonged south-westward from the great St. Lawrence valley. In crossing these ridges in a southerly direction the face of the country is seen to change, not uniformly, but by successive stages, marked by the location of the ridges. That part of the county north of the St. Mary's Ridge is flat, and has a close, often damp, clay soil. That portion between the Wabash and the St. Mary's Ridges is also flat, but is characterized by several prairie tracts. It shows very rarely any gravel in the soil or stones on the surface. It is also, strictly, a portion of the Black Swamp, and has all its features. Between the Wabash and the St. John's Ridges the surface has a very noticeably rolling contour, although with some flats. The soil is sometimes gravelly. The color of the clay is somewhat lighter, and in general it is more easily subjected to perfect artificial drainage. That portion of the county south of the St. John's Ridge is still more gravelly and rolling.

GEOLOGICAL STRUCTURE.

The only rock seen in outcrop within the limits of Mercer county belongs to the Guelph phase of the Niagara. These exposures, however, extend over the entire length of the county from north to south, and there can be but little doubt that that rock underlies the greater part of the county. It has not been seen in the eastern portion. Near Fort Recovery, section 19, it is slightly worked and burned for quicklime by Thomas Atkinson. It is taken from the bed of the Wabash. It is porous and fossiliferous, in beds of three to six inches. It is generally of a light blue color, with spots of a darker blue, weathering buff or white.

It makes a white lime of great quickness and strength. The Niagara is again seen in the Wabash, N. W. ¼ section 33, in Washington township, on the land of John Oswald; and near the same place on the land of Seth Snyder, at the junction of the Totti Creek with the Wabash. It appears again in the Wabash, N. W. ¼ section 22, of the same township, land of Philip Gardner. It is also said to have been formerly taken from the Wabash at Monterey for quicklime. In sections 7 and 8, Jefferson township, the Niagara rises near the surface of the Drift and is seen in a number of exposures. On the S. W. ¼ section 7 it is worked by Dr. Walter. The stone is here similar to that seen in the Wabash at Fort Recovery. The beds are about three inches in thickness, lenticular, vesicular, fossiliferous, rapidly rusting with peroxide of iron. It finally weathers a light buff. Exposure, about three feet; dip, undistinguishable. On the S. W. ¼ section 8 Mr. Thomas Godfrey has a quarry in similar beds for purposes of lime-burning, and has opened them to the depth of about four feet. On the N. W. ¼ section 8 Herbert Richardson owns a quarry in the same beds. The dip here is unmistakable, and about eight degrees toward the south-west. The beds are here exposed to the depth of about nine feet, without showing much variation. In the State survey of the Wabash for ditching purposes, the surveyor reports rock struck at thirteen different places, in all cases but one covered with alluvium or Drift, sometimes to the depth of eleven feet. At a point three miles west of Celina the rock was not so covered, on land of Herbert Richardson and Sylvester Brooks. It is said to have a dip to the south. On the N. E. ¼ section 32, Liberty township, Joseph Felver has taken stone from the bed of the Wabash. Near the State line D. W. and John Leininger have quarries in the valley of the Wabash, on opposite sides of the stream. It is here of the same character as already described, and belongs to the Guelph of the Niagara. This character of the formation prevails as far west at least as New Corydon, in Jay county, Indiana, where it is quarried and burned for lime. It is also met at Willshire, in Van Wert county, where Mrs. Ann Ramsey has burned lime and taken out stone for foundations from the bed of the St. Mary's and of a small stream tributary to it. The dip here cannot be made out with certainty. It is a porous and fossiliferous rock, in beds of about three inches, of a light blue color when freshly broken, but which soon weathers buff. On section 8, Dublin township, within the limits of the Godfrey Indian Reserve, Mr. Claiborne Work has opened a quarry in the river bottoms of the St. Mary's, disclosing the same characters of the Niagara. This quarry at the present time affords feeble opportunity to examine the formation, yet pieces which were gathered near the opening are porous, and bleached nearly white. This stone here affords a quicklime of superior quality. Stone was formerly taken from the bed of the St. Mary's at Mendon, but the place is now inaccessible, and no inspection of its characters could be made. It is, however, believed to be the same as that seen near Shanesville, in the quarry of Mr. Work.

The Drift—The characters of this deposit are such as prevail throughout the Black Swamp generally, although much of the southern part of the county is more broken and gravelly. Its chief constituent is clay, which, below ten or twelve feet, is blue, but to that depth is of a yellowish or light brown color. The original color of the whole was probably blue, the brown or yellow colors being due to oxidation from above. No distinct, constant characters, or line of demarkation separating the brown from the blue, indicative of different or successive origins or deposition, have been seen in the county, nor in north-western Ohio. On the contrary, the colors have been seen to gradually fade into each other in a great many instances. This clay is usually a compact, unstratified mass, impervious to water, and embracing stones and bowlders of all sizes up to several tons weight. At Mercer, in Dublin township, and throughout a radius of four or five miles, it acts as the confining stratum for a number of artesian wells which flow from sand at the depth of thirty-five or forty feet, the water rising from five to eight feet above the surface. Such wells may be seen on the farm of Mr. J. Keith. Near Celina, on the north side of the Big Beaver River, it has afforded a great number of bowlders of the Lower Corniferous, some of which have been worked into stone for building. They are met near the surface in plowing the field. One was worked up on the land of Mr. Petre, which furnished eight or ten wagon-loads of good blocks, suitable for common building purposes. The ridges which cross the county consist of gravel and sand in glacial stratification, usually overspread by a few feet of this clay. The thickness of the Drift can not be stated. A well at Shanesville was in the blue clay, at a depth of sixty feet, without water.

MATERIAL RESOURCES.

The soil of Mercer county will necessarily always be the source of its greatest material wealth. It will, however, reach its highest development and yield its greatest revenue only when it has been subjected to thorough artificial drainage, and to careful and skillful tillage. Much of the county is still covered with forest, while the soil of that which has been occupied by farmers is not infrequently too damp and cold to bear a high market price. There is no doubt that the agricultural development of Mercer county has been, and still is, retarded by the lack of railroad communication. The common roads are almost impassable in the wet seasons of the year, and the shipment of the products of the farm through the Miami Canal is not only difficult, but also expensive. Thus the income of the farm is often not pushed beyond the necessities of the occupant. Improvements are retarded, and the growth of the county correspondingly slow. The rock which underlies the county will answer for common use in foundations and walls, and will be a great convenience in the manufacture of lime for the local market. When the facilities for shipment become greater, there is no reason why the Niagara in Mercer county may not be extensively and profitably burned into quicklime. It will certainly compare favorably with any manufactured in north-western Ohio. At the present time the quarries in the Niagara at Piqua furnish most of the building stone used in the county. Gravel and sand are taken from the St. John's Ridge, near Fort Recovery, and from the St. Mary's Ridge, near Shanesville. At the latter place it is on the land of Jeremiah S. Decker. At the same place a bed of bog ore is said to occur on Squier Dilbone's land.

For brick, tiling, and common red pottery, the surface of the Drift is generally well adapted, and a number of establishments of that kind are already in existence. The following were noted in the survey of the county:

Gast and Gake, St. John's	Brick.
John Hargedorn, section 20, Marion township	Tiling.
Antony Horst, section 30, Marion township	Brick.
Herr Von der Bush, section 24, Granville township	Brick and Tiling.
Jacob Myers, section 22, Republic township	"
Edward Jones, section 16, Gibson township	Brick.
S. P. Shipley, Celina	"
Baker and Larner, Celina	"

CHAPTER XLVIII.

REPORT ON THE GEOLOGY OF HENRY COUNTY.

BY N. H. WINCHELL.

SITUATION AND AREA.

This county belongs to the celebrated Black Swamp area, in which it lies very near the center, the Maumee River crossing it so as to divide it into two parts nearly equal. Its area aggregates 262,106 acres, the average value per acre being, in 1870, $10.35. It contains 204,297 acres of uncultivated or wood land. Meadow or pasture land comprises 11,993 acres. It has 45,816 acres of arable or plow land, of which the township of Liberty contains 7,046, a greater cultivated area than that of any other township. Napoleon and Flatrock rank next to Liberty. The southern portion of the county is almost an unbroken, dense forest.

NATURAL DRAINAGE.

The Maumee crosses the county in a north-easterly direction. It has a number of unimportant tributaries which join it in Henry county from the north in a south-easterly direction. Those that join it from the south-west run in a direction at right angles to those from the north-west. But one important stream joins the Maumee from the south within the limits of the county, viz., the Turkey Foot; but the Beaver and the Portage cross the south-eastern portion of the county in the same general direction, the former uniting with it in Wood county, and the latter reaching Lake Erie at Port Clinton, in Ottawa county. The streams are all sluggish.

SURFACE FEATURES.

The whole county is flat. There is a little diversity of surface, occasioned by the Belmore Ridge, in the townships of Pleasant and Marion, and also in the north-western corner of the county, for the same reason. The inner margin of the Blanchard moraine is not prominent in Henry county, but it is in Putnam, lying immediately south.

Soil and Timber.—The soil is generally a black, rich, swampy loam. It occasionally becomes clayey. This is the case along the bluffs of the

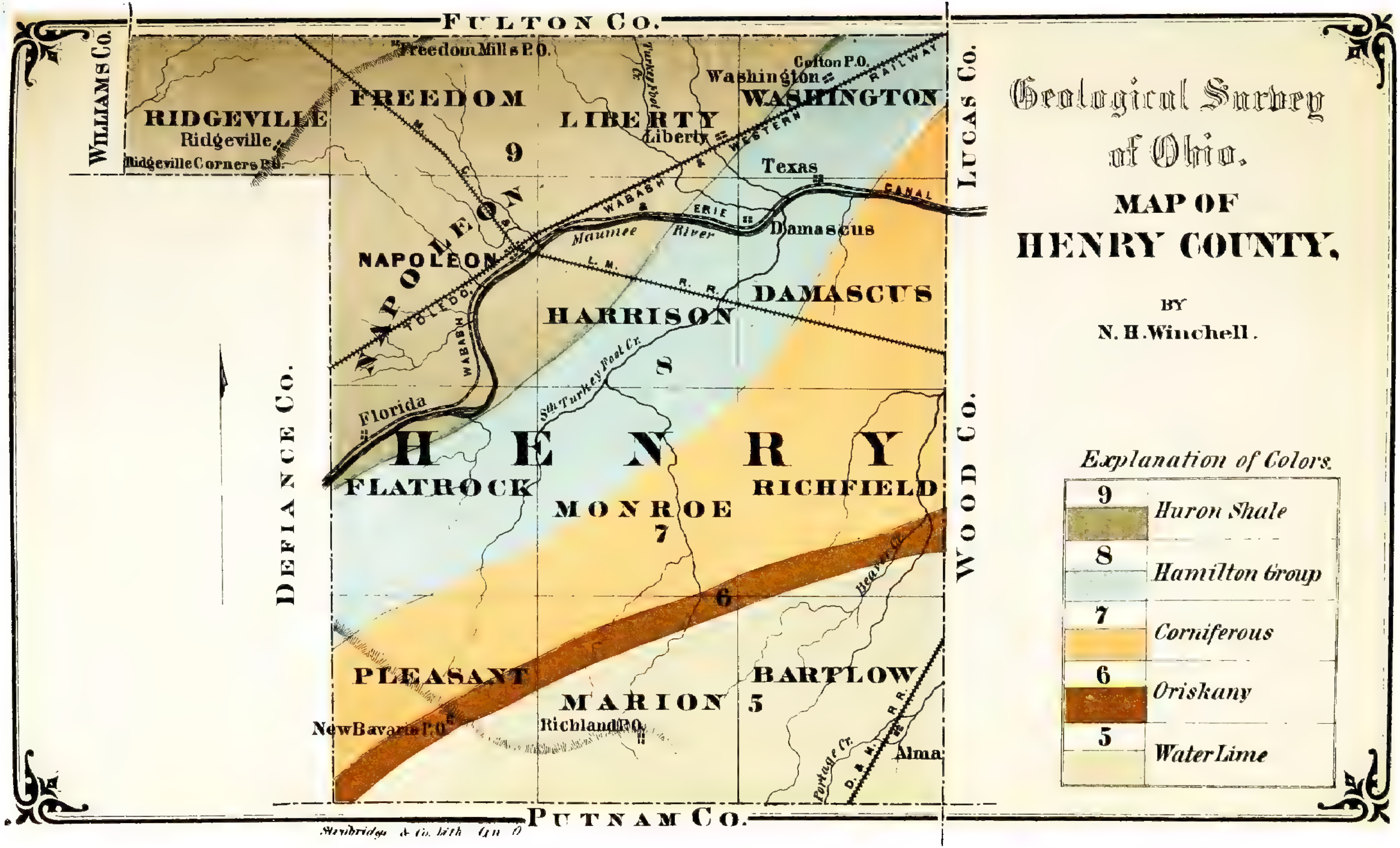
Maumee, or in situations where the surface drainage has carried the black soil into the valleys. In the vicinity of the Belmore Ridge it constitutes a very fine, sandy loam. There are also a few patches of fine, yellow, lacustrine sand, which form a very light and easily exhaustible soil.

The following varieties of trees are characteristic of the county:

Quercus alba—White Oak	L.
Fagus ferruginea—Beech	Ait.
Ulmus Americana—Elm (pl. Clayt.)	Willd.
Quercus (?)—Chestnut-leaved Oak	
Platanus occidentalis—Sycamore	L.
Populus monilifera—Cottonwood	Ait.
Fraxinus Americana—White Ash	L.
Quercus macrocarpa—Burr Oak	Michx.
Juglans nigra—Black Walnut	L.
Juglans cinerea—Butternut	L.
Fraxinus sambucifolia—Black Ash	Lam.
Acer saccharinum—Sugar Maple	Wang.
Quercus rubra—Red Oak	L.
Acer rubrum—Soft Maple	L.
Æsculus glabra—Buckeye	Willd.
Tilia Americana—Basswood	L.
Asimina triloba—Pawpaw	Dunal.
Populus tremuloides—Trembling Aspen	Michx.
Salix nigra—Willow	Marsh.
Gymnocladus Canadensis—Kentucky Coffee Tree	Lam.
Prunus serotina—Black Cherry	Ehr.
Quercus palustris—Pin Oak	DuRoi.
Morus (?)—Mulberry	
Prunus (?)—Wild Plum	
Euonymus atropurpuréus—Wahoo	Jacqs.
Carya alba—Shagbark Hickory	Nutt.
Viburnum opulus—Highbush Cranberry	L.
Fraxinus quadrangulata—Blue Ash	Michx.
Gleditschia triacanthos—Honey Locust	L.

GEOLOGICAL STRUCTURE.

The details of the geology of Henry county are not well known. The rock exposures are confined to the bed and banks of the Maumee. It is only known that the formations of the Devonian make their way across the county from the north-east to the south-west, the south-eastern portion being taken up with the Waterlime. The exposures that occur in the Maumee are of the black slate or of the Hamilton, and are sufficient to fix pretty certainly the points of crossing of the strikes of those forma-


Geological Survey of Ohio.
MAP OF
HENRY COUNTY,
BY
N. H. Winchell.
Explanation of Colors.
9 Huron Shale
8 Hamilton Group
7 Corniferous
6 Oriskany
5 Water Lime
FULTON CO.
PUTNAM CO.
DEFIANCE CO.
WILLIAMS CO.
LUCAS CO.
WOOD CO.
HENRY
RIDGEVILLE
Ridgeville
Ridgeville Corners P.O.
FREEDOM
Freedom Mills P.O.
LIBERTY
Liberty
Turkey Foot Cr.
WASHINGTON
Washington
Colton P.O.
Texas
CANAL
Damascus
DAMASCUS
NAPOLEON
NAPOLEON
HARRISON
Maumee River
WABASH & ERIE
TOLEDO, WABASH & WESTERN RAILWAY
L. M. R. R.
WABASH
Sth. Turkey Foot Cr.
Florida
FLATROCK
MONROE
RICHFIELD
PLEASANT
MARION
BARTLOW
New Bavaria P.O.
Richland P.O.
Beaver Cr.
Portage Cr.
D. & M. R. R.
Alma
9
8
7
6
5
Sandbridge & Co. lith. Cin. O.

tions. With that exception, the accompanying map of the county is largely conjectural.

A short distance above Florida is the quarry of Wesley King and brother, in the left bank of the Maumee. It consists of the following succession of parts:

No. 1.	Compact, blue limestone, the same as at Dilz's quarry, in Defiance county; very hard, showing few fossils, none of which are distinct. It contains considerable pyrites and calcite, and some chert	1 ft.	2 in.
" 2.	Porous bluish or gray stone; fossils indistinct from crystallization and absorption; stone crystalline and hard, somewhat resembling the Niagara; crinoidal joints and Cyathophylloids, including a Cystiphyllum, can be identified. Exposed	2 "	
	Total	3 "	2 "

These beds lie nearly horizontal, but dip slightly into the river south-east, east, and north-east. Fifteen rods further down the black slate is found in the river, making it impossible for more than two feet of shale (the representative of the Olentangy shale of Delaware county) to intervene between this stone and the overlying black slate.

At Florida there is a stratum of thick-bedded black limestone within the black slate, though near its base. It is exactly the same, in all outward aspects, as a heavy-bedded black limestone seen in the black slate in the northern portion of the lower peninsula of Michigan, outcropping at Sulphur Island, in Thunder Bay, and at Sunken Lake, in Presque Isle county. At Florida it is used for all common purposes by the country people, and has been burned into lime. Below this place the Maumee is filled with the slack-water from the Providence dam, constructed for canal purposes, and no other view of the bed-rock can be had. At Napoleon, however, a well was drilled by Mr. H. T. Osborn, in 1872, which, according to his record, struck a gray limestone, after passing through the Drift, at the depth of forty-five feet. It had a thickness of about thirty feet. The well was continued to the depth of seven hundred and fifty feet. Water was obtained at seventy feet, and again at ninety feet. Another well was drilled at Texas to the depth of one thousand one hundred and eighty feet, which furnished strongly sulphurous water from the depth of four hundred and fifty-two feet. The rocks passed through here are said to be the same as at Napoleon, but the records at both places are not reliable for geological purposes. The black slate was struck at one hundred and fifty-seven feet at Wauseon, in Fulton county. Water was thrown out, with gravel-stones, to the height of nearly one hundred feet above the earth, by a powerful escape of gas.

The Drift.—The general character of the Drift in this county is the same as in Defiance, and the reader is referred to the report on that county for a full description. The following details, relating to the Belmore and Blanchard Ridges that cross the county, will be of interest to the student of the phenomena of the Post-Tertiary. At Lake Ridge village, in Michigan, as well as at other points further north, numerous bowlders are piled on the ridge. They have been gathered from the fields. Toward the Lake there is uniformly a descent from the summit of the ridge, but not always in the opposite direction. Similar bowlders are seen strewn variously over the easterly slope of the ridge. This is particularly the case soon after passing the Macon, going south. They are also very numerous in the fields beyond, on the easterly side of the ridge, where the soil is black, some being three or four feet across. The people denominate them "field stones." This ridge can be traced and located by the road to about four miles south of Ridgeway, when the road leaves it. Here the ridge also becomes less marked, but at about three miles south of Ridgeway a series of sandy knolls and ridges branch off more westerly than the real ridge, and at a distance, looking from the east, this prominent, almost continuous, series of short ridges has more the aspect of the real ridge than that on which the real ridge is said to be located. The road, however, follows the real ridge, but at last leaves it, running in a direction to pass a little east of or near Palmyra. The ridge here becomes obscured by lake sand, and different opinions are held by the people as to its true location, some maintaining that it runs to the east of Palmyra, others to the west. The country south and east of Adrian is all rolling and sandy as far as two or three miles south of Fairfield, when the road enters the low, black land of the swamp. This low, black land is strongly defined along here. The "oak openings" border it on the north-west. They are sandy. The swamp is known as timbered land, in distinction from the "openings." North and west of the openings we come upon the old, gravelly drift surface, which is rough and rolling, with many bowlders. The location of the ridge at Fairfield is unknown. The country is sandy. At a number of places in Lenawee county may be seen a gradual passage from lake sand into gravelly sand, then to a clayey sand, and finally into a typical hard-pan. On some of the sandy knolls bowlders are seen scattered. Indeed, this occurs more frequently than will admit of the sand and its contents being derived entirely from the agency of lake currents and waves. These bowlders may be due to floating ice when the Lake covered this part of the country, according to the theory of Dr. Newberry. If they were deposited when the sand was, they must have been put there by some other and separate force. This may account for them, as well as for the bowlders spread over those places in the Black Swamp where there has been no apparent erosion. A short distance north of Fairfield there is an opening in the road in a ridge of gravel which runs south-west. Traveling east from Phillips's Corners to Metamora, after passing over a flat of the Black Swamp kind, the only indication of the Belmore Ridge that can be seen occurs a mile and a half west of Metamora, running south-west. This ridge consists of clay (hard-pan) outwardly, and rises about eight feet above the road, which it crosses between sections 4 and 9, Amboy. The people regard it the "same as that running north-east toward Detroit." No ridge is seen at Metamora. Two ridges of lake sand occur at Ai, where they seem to diverge. The most westerly runs about north and south in section 4. The other runs more north-east, in section 3. These sandy ridges accompany and cover the real Belmore Ridge. They continue to Delta, the gravel of the Belmore Ridge being only occasionally visible. At Delta there is a hard-pan ridge, cut by the railroad, showing about nine feet. A short distance south of the railroad Mr. Spencer, in digging his cellar, has found a hard-pan covering of twenty-three feet, but at Mr. Johnson's, half a mile further south, the ridge is of gravel. At numerous other places between Delta and West Barre the contents of the ridge are found to be gravel; no lake sand seen south of Delta. The ridge maintains its typical characters for several miles south of Delta. It is constant, well marked, and always hard, a gentle slope toward the south-east, but not always one in the opposite direction. At Mr. Spencer's, near Delta, where the main ridge is one of hard-pan, there is a second, low ridge on the inner side of the main ridge, consisting more especially of stones and bowlders. The main ridge here seems to be the inner margin of the Blanchard Ridge, this low one being the true Belmore Ridge. From West Barre to Ridgeville the ridge is well defined. About half a mile south-west of Ridgeville it is less marked. On section 11, Adams, Defiance county, it becomes more sandy, as at Ai, and north to Lenawee Junction, but not to so great an extent; the ridge can be easily traced. This ridge is generally less than ten feet high above the adjoining level, and sometimes not more than four; but it is continuous and remarkably uniform. Streams only seem to disturb its outline. Their channels are cut wide and far beyond the possible effects of the present amount of water. From Ridgeville to the Maumee (section 17, Richland) the ridge is well defined and has the usual features. The sandy element mentioned half a mile west of Ridgeville has disappeared. South of the Maumee there are more evidences of the inner margin of the Blanchard Ridge. At Ayersville there is an irregular accumulation of lake sand covering the inner margin of both the Blanchard and the Belmore Ridges; yet less than half a mile east of the village the former ridge emerges with its characteristic form and gravelly composition, and so continues easterly, being quite conspicuous for three or four miles east of Ayersville. Beyond that point it is apt to sink away, becoming almost lost in the flatness of the Black Swamp; but even in the flat places the gravelly character of the surface soil reveals the location of the true ridge. After intervals of disappearance it rises again as plain as before. Such low intervals occur especially through sections 19, 29, and 33, in Pleasant township. In the N. E. ¼ section 3, Palmer, Putnam county, Mr. John Burkhardt lives on a little knoll or short ridge, which, surrounded by the usual characters of the Black Swamp, is an evident proof of the location of the inner margin of the Blanchard Ridge. Mac. Maguire, near Burkhardt, is on a similar ridge. These are similar to those about Medary Swamp. The ridge cannot be traced continuously through sections 33 and 3, but may be occasionally seen. It is also spread laterally. Job's farm, section 1, Palmer, and Cyrus Markley's, section 6, Liberty, are on this ridge, which here is known as the "Leipsic Ridge," from its passing through a village of that name further east. This ridge runs mainly or entirely south of the Medary Swamp. It emerges from the entanglement of that swamp toward the east with a marked and unusual development on section 15, Liberty. It there seems to be half a mile over, and maintains that size to Leipsic. It is more clayey than the Belmore Ridge, as before described, between the swamp and Leipsic, being little more than a shoulder in the general surface, sloping northeast into the low land of the swamp. The soil of this ridge at Leipsic is not much different from that south of the ridge, yet in some places it is very gravelly, and has red spots along the north side. Thence to McComb this ridge has more the characters of a shoulder, with a slope only to the north; but at that place, and east of it, it is a complete ridge, and more gravelly, descending both to the north and south. Its outline is rolling, and it rises sometimes twenty feet. Before reaching Van Buren it spreads irregularly, or splits into two, which run independently a short distance, or sometimes are connected by spurs. The whole width is usually forty or fifty rods, and in some places a rolling surface prevails for some distance south of the true ridge. Sometimes cobble-stones and bowlders may be seen on it. From Van Buren to Fostoria this ridge is well defined, and has all the usual features, including a descent both north and south. It is, however, apt to become broad and branched, or double. At Fostoria, approaching from the west, it can be seen to separate into three parallel ridges, all included within the space of half a mile. It is very commonly a real hard-pan, showing no more gravel than the rest of the country. Where the Baltimore and Ohio Railroad is graded through it, about a mile west of Fostoria, a section of about eight feet is exposed. The upper four feet are here gravelly hard-pan, and the lower, stratified gravel with coarse sand, embracing some stones. New Riegh, in Seneca county, is on a hard-pan ridge, or at least a hard-pan knoll. About mid-way between Berwick and McCutchenville is a very conspicuous hard-pan ridge, which, on the left bank of the Sandusky (S. E. ¼ section 26, Seneca), forms a bluff about sixty feet high. This ridge can be traced westwardly, running about a mile north of Adrian and the same distance north of Springville, forming the outer margin of the Blanchard Ridge.

WELLS AND SPRINGS IN HENRY COUNTY.

Owner's name.	Location.	Feet above the rock.	Feet in the rock.	Total depth.	Through what.	Remarks.
Charles Hornung ...	New Bavaria..	68	......	68	On the rock.....	Slightly sulphurous; stands 20 ft. from top.
Henry Dirr............	Sec. 17, Pleasant	72	8	80	....	Sulphur water;—some gas escapes.
Henry Eberly	Sec. 14, Flatrock	56	......	56	....	Artesian.
John Ricker..........	Sec. 14, Flatrock :.........	56	......	56	....	Artesian; sulphur.
Conrad Clay..........	S. E. ¼ sec. 5, Napoleon ...	68	......	68	....	Artesian.
J. Butterfield	S.W. ¼ sec. 10, Napoleon ...	65.	......	65	....	Stands 5 feet from top. "Boils."
Peter Desgranges ...	N.W. ¼ sec. 32, Pleasant	65	5	70	....	Slightly sulphurous
Philip Wolf	S.W. ¼ sec. 29, Pleasant	65	12	77	....	Good water.
Charles Hornung ...	Sec. 22, Pleasant...........	13	......	13	On the ridge...	"
Bart. Tomy..........	Sec. 23, Pleasant	12	......	12	" ...	"
Mr. Daum.............	Sec. 23, Pleasant	80	......	80	" ...	
Charles Heser	Sec. 30, Marion	12	......	12	" ...	"
Josiah Zoll	" 29, " ..	8	......	8	" ...	"
Casper Zerliff.........	" 29, " ..	65	......	65	" ...	"

CHAPTER XLIX.

THE GEOLOGY OF DEFIANCE COUNTY.

BY N. H. WINCHELL.

SITUATION AND AREA.

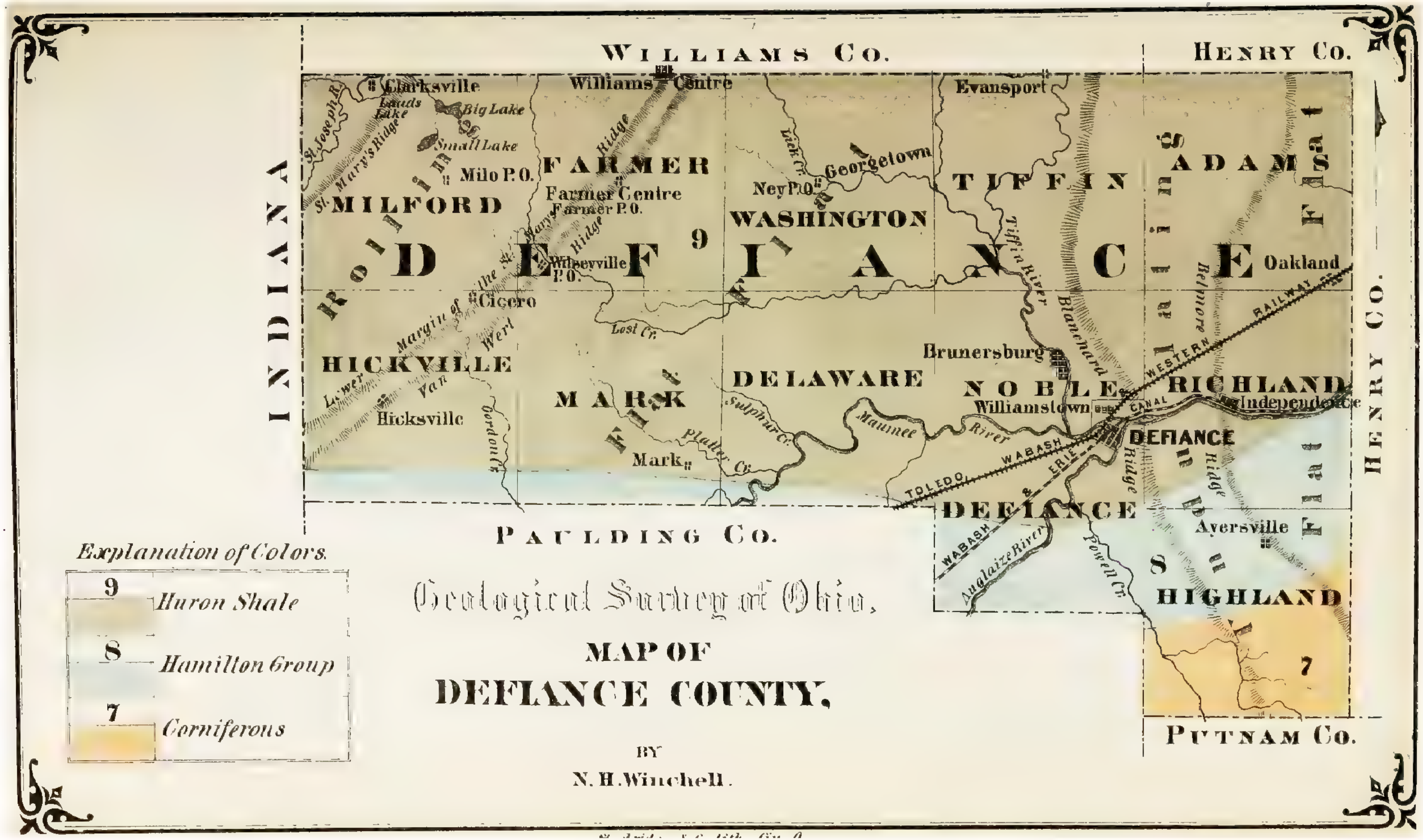
Defiance county is in the north-west corner of the State. It touches Indiana on the west, and Williams county intervenes between it and Michigan on the north. On the east it is bounded by Henry county, and on the south by Paulding. Its area is 257,492 acres. Of this, 58,912 acres are arable or plow land, 27,297 acres are meadow or pasture land, and 173,238 acres are uncultivated or woodland. The average value per acre is $11.16.

NATURAL DRAINAGE.

The Maumee River crosses the south-eastern portion of the county in a direction a little north of east. At Defiance it is joined by the Auglaize from the south and by the Tiffin from the north. The St. Joseph River, flowing in a south-westerly direction, crosses the town of Milford, in the north-western corner of the county. The small tributaries of the Maumee from the north, and of the Tiffin, with Powell Creek, from the south, constitute the only important streams of the county. These streams are generally sluggish, and do not furnish good water-power. For power for milling and manufacturing the locks of the canal are generally depended on, not only in this county, but in most of those through which the State canals pass in the north-western quarter of the State.

SURFACE FEATURES.

The whole of this county, except a small portion in the north-western corner, which is rolling, is embraced in what is well known as the Black Swamp of Ohio, and exhibits the surface characters that prevail in most of the Fourth Geological District. The surface is flat and unvaried, and the roads generally very muddy in the wet season of the year. The drainage is slow. The valleys dug by the streams are wholly within the Drift, and rarely disclose the rock. They are sometimes fifty or sixty feet in depth below the general level of the country, and along the flood-



Geological Survey of Ohio,
MAP OF
DEFIANCE COUNTY,
BY
N. H. Winchell.
Explanation of Colors.
9 Huron Shale
8 Hamilton Group
7 Corniferous
WILLIAMS CO.
HENRY CO.
INDIANA
PAULDING CO.
PUTNAM CO.
DEFIANCE
MILFORD
FARMER
WASHINGTON
TIFFIN
ADAMS
HICKVILLE
MARK
DELAWARE
NOBLE
RICHLAND
DEFIANCE
HIGHLAND
Clarksville
Williams Centre
Evansport
Georgetown
Ney P.O.
Milo P.O.
Farmer Centre
Farmer P.O.
Cicero
Hicksville
Mark
Brunersburg
Williamstown
Oakland
Independence
Aversville
Big Lake
Small Lake
St. Joseph R.
St. Mary's Ridge
Lick Cr.
Lost Cr.
Tiffin River
Blanchard
Belmore
Maumee River
Sulphur Cr.
Platter Cr.
Gordon Cr.
Auglaize River
Powell Cr.
Margin of the St. Mary's Ridge
Lower Van Wert
Ridge
WESTERN RAILWAY
TOLEDO, WABASH & WESTERN RAILWAY
WABASH & ERIE CANAL

plains, as well as in the streams themselves, are numerous northern bowlders. The valleys of the streams are not terraced.* They consist of a single main descent from the surface of the country to the flood-plain. The chief diversity of surface in the county consists of the ridges that cross the county, which are particularly described under the head of *The Drift.* Outside the upper ridges in the towns of Milford and Hickville the country is much more rolling, consisting of a gravelly clay, or, occasionally, of gravel, more or less mingled with stones and sand, and has the character of *oak openings.*

Soil and Timber.—The prevailing soil is clay. Throughout the most of the county this clay is gravelly and stony. It is slightly undulating in some places, but generally needs artificial drainage. This clay in Milford township loses much of its refractory character, and becomes very gravelly. It is of a yellowish ash color. In other parts of the county it is locally covered with a light beach sand. This is often spread out over many acres or square miles, making a very light soil. The Belmore ridge, crossing the eastern part of the county through Highland, Richland, and Adams townships, consists largely of gravel, or of gravel and sand. It is also associated with considerable light, yellow sand, as at Ayersville. This sand, in favorable situations, is converted by the accession of vegetable remains into a rich black loam. This is the case in some places in Farmer and Mark townships, and at Brunersburg, and along the valley of the Tiffin to Evansport. About Defiance a peculiar beeswax soil prevails. It may be seen in its typical characters along the road from Defiance to Brunersburg. It is an exceedingly fine clay, waxy, and difficult of agriculture. It has the same color as the gravelly clay that prevails over the most of the county. It comprises the surface of the horizontally stratified fine clay, and is due to the action of the waters of Lake Erie on the glacial Drift at the moment of deposition. Its stratification can be seen in excavations along the road on the north side of the river at Defiance. It is underlain by typical unmodified Drift. It may be called lacustrine clay. It is probably the equivalent of the Saugeen clay of the Canadian geologists, together with that portion of the Erie clay that is similarly stratified. In Mark township is an extensive marsh, with one to three feet of muck lying on a level clay surface. The prevailing trees about this marsh are black ash, elm, soft maple, etc. The swamps in Milford, on the outside of the ridge, are

* To this statement there is one exception. Between Defiance and Independence, where the Maumee crosses the Blanchard moraine, it has a "second bottom," *i. e.*, one in addition to the flood-plain. See under *The Drift*, in Defiance county.

deeper, but less extensive, and are frequently characterized by tamarack trees.

In the survey of the county the following species of trees were noted:

Quercus alba—White Oak	L.
" ?—Chestnut-leaved Oak	
" rubra—Red Oak	L.
Carya alba—Shag-bark Hickory	Nutt.
Juglans nigra—Black Walnut	L.
Æsculus glabra—Buckeye	Willd.
Ulmus Americana—American Elm (pl. Clayt., Willd.)	L.
Fraxinus quadrangulata—Blue Ash	Michx.
Tilia Americana—Basswood	L.
Fraxinus sambucifolia—Black Ash	Lam.
" Americana—White Ash	L.
Prunus Americana—Wild Plum	Marsh.
Quercus imbricaria—Laurel-leaved Oak	Michx.
Acer saccharinum—Sugar Maple	Wang.
" rubrum—Soft Maple	L.
Prunus serotina—Black Cherry	Ehr.
Crataegus tomentosa—Thorn	L.
Ostrya Virginica—Ironwood	Willd.
Quercus macrocarpa—Burr Oak	Michx.
" palustris (Pin Oak)	DuRoi.
Celtis crassifolia—Hackberry	Lam.
Salix nigra—Willow	Marsh.
Populus tremuloides—Aspen	Michx.
Gleditschia triacanthos—Honey Locust	L.
Populus monilifera—Cottonwood	Ait.
Platanus occidentalis—Sycamore	L.
Fagus ferruginea—Beech	Ait.
Nyssa multiflora—Pepperidge	Wang.
Juglans cinerea—Butternut	L.
Rhus glabra—Sumac	L.
Sassafras officinalis—Sassafras	Nees.
Carpinus Americana—Water Beech	Michx.
Asimina triloba—Pawpaw	Dumal.
Morus rubra—Mulberry	L.
Zanthoxylum Americanum—Prickly Ash	Mill.
Gymnocladus Canadensis—Kentucky Coffee Tree	Lam.
Liriodendron tulipifera—Tulip Tree	L.
Populus balsamifera—Balm of Gilead	L.
Populus grandidentata—Great-toothed Poplar	Michx.
Euonymus atropurpureus—Wahoo	Jacq.
Ulmus fulva—Slippery Elm	Michx.
Pyrus coronaria—Wild Apple	L.
Larix Americana—Tamarack	Michx.

GEOLOGICAL STRUCTURE.

The rocks of the county embrace the limestones of the Devonian and the overlying shales. The highest observed rock is the black slate, but it is very probable that higher formations of shale, corresponding to those above the black slate on the eastern side of the anticlinal, also succeed in ascending order in Defiance county, occupying a surface area comprising most of the northern tier of towns. The general dip is toward the north. The lower portion of the great Corniferous group of Dr. Newberry forms the surface rock of the south-eastern half of Highland township. The upper portion of the same, represented by the blue stripe on the map, succeeds it on the north, its northern boundary crossing the Auglaize River in section 3, Defiance township. The greater portion of the Hamilton fossils found in this county pertains to the lower part of this limestone, but they are found also throughout its whole thickness. It is hence styled Hamilton on the accompanying map, that shale which Dr. N. regards as Hamilton in the central portion of the State not having been discovered in Defiance county. Its place is occupied by the base of the black slate or Huron shale. (See the Reports on the Geology of Paulding County and of Defiance County.) This belt of Hamilton, or Upper Corniferous, as it has been styled in the reports on Sandusky and Seneca counties, crosses Highland and Defiance townships, underlying also the south-eastern portion of Richland. The black slate underlies Defiance city. The Maumee River runs over the black slate from near the point of its entrance within the county to within a mile and a half of the Henry county line. The remainder of the county is colored to represent the black slate, although it is not known, as already remarked, but higher formations succeed it in the northern towns of the county. The Drift is so uniformly spread as to hide the rock from view.

The Huron Shale.—The only known exposures of the black slate are in the valleys of the Auglaize and the Maumee. Beginning on the south, the outcrop at the mouth of Powell's Creek is the first and most important, owing to the enterprise there started by Mr. Gleason of manufacturing hydraulic cement from its lower beds. (See Geology of Marion County.) This is on the S. E. ¼ section 34, Defiance township, on the right bank of the Auglaize. The thickness of the black slate here developed is seventeen feet. This includes that passed through in digging a well at the same place. This well was drilled for the express purpose of testing the thickness of the slate. The drill then struck a very hard rock, which, after two or three hours' drilling, was so little affected as to cause the abandonment of the well. The rock here struck can have been no other than the hard limestone burned by Mr. Dilz for quicklime a short distance further up the Auglaize. It thus appears that the black slate is not underlain in Defiance county by the Olentangy shale of Delaware county, but lies immediately on that which Dr. Newberry has designated the Corniferous limestone. This necessitates a hiatus in the Devonian series covering the Hamilton. If, however, the blue limestone be of Hamilton age, as claimed in the neighboring State of Michigan, the order of succession is unbroken. (See Geology of Delaware County.)

There are indications of the outcrop of the black slate below the water of the Maumee at a number of places below Defiance, but at the dam at Independence are large slabs of black slate thrown up by the force of the water and ice. It continues in the river to within about eighty rods of the west line of section 24, where the hard limestone struck in the well at Gleason's appears in the river and is quarried quite extensively. At Gleason's and at Florida the black slate holds a bed of compact black limestone. It is used for all building purposes by the people, and has been burned into lime. It is thought by Mr. Gleason to be preferable in making hydraulic cement. It overlies a certain, unknown thickness of black slate, probably not less than ten feet. At Brunersburg Brice Hilton owns the land that contains the only outcrop of a lenticular, shaly limestone like that which pertains to the horizon of the base of the shale which by Dr. Newberry has been regarded as representing the Hamilton, but which, in reporting on Delaware county, the writer distinguished as Olentangy shale. It occurs in the Tiffin Creek. The stone is exceedingly argillaceous, and under the weather crumbles to a blue clay. This bed here is associated with the base of the black slate, and resembles other beds that occur in the Olentangy shale in Delaware county. There are large, loose pieces of the black slate in the river near this outcrop, but the exact relation to the shaly limestone is obscured by the Drift, and can not here be satisfactorily made out. It is said to occur up the Tiffin for a mile, but is not found below Brunersburg. Its position with respect to the southern boundary of the black slate indicates that it overlies ten or twenty feet of the black slate.

The Tully Limestone.—The hard, silicious, dark-blue limestone seen along both sides of the Auglaize in N. E. ¼ section 9, Defiance, is the first below the black slate, and constitutes the uppermost portion of the Hamilton. It is believed to be the equivalent of the Tully limestone of New York. It is here extremely hard, crystalline, bluish-gray, and contains some crinoidal joints, calcite, and iron pyrites. It is somewhat vesicular, especially the second course or layer, and embraces nodules of chert. It consists, so far as seen at this point, of the following section :

No. 1.	Very hard, fine-grained, dark-blue or bluish-gray limestone, in one layer, containing iron pyrites; no fossils visible	1 ft.
	[This is the equivalent of the limestone quarried below the mill-dam near Waldo, in Marion county, and a few miles further south, by Mr. Brandage, in Delaware county. It there underlies immediately the Olentangy shale.]	
" 2.	More vesicular, less silicious, bluish-gray, in one bed of three feet thick, showing some crinoidal joints, its upper surface having vermicular markings and fucoidal impressions	3 "
" 3.	The same as No. 2, but in thinner beds; seen, about	1 "
	Total	5 "

There is a slight dip to the north. Near here Andrew Dilz burns lime from these beds, the lime being of a bluish-ashen color, and having a noticeable hydraulic quality. No. 3 has considerable thickness, and graduates below into the Hamilton. Another quarry in this stone is mentioned under Geology of Henry County. That of Wm. Wileman is in the same beds, situated in the Maumee River, near the Henry county line.

The Hamilton.—In the N. E. ¼ section 17, Defiance, on the land of Michael Humbert, is a quarry in the Auglaize River, in a crystalline, vesicular, bluish-gray limestone, that contains considerable chert between the bedding. It holds indistinct cyathophylloid corals. Also, in the chert may be seen the cells of a coarse Favosites. One bed is about a foot thick. About three feet can be made out. This stone is probably the downward continuation of No. 3 of the last section, although there is an unexposed distance of about two miles between them. How much of this belongs to the Hamilton, or whether anything below No. 1 of the last section should be included with the Tully, it is not possible to say. It is true, however, that No. 1 of the last section above is the only part that resembles strongly the beds referred to the same horizon seen in Marion and Delaware counties.

On section 17, Defiance, is the quarry of Town Newton. Stone is taken out there for the Paulding Furnace. The color, grain, and all the external characters of this stone resemble those of the stone quarried at Sandusky and used in the basement of the court-house at Defiance. The dip is north or north-east. Further south in Paulding county are other exposures of the same stone, likewise situated in the valley of the Auglaize. The reader may consult the report on that county for remarks on the supposed equivalents of these limestones in New York.

On section 24, Delaware, Elias Bruner has discovered a stone in the bottoms of the Maumee which belongs to the Corniferous limestone, *i. e.*, to the fossiliferous, light-colored beds that first underlie the blue limestone above described. It seems to belong to a large bowlder brought from the north-east at such an angle with the strike of the Devonian as to bring it over the higher beds of the blue limestone, depositing it six or eight miles to the north of the nearest outcrop of its native beds, though probably many miles from the place of its origin. This bowlder is similar to others of the same formation that have been discovered in north-western Ohio. That particular portion of the Devonian limestones seems to have had a peculiar tenacity under the forces of the glacial period, large pieces from it being more numerous in the Drift than from any other. This bowlder has been found to extend in one direction at least thirty feet, and to have a width of at least fifteen feet. At one end, where some quarrying has been done, it has a thickness of eight feet, with "washed sand" below. It dips north-west, at a slight angle. Its surface is about six feet higher than the water of the Maumee. It lies twenty rods from the channel. Men, in "driving" logs down the river in spring-time, report rock in the bottom of the river near the place of the bowlder, and the river shows a decided ripple at that point. There are no black slate fragments along the river bank, nor in the river. It must be admitted that these facts point strongly to the probably undisturbed condition of this Corniferous outcrop. Its position, however, with respect to the general trend of the strike of the formation, and especially with the outcrop at Antwerp, in Paulding county, is anomalous. It is wholly disregarded in the coloring of the accompanying geological map. While this exposure, being to the north of the supposed trend of the Corniferous, has an influence toward the movement of the colored Corniferous belt several miles northward, the similar indications of a Corniferous, or Hamilton, area in the central portion of Paulding county (see report on that county) draw the area of the same formation toward the south.

The Drift.—The Drift in Defiance county exhibits the most interesting characters. It can be described best by taking them in the following order:

1. Hard-pan, or bowlder clay.
2. Horizontal laminations of fine clay.
3. Oblique and various strata of sand and gravel.
4. Lacustrine, unstratified sand.
5. The ridges.

The hard-pan, or bowlder clay, which is spread out over most of the county, and rises to the surface, constituting the bulk of the Drift every where in the Fourth Geological District, also underlies those portions that are superficially covered with fine, horizontal, clay formations. It may be seen in the banks of the Maumee and the Auglaize at a great many places—indeed, every where that fresh-water sections of the Drift banks disclose their composition. It is not necessary to describe it here, as its characters have been fully detailed in many places. Where it is not overlain by the laminated, fine clay, as it is at Defiance, it forms a surface soil that, in level tracts, is rather clayey, with but little gravel. In more rolling districts, as in Milford, and the north-west portions of Hickville and Farmer townships, it becomes not only gravelly, but even stony. Perpendicular sections of it in such rolling districts often show that it is largely composed of beds of obliquely stratified gravel and sand, such beds also sometimes embracing stones and bowlders of considerable size. These beds of stratified gravel and sand are scattered through the whole thickness of the deposit, but in most places are most abundant at or near the top. There is almost always a bed of a few inches, or a few feet, of sand and gravel between it and the rock. Typical, gravelly soils that are based on this deposit prevail in Milford, Hickville, and Farmer townships, as already mentioned. In most of the rest of the county, where this deposit forms the basis or subsoil, the immediate surface is much changed by marshy and vegetable accumulations, and the country is there known as Black Swamp, from the flatness and blackness of the surface. This constitutes by far the larger portion of the entire county. The ridge on which Williams Center is situated is formed of this kind of Drift.

Horizontal laminations of fine clay locally cover the foregoing hardpan clay, and in Defiance county sometimes show a thickness of fifteen feet. This character may be seen on the north side of the Maumee, at Defiance, and for five or six miles toward the west, where it becomes overlain with a loose, sandy loam, which appears to be also marly, somewhat resembling the alluvium of streams. In some places the finely laminated clay seems to graduate into a sandy loam that constitutes the fourth condition of the Drift to be described. This may be particularly seen along the Tiffin River, in Tiffin township. These laminations are usually entirely free from stones. They graduate insensibly between very fine sand and clay. Their color is not an essential character—a statement which is also true of all parts of the Drift. The original color of the Drift seems to have been blue, and that color is seen at the depth of ten or twenty feet below the surface in all cases, whether it be hardpan or stratified Drift. The region where this fine, laminated condition of the surface of the Drift exists, is a belt from three to six miles wide, running north and south through Defiance, Noble, and Tiffin townships. It lies apparently on the western half of this tier of towns. It has not been seen to extend on the east side of the Tiffin and Auglaize, except in the immediate valley of the Maumee, and that not east of the town line of Noble.

Oblique and various strata of sand and gravel constitute a large portion of the Drift, especially near the surface, in the most elevated portions of the county, *i. e.*, in the north-western corner, embracing Milford township and a portion of Hickville and Farmer. This is no exception to the usual character of the Drift at those heights above Lake Erie. In north-western Ohio generally, however, this elevation is not reached so near the lake shore, but there is a broad sweep toward the south, passing into Indiana, of those features that characterize the Black Swamp. The Van Wert Ridge, which is the inner of the two ridges passing through Hickville and Farmer townships, is composed almost entirely of Drift of this kind. The same is true of the Belmore Ridge, which passes through Adams, Richland, and Highland townships. The latter, however, is more subject to an overspreading of fine, lacustrine sand; this is particularly the case at Ayersville. Where the latter ridge crosses the Maumee River, about a mile above Independence, in Richland township, the extreme height of the left bank of the river, measured by Locke's level, on the land of Charles Wilson, is seventy-nine feet two inches from the level of the water in the river, which is dammed back from Independence. The bank of the river appears to have been originally very gravelly throughout the most of this height, but it is now turfed over, and supports a large orchard of apple trees. The ridge here rises several feet above the level of the surrounding country.

Unstratified lacustrine sand is spread over the surface of some portions of the county. It lies usually in a sheet of a few inches or a few feet in thickness, but it also forms some very conspicuous ridges and knolls. This sand must not be confounded with that which lies in oblique strata. It is distinguishable from that in being of a very uniform, fine grain. It is made up almost entirely of silica, while the sand referred to has grains of other minerals. The color is also usually different. This is generally yellowish, unless mixed with carbonaceous materials, when it is black, or has some shade of brown. The yellow tint comes from a deposit of iron-rust, that exists as minute scales, or thin incrustations, on the separate grains. When this lacustrine sand is so situated that it is not rapidly and exhaustively drained, it forms a very rich and easily tilled black loam.

A sandy loam of this nature occurs at Brunersburg, and affords fine wells at six to ten feet. It extends about half a mile toward the west, but toward the north a similar surface characterizes the valley of the Tiffin as far as Evansport. This is the ancient alluvium of the Tiffin, and sometimes appears stratified. At Brunersburg it is confined to the west side of the creek, the east bank being high, and made up, near the top, of fine, laminated clay, but on the town line between Noble and Tiffin it extends about a mile east of the river, and is not distinguishable from the lacustrine sand. West from Evansport the country is sandy for about two miles, when it begins to assume, and finally acquires entirely, the features of the Black Swamp. Continuing westward, there is no noticeable change till within about a mile and a half of Lick Creek, when a yellow color in the soil appears in occasional little mounds. These are followed by a slowly rising surface to Lick Creek. For a mile east of the creek the surface is quite gravelly and sandy, making, sometimes, a fine loam, and sometimes a gravelly loam. This is, for the most part, black, but occasionally of a yellow color in spots of a few rods, such spots also being gravelly and loose, although a little elevated above the rest of the surface. They appear not of the hard-pan type. Sometimes stones of a considerable size lie on the surface, but the most conspicuous element of the surface soil at this point is the gravel stones, although it also contains much sand. Wells pass through blue hard-pan below. The surface features present apparently the effect of a retiring beach line on the previously deposited hard-pan, the gravel resulting from the consequent washing out of the fine clay. In other places there seems to have been a tendency to accumulation; there the lacustrine sand is heaped up or spread out evenly. Here there seems to have been a tendency to carry away, due to currents setting one way or the other. A great many such places may be seen along the shores of Lake Huron, or any of the great lakes, where the beach consists of aacumulating sand, and where the bottom is sandy and soft for half a mile or more from the shore, while in other places, perhaps at no great distance, the beach is gravelly and stony with materials of northern origin. This all depends upon the slope of the coast line, and the direction of the prevailing winds and currents. In the banks of Lick Creek the thickness of this loose deposit is seen to be about three feet. It passes below into typical hard-pan Drift. About half a mile west of Lick Creek is a little eminence, having some of the aspects of a shoulder or bench, running north and south. The soil also becomes less gravelly, having more the characters of a hard-pan soil. A great deal of this lacustrine sand lies on the gravel ridges in Highland and Richland townships.

The ridges that cross Defiance county have been elsewhere named by the writer (see *The Drift in North-western Ohio*) in the following way: That which crosses Milford township, deflecting the St. Joseph River to Fort Wayne, has been called the St. Mary's Ridge. It consists of a vast accumulation of glacier Drift, mainly hard-pan, and has a width of five or six miles. Its inner margin forms the prominent ridge on which Williams Center is situated, and which runs about a mile west of Hickville and Farmer Center. That on which Hickville and Farmer Center are situated has been styled the Van Wert Ridge. It consists of gravel and sand in oblique stratification, rises from six to twelve feet, and is but a few rods in width. That which deflects the Auglaize and the Tiffin from flowing directly toward Lake Erie has been named the Blanchard Ridge, from the Blanchard River, which flows along its outer periphery for a distance of about thirty miles. It is similar to the St. Mary's Ridge both in width and composition. Its inner margin is very much like that of the St. Mary's Ridge, and very often takes the name of ridge. It passes through Leipsic, in Putnam county. It is followed by the Belmore Ridge, which crosses Highland, Richland, and Adams townships, and is intersected by the Maumee near Independence. At Defiance the rock is struck at fifty feet.

The following details will be of interest in respect to these ridges in Defiance county. The inner margin of St. Mary's Ridge at Williams Center is prominent as a ridge of hard-pan Drift, rising abruptly on both sides to the height of about forty-four feet above the flat on the east. It has a rolling, diversified contour. The various gullies and channels cut in it by the erosion of natural drainage show stones and bowlders embraced tightly within the clay, some of the latter being two and three feet in diameter. Wells get water at Williams Center in a five-foot bed of gravel eighteen to twenty-five feet below the surface. But when the blue hard-pan is penetrated, the water in the gravel on the rock rises from the depth of eighty or ninety feet quite to the surface, making valuable artesian wells. There is an important area of artesian wells just east of Williams Center. Along the east side of this ridge the Van Wert Ridge can be traced independently. It is about thirty feet lower. Mr. D. Hoffman lives on this ridge at Williams Center. His cellar is dug in gravel and sand, depth of gravel unknown. A well at his barn, on the south side of this ridge, went through two feet of gravel at ten feet, with abundance of water, not artesian. Bowlders are strewn over this ridge at Mr. Huffman's in great abundance. The shallow wells east of Williams Center throw up great quantities of quicksand. Hundreds of loads are said to have come out of Mr. Ensign's. Wells at Farmer Center are about fifteen feet deep, with abundance of water. Near Williams Center bog ore is found in lumps on the inner side of the St. Mary's Ridge. A short distance south of Williams Center this hard-pan ridge has more the form of shoulders or terraces in the general surface, there being little or no descent toward the west, yet in some places between Farmer Center and Williams Center it has a marked descent both ways. At the former place there is a half mile interval between this and the Van Wert Ridge, and the country is generally somewhat broken. The Van Wert Ridge is easily discernible at this point in but few places. Between Defiance and Independence the Maumee River shows two terraces besides the flood-plain, the height of the bank being about equally divided between them. The upper terrace, or that which furnishes the ascent to the level of the country, does not accompany this river further than Independence, but seems to merge into the inner margin of the Blanchard Ridge, and thence to strike off in opposite directions at right angles from the river, while a little further east the gravelly Belmore Ridge rises and accompanies it toward the north and south. This terraced condition of the Maumee is not seen at any other place below this point. It is, however, seen at Fort Wayne, and for a few miles below, where the river crosses the St. Mary's Ridge. In the same manner, there the upper bench strikes away from the river and forms the inner margin of the St. Mary's Ridge. On the N. E. ¼ section 24, Defiance, in the bank of a little ravine known as Sulphur Hollow, a section of the Drift was seen, as follows:

No. 1.	Sandy loam, forming the surface soil	4 ft.
" 2.	Fine, laminated clay	6 "
" 3.	Bluish-brown hard-pan, containing gravel, stones, and small bowlders that are scratched as if glaciated, very hard, and compact	4 "
" 4.	Fine sand in distinct, oblique stratification; seen, about	8 "
	Total	22 "

Between Defiance and the S. E. ¼ section 30, in Richland, the surface is clayey, high, and somewhat gravelly when not covered with lake sand. For about a mile out from Defiance the soil is quite fine, and is apparently of the nature of the "beeswax soil" already mentioned. The ridge, in section 28, Richland, is thirty feet high, with a conspicuous descent into a flat, having the Black Swamp features, in both directions. This ridge here is considerably enlarged by lake sand, and doubtless lay as a sand-bar, where waves broke in high winds when the lake had sufficiently retired. This is the Belmore Ridge. There are two ridges of gravel, each like the Belmore Ridge, running south from the Maumee to Ayersville, and further east. About Ayersville they are covered with sand, and roads cross from one to the other on ridges of sand. This has given the idea that the divergence is there, the sand not being distinguishable from the gravel. The outer one of these two ridges runs to

Leipsic. It constitutes in many places a true gravel ridge, and in others is made up of hard-pan. In the latter case it is a bench, facing toward the north and north-east, instead of a ridge, and forms the continuance of the upper terrace of the Maumee River noticed between Defiance and Independence. To distinguish it from others, it has been called the inner margin of the Blanchard Ridge. The inner ridge runs to Belmore. It is constant, and about five to ten feet above the common surface. It uniformly has a descent in both directions, at least as far east as New Bavaria.

In following this ridge toward the Maumee from Ayersville, it is found to be occasionally covered with sand. A very distinct and prominent sand ridge, on which a road is located, diverges from it, running on toward the river, nearly parallel. The gravel ridge gradually becomes lower, and when the sand is reached the road forks, one branch going due north on the section line, and the other following the direction of the sand, the real ridge having so dwindled as not to control the location of the road. It was found impossible to trace the Belmore Ridge further north toward the Maumee than section 34, Highland, although it reappears on the north side of the river. Near there the main road leaves the Belmore Ridge and unites with the outer ridge on the south line of section 28. The cross-ridge of sand from Ayersville strikes the Belmore Ridge on section 1, Highland.

Wells and Springs.—In order to investigate the Drift and its phenomena, considerable information was gathered concerning the common and artesian wells of the county, some of which present very interesting phenomena. There are a great many artesian wells in the county that depend entirely upon the arrangement of the impervious portions of the Drift for their constant supplies. The water of these wells is of the best and most wholesome kind. They are most numerous in Farmer, Mark, Washington, and Hickville townships, on the east side of the Van Wert Ridge. The facts gathered are shown in the following tabulated list of wells. It is not supposed that all of the artesian wells of the county are here named. The facts demonstrate the same general conclusion as in other counties in north-western Ohio, viz., that the confining stratum for these artesian wells is a thickness of "blue clay" reaching sometimes nearly or quite one hundred feet, and constitutes the great bulk of the Drift itself.

WELLS IN DEFIANCE COUNTY.

Owner's name.	Location.	Feet above the rock.	Feet in the rock.	Total depth.	Through what.	Remarks.
C. Williams	Brunersburg	10	......	10	All sandy loam	Good water, hard.
J. H. Benton	"	20	......	20	" "	"
John Shier	"	10	......	10	" "	"
D. Bruner	"	7	......	7	2 ft. gravel and sand; 5 ft. sandy loam	"
F. A. Kuntz	N. E. ¼ section 16, Noble	80	......	80	Yellow clay and hard-pan	No water.
A. Ashbacker	"	80?	......	80?	......	"
Calvert Dye	Sec. 22, Noble	70	......	70	......	"
Brice Hilton	Brunersburg	20	......	20	On the rock	In the bottoms of Tiffin Creek.
Wm. Travis	Sec. 20, Noble	28	......	28	Clay and gravel	In Maumee bottoms.
C. Templeman	"	40	......	40	......	Sulphur.
Court-house sq	Defiance	32	......	32	28 ft. blue gravelly clay, 4 ft. sand	Good water rises from gravel 15 feet.
John Dietch*	Sec. 26, Richl'd	56	......	56	Hard-pan bottom; fine clay on top	Water in gravel.
Judge A. S. Latty	Defiance	10	......	10	8 ft. sand and clay, 2 ft. fine clay	Good water in gravel.
M. Arrowsmith	Sec. 31, Farmer	93	......	93	Tube driven	Water stands 3 ft. from surf'ce.
Wm. Rohrs	N. E. ¼ section 12, Noble	69	......	69	"	Good water.
Lewis King	Evansport	90	7	97	Clay 7 ft.; sand and gravel 3 ft.; blue clay 80 ft.	Water only at 10 ft. Struck the black slate.
J. Urguhart	Sec. 6, Tiffin (county line)	78	40	118	Water at 60 feet	Sulphur water on striking the black slate.
John Bail	Williams Center	45	......	45	Water at 23 feet and at 45 feet	On the ridge. Good water.
G. H. Tomlinson	Williams Center (on the ridge)	82	......	82	Clay with gravel 18 ft.; sand 5 ft.; clay with gravel 15 ft.; clay with more gravel 40 ft.; gravel and sand 4 ft	Water at 18 ft., at 38 ft., and at 80 ft. Rises to 15 ft. of top.

* A half dozen within the circuit of a mile are 56 to 66 feet, water standing 4 to 10 feet of the top.

WELLS—Continued.

Owner's name.	Location.	Feet above the rock.	Feet in the rock.	Total depth.	Through what.	Remarks.
G. H. Tomlinson	Williams Center (not on ridge)	110	......	110	No rock	No water.
Benj. Hoffman...	Williams Center (on Van Wert Ridge)	103	......	103	"	Artesian.
D. Tomlinson.....	S. W. ¼ section 6, Washington	62	......	62	....	Artesian.
Henry Dietricht	N. E. ¼ section 1, Farmer	80	......	80	....	Gas, visible several miles if lighted. No water.
G. H. Tomlinson	Williams Center (east side of ridge)	73	......	73	Blue clay, with one or two small beds of sand	Good water in sand only, at 73 ft.
G.H.Tomlinson*	Williams Center (just east Van Wert Ridge)...	32	......	32	Blue clay and gravel	Artesian at 32 ft.
Hugh Mills	Williams Center	50	......	50	North side Van Wert Ridge	Artesian at 47 ft.
"	"	90	......	90	10 rods E. of last...	Artesian at 90 ft.
"	"	90	......	90	"	"
"	N. W. ¼ sec. 17, Washington ...	90	......	90	....	"
"	Williams Center	50	......	50	100 rods west of ridge	Rises within 8 in. of surface.
Benj. Hoffman...	"	78	......	78	In a ravine thro' the Van Wert Ridge	Irony water. Artesian.
O. E. Ensign......	Sec. 36, center Williams Co...	54	......	54	....	Artesian.
"	"	28	......	28	....	Rises 14 ft. above the ground.
Eli Castor	Sec. 1, Farmer ..	38	......	38	....	Artesian.
Geo. Kerns	"	60	......	60	Surface caved	"
J. Fetters	"	53	......	53	....	"
James Gardner..	Farmer	31	......	31	....	"
"	"	48	......	48	....	"
W. Tomlinson ...	"	37	......	37	....	"
Jacob Rager	"	18	......	18	Water in sand	Artesian. In a ravine.

* Three or four others near Mr. Tomlinson's strike gravel at about the same depth All artesian.

WELLS—Continued.

Owner's name.	Location.	Feet above the rock.	Feet in the rock.	Total depth.	Through what.	Remarks.
Elisha Tharp	Sec. 12, Farmer	18	......	18	Surface soil 2 ft.; brown clay 10 ft.; blue clay and stones 6 ft	Artesian. Water from sand.
"	"	48	......	48	Blue clay and sand	Artesian.
D. B. Ensign......	Sec. 11, Farmer	50	......	50	....	"
Brittan & Co......	Hickville	77	......	77	....	West side ridge.
Craig Bigelow ...	Sec. 23, Farmer	92	......	92	....	Artesian.
Hotel	Farmer Center..	20	......	20	....	Good water.
C. T. Gollu	Sec. 18, Washington...........	106	......	106	....	Artesian. Water only at 34 ft.
W. M. Powell.....	Sec. 19, Washington...........	28	......	28	....	Artesian.
Aug. Haase	"	98	......	98	....	Artesian at 78 ft.
Dr. N. Hartshorn	Georgetown	48	......	48	....	Artesian.
"	"	42	......	42	....	"
Jacob Smith	"	87	......	87	....	"
R. McCulloch ...	"	86	......	86	....	Good water.
Wm. Donnelly...	"	45	......	45	....	"

MATERIAL RESOURCES.

For common red brick there is plenty of good clay in Defiance county. The following establishments for its manufacture were noted in the survey of the county:

Joseph Chalat, Defiance	Brick.
——— Trompe, "	"
Booth & Aldrich, "	"
Enoch Randall, Farmer Center........	"
Mr. Fitz Charles, S. W. ¼ section 21, Milford................................	"

A very hard, dark-blue limestone is burned for quicklime by Andrew Dilz, N. E. ¼ section 9, Defiance. Three cords of mixed wood are required here for calcining one hundred bushels, at a cost of one dollar and fifty cents per cord. The lime, which is very strong, and of a gray color, weighs seventy-two and a half pounds per bushel, and retails at the kiln at twenty-five cents. It is said to be somewhat hydraulic. This is the only lime-kiln in Defiance county.

For building stone Defiance county depends on the Oriskany sandstone quarried at several places further down the Maumee River, and upon the Charloe quarry, in Paulding county. The blue limestone of the Auglaize, although exactly the same as that at Sandusky, has not been developed in north-western Ohio. It is used in the basement of the new court-house at Defiance, but was imported from Sandusky for that purpose. The most of the stone used in this building is from Charloe. There is also some stone in it from Chicago (not Niagara), used as keystones in arches. When dressed, this is of a white (more cheerful) color than the Charloe stone, but on the ground it is light blue, or gray, streaked with bituminous films. It appears a little impure, or earthy. The ornamental cut-stone is mostly from Charloe. In the foregoing pages a number of exposures of the blue limestone favorable for opening valuable quarries in Defiance county have been mentioned. These occur in the Auglaize, about the mouth of Powell's Creek.

The "Auglaize cement" is manufactured by Mr. E. H. Gleason, S.E. $\frac{1}{4}$ section 34, Defiance, from the black slate. This cement has already been mentioned in the first volume, in giving the geology of Marion county. Mr. Gleason continues the manufacture. He uses the lowest seventeen feet of the formation. Immediately below the black slate is a very hard limestone, struck in a well drilled by Mr. Gleason, but abandoned after several hours' labor with very little effect. The stone is burned at a red heat for six or eight hours, when it is ground by steam. The lime has been used in various ways, and seems to afford very satisfactory results. The greatest natural wealth of this county lies undoubtedly in the strong and fertile soil with which the greater part of it is furnished. There is also an area of a hundred and seventy-thousand acres of heavy forest, which supplies material for ship-building and for the manufacture of a number of domestic articles. Hard-wood logs are floated down the Maumee to Toledo.

REPORT ON SECOND DISTRICT.

BY E. B. ANDREWS.

PROF. J. S. NEWBERRY, *Chief Geologist:*

DEAR SIR—I herewith transmit to you my report of labors in the Second Geological District. The counties within the Coal Measures reported upon are Washington, Noble, Monroe, and the southern portions of Guernsey and Belmont. My assistant in 1872 was Mr. W. B. Gilbert, and in 1873 Mr. William Holden. Both of these gentlemen have done most excellent work.

Very truly yours,

E. B. ANDREWS.

COLUMBUS, October 15, 1874.

CHAPTER L.

SURFACE GEOLOGY.

DRIFT IN THE SECOND GEOLOGICAL DISTRICT.

The Drift in the Second District may be divided into two classes—the original Drift, composed of bowlders, gravel, etc., often found on high ground in the north-western part of the district, and the modified valley Drift, constituting terraces along certain streams.

The first is a part of the general outspread of drift found throughout all the northern and north-western States, and popularly known as the Drift. It is found over the whole of the north-western portion of the Second District, and along the hills bordering the Hocking River, some distance below Lancaster. Scattered bowlders have been found in the western part of Vinton county. South of the Ohio River a considerable area covered with Drift is found near Ashland, Boyd county, Kentucky. This was first observed by Sidney S. Lyon, of the Kentucky Geological Survey. Here the Drift is pretty high in the hills, perhaps two hundred feet above the low water of the Ohio.

The eastern limit of the Drift is a line running nearly north-east and south-west through Muskingum, Perry, Fairfield, and western edge of Vinton counties. If, however, we take the Kentucky deposit into the account, the line will be almost a north and south one. A single quartzite bowlder was found in Washington county, on a ridge between the Muskingum River and Duck Creek, about three hundred feet above the former stream. This bowlder may have been taken from the valley Drift on the banks of the Muskingum, and carried to the top of the ridge by human agency.

The bowlders of the general Drift are often found on very high ground, from two hundred to three hundred feet above the principal valleys. In some regions they are quite numerous, and very large. In the vicinity of Lancaster they are found at elevations two hundred and fifty to three hundred feet above the Hocking River. On the slopes, and near the top of Mt. Pleasant (an old river hill, with bold cliffs on the western and northern sides), on the high ground between Lancaster and Rushville, and on the high lands on the west, which divide the waters of the Hocking and Scioto rivers, large bowlders are abundant. Many are also found in valleys which contain no modified or valley Drift. Over the whole region they have evidently been dropped in a very miscellaneous way, as if from floating icebergs.

The largest bowlder seen in the Second District is in a valley about a mile north-east of Lancaster. It is where it could not have been brought by any motive force acting in the immediate valley of the Hocking. High hills lie to the northward. An approximate measurement gave eighteen feet for its larger and sixteen feet for its smaller diameter. Smaller bowlders are not uncommon in the neighborhood, and one measuring seven by five feet is seen almost on the top of Mt. Pleasant, or about two hundred and fifty feet above the large bowlder just referred to, which lies near the base of the hills. The bowlders of this region show all the lithological characters of northern bowlders, being granites, quartzites, etc. Over the more western portion of the Drift area in the Second District we find more or less gravel on the high grounds, but toward the extreme eastern limit of the Drift no gravel has been observed.

In the Hocking valley, and probably over a very considerable portion of the Second District, there is found in the low grounds a blue clay in which bowlders are occasionally seen. This clay is variable in thickness. It is sometimes only two or three feet thick, and, indeed, it is often not found at all. There is proof that in some places channels were cut through it, and much of it carried away, after deposition by currents of water during the Drift era. I have never seen any of this clay upon the hills within the Drift areas. In this blue clay are remains of ancient vegetation in the form of trunks, roots, limbs, and twigs of trees, generally remarkably well preserved. In some localities nearly every deep well revealed fragments of such vegetation. The wood is apparently allied to the cypress of the lower Mississippi valley. It was buried by the mud brought in by the waters in the earlier portion of the Drift era. In the valleys of the Second District this Drift clay seldom, if ever, rests upon the rock bottom, but upon what I suppose to be the old alluvial sands and clays of the pre-glacial period. Above the Drift clay are the gravel and bowlders of the modified Drift, or terrace Drift, which were not deposited until long after the deposition of the Drift clay. We have thus two features of the original Drift—the gravel and bowlders scattered upon the higher grounds, and the Drift clay found in the low valleys.

The Valley or Terrace Drift.—This is simply the sand, gravel, and smaller bowlders brought down the leading valleys and distributed along the banks in great sand-flats and gravel-bars. The materials in all cases come from the general Drift, except such as would naturally come from the valleys and adjacent hill-sides, and become intermixed with the rest. In the terraces of the Muskingum valley we find pebbles of coal and of the sandrock of the Coal Measures, all evidently of home origin. The pebbles of coal could not have traveled far—the material is too soft to endure the friction and rough usage of a long journey.

The Drift terraces are found along the Ohio, Muskingum, Licking, Hocking, and Scioto rivers, but on no others in the Second District. These are the only streams whose sources lie within the area of the general Drift, and, consequently, the only ones which could obtain the materials needed for true Drift terraces. These terraces have been more or less wasted and reduced in height since they were formed, but eighty feet above the stream is about the elevation of those best preserved. Being dry and easily drained, they afford desirable locations for the towns and villages of the present inhabitants, as they did for the Mound-builders, whose finest works are generally upon them. Zanesville, Marietta, Lancaster, Gallipolis, Ironton, Portsmouth, and other towns of less size, are built wholly or in part on Drift terraces. The Ironton terrace has more clay mixed with the sand than is usual. The terrace on which a part of the city of Lancaster is built, the new and beautiful court-house having a commanding site on the summit, is one of the old Drift gravel banks. It is from seventy-five to eighty feet above the present bed of the Hocking River. We have now only a remnant of the original terrace, for the waters have swept around in rear of it, and left only an insular hill in the broad fertile valley. On the southern edge of the present hill the gravel is very coarse. This gravel at some points is found to be cemented together by carbonate of lime, and a stratum of coarse pudding-stone has been formed, which is used for rock-work, ferneries, ice-houses, etc., where picturesque effects are desired. A similar pudding-stone is found in a Drift terrace a few miles below Logan.

Marietta is built on a large and beautiful terrace, formed at the confluence of the Muskingum and Ohio rivers. It is composed of sand and gravel, the sand in some places fine enough for molders' use. The gravel is often quite coarse, and contains pebbles of considerable size. In the south-eastern portion of the terrace, where it is crossed by Putnam street, there is a well-defined horizontal layer of fine blue clay, which indicates that at one time the currents of the two streams were of such equal level and equal force as to form an eddy of still water, from which the fine clay sediment was deposited.

The terraces at Columbus and vicinity are broader than the usual valley terraces, and constitute a part of a far wider outspread of Drift materials in the more flat country to the north The transition from the valley Drift to the general northern Drift, as it has been distributed and arranged by water, is almost imperceptible. Perhaps the same aqueous action which carried southward Drift materials and left them in terraces along the streams, modified to some extent the old Drift, giving it a somewhat terraced character.

There is in the Second District another and very distinct system of terraces found on streams emptying into the larger streams bordered by true Drift terraces. They may be called back-water terraces. When in the Ohio, Muskingum, Hocking, etc., rivers, the water in the Drift era stood eighty or ninety feet higher than at present, the back-water would set back up all the tributaries. In this still water the sand and sediment brought down these tributaries were depoisted, or, in other words, the still-water areas were silted up, as mill-ponds often are. When afterward the main streams gradually fell to their present level, these affluents cut through the back-water beds and carried away much of the soft materials, but left in many places fringing terraces, which tell very plainly how they were formed. In these back-water terraces we find no true Drift sand and gravel. The beds are entirely of home origin. Such terraces I have seen on the Little Scioto River, above its junction with the Ohio at Sciotoville, on Duck Creek, and on the Little Muskingum River, in Washington county, and on Sunday Creek, in Athens county. I have no doubt they are to be found on a large number of streams.

When we carry back the study of our surface geology to the period immediately antecedent to the Drift, we find that all the leading valleys had been eroded by the same system of surface drainage which now exists. The general surface features of the whole State were the same as now. The Scioto, Hocking, and Licking rivers drain by their upper waters much of the central and level portions of the State, a region now thickly covered with a mantle of Drift materials. They drained the same area before the era of the Drift. The Drift agencies could not have planed down or essentially modified this upper flat country to any appreciable extent—they merely covered it with debris. The same reasoning applies to the northern slope of the State. The Cuyahoga River, for example, had, as shown by Dr. Newberry in Vol. I., in his report on Cuyahoga county, eroded a very deep channel, which was subsequently filled with Drift. This stream flowed northward into a deep valley now occupied by Lake Erie and by the Drift clays which form its bed. Similar valleys and channels of streams emptying into the Lake were doubtless filled by the Drift. These facts furnished by Dr. Newberry tend to show that the surface features of the State were essentially the same before the Drift era as now. The clays, gravel, and bowlders of that period were laid down upon a surface already brought into its present form and contour by agencies at work during an indefinite period antecedent to the Drift era. So far as I have observed, the work done by the Drift agency itself in sculpturing the rock surfaces of Ohio has been almost infinitessimally small. With the valley of the Ohio River and its tributaries on the southern slope of the State before the Drift era as now, and with the great northern depression, or valley, now filled by Lake Erie, and the streams draining the northern slope into it as now, there was little for the Drift forces to do except to scatter over an old surface its various materials of clays, bowlders, etc. Doubtless wherever there were rock surfaces exposed, these forces, whatever they may have been, acted as a file or sand-paper upon wood already carved, to smooth down many of the minor asperities, and the tool-marks remain at various points on the smoothed or striated rocks.

The larger streams in the Second District 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 formed pools separated by ripples or waterfalls. The ancient pools are now filled with alluvial materials, excepting where we find the Drift clay, and the latter, so far as I have observed, seldom, if ever, rests directly upon the bed-rock, but upon sand or gravel. The harder rocks were where the ancient rapids or falls are now sometimes seen, and constitute the present bed-rock of the streams. The Ohio River now flows upon a solid rock floor at Letart Falls, in Meigs county, and such bed-rocks are reported by the United States engineers, who have carefully investigated the Ohio River with reference to the improvement of its navigation. Similar rock beds are found in the Muskingum and Hocking rivers. The following facts have been obtained through the courtesy of E W. Sprague, Esq., of Lowell, Washington county, who was connected with the construction of the slack-water improvement of the Muskingum River: "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 soap-stone,' no harder rock appearing, except near the lock at the east end." This soapstone is a common red clay shale found in the upper Coal Measures. 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 the depth of sixty feet." "At Luke Chute the lock and east end of dam are built on rock, but at the west end no rock is found to the depth of eighty feet." "At Windsor the dam is built on soap-stone 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 the bed-rock. At Symmes Creek the dam and lock are on soap-stone at the east end, but no rock was found at the west end within a depth of sixty feet."

The Muskingum and Licking rivers, at their junction at Zanesville, flow upon the hard, stratified rocks, the most important of which is a fossiliferous limestone. Under Putnam Hill we see the rock strata extending beneath the water. About a half a mile below, on the east side of the Muskingum, we find the stratified rocks also extending out under the river. It is, however, quite possible that the Licking once had a deeper channel east of the present one, and united with the Muskingum much higher up the latter stream, and from that point the united streams flowed under the present site of the city, coming into the existing channel down toward the lower lock on the canal. If this were so, the Drift gravel choked up this old channel, and both streams flow now upon the marginal rock platform which was once the western shore.

The falls of the Hocking, at Logan, are in a hard conglomerate—the top of the Waverly conglomerate—while east of the falls the alluvial sands extend down lower than the surface of the rock at the falls. At these falls there are many pot-holes. In a mining shaft sixty feet deep, a mile or two above Salina, in the immediate valley of the Hocking, the usually heavy sandrock over the coal was found to be eroded, leaving only a very few feet of it, and in a drift-way from the bottom of the shaft a pot-hole extending through the sandrock into the coal seam was struck. In the explorations considerable quantities of buried wood were found. The erosion of the rock and the pot-hole would indicate that in the pre-glacial time there had been at this point falls or rapids. The shaft revealed nothing but alluvium in penetrating to the sandrock, no true Drift materials being found. In a well near this shaft the lower jaw of a mammoth was found sixteen feet below the surface. Before the Drift, we may reasonably believe that the larger streams of south-eastern Ohio showed exactly the same inequality in their beds that would naturally be made by streams of considerable current passing over strata of unequal hardness, and exactly such as has been made by the Kanawha and other streams in similar geological formations south of the Ohio, in West Virginia, and beyond the region of the Drift. There were ledges of hard strata crossing the channels and making falls and rapids, while below were pools of varying depth, partially filled with sand and mud.

This I suppose to be the law of erosion in rocks of unequal hardness, and has innumerable illustrations.

Any elevation of the continent would not tend to change this law, although such elevation is required for the explanation of the erosion of channels and of bays now below the level of the sea. But inland, and in regions so high that the streams could not be affected by any back or dead-water, the drainage has always been the same as now. The erosion of the pools in the softer rocks would, after a time, reach its maximum, and the pools would gradually fill up with sand and mud, and then the chief erosion would be on the hard strata of the intervening ledges, reducing them slowly to the common level of the bed of the stream, to be covered in time with alluvial materials. In our larger streams only a few of the old rock barriers are now to be seen, but there are doubtless large numbers which are covered with only a few feet of sand or mud.

The work of erosion in southern Ohio has been going on ever since the Carboniferous era, and it has been, consequently, very great. Standing on the summit of one of our high hills, we may look for miles across intervening valleys to some distant knob, and realize that by the slow process of surface drainage the rock strata which once connected the two points have been removed. The tops of anticlinals, such as the Newell's Run uplift in Washington county, have also been removed by the same slow agencies. A few miles south of the Ohio River, in West Virginia, the continuation of the Newell's Run anticlinal ridge was once a narrow mountain a thousand feet high above the present streams. It has been eroded away, leaving hills no higher than the others in the neighborhood, and these are intersected in all directions by valleys.

In these ancient valleys of southern Ohio, and doubtless over the hills as well, there was a growth of vegetation, and trunks and branches of trees indicate a forest growth. These remains are found both in the alluvial materials at very considerable depths, and also in the blue clays of the Drift. It is, however, improbable that these valleys were ever occupied by moving glaciers, for such glaciers would entirely sweep away all the local vegetation. The short, sharp curves of many of these valleys would apparently entirely prevent any glacial motion in such deep and crooked river beds. In the subsidence by which the land was lowered so that the waters could bring in and deposit as sediment the blue clays, the overthrow and burial of the old forest trees of the valleys took place. This was the first work of the Drift period, as recorded in south-eastern Ohio. These waters were connected with a great northern subsidence, and in the waters of this sea was floating northern ice, from which bowlders were dropped into the same mud, which buried the old vegetation. The Drift gravel terraces which often overlie the blue clays were formed long afterwards. The subsidence increased so that the waters in the Second District were several hundred feet—probably not less than five hundred feet—above the present level of Lake Erie, as shown by the heights of the bowlders on the hills. A few facts would indicate a somewhat deeper submergence than this. There is no proof that at any time was there in the Second District any great continuous sheet of glacier ice. There is no general planing off of the rocks, but every where among the hills where the northern bowlders are most abundant, are projecting knobs or outliers of soft rocks, which would naturally be an easy prey to such a destructive force as would be exerted by the movement of a vast glacier. Fine exhibitions of such outlying knobs and cliffs of soft sandstone rock are seen on the high table-land west of Lancaster dividing the waters of the Hocking and Scioto rivers. The Drift sea was around these small knobs, for all about are Drift bowlders and gravel. The small knobs could not have survived the abrading power of a great glacial sheet moving on irresistibly from the north. At the time of the greatest submergence, all, or very nearly all, of the Second District was below the water, and at that time no local glaciers were possible; but such glaciers would be possible both during the progress of the subsidence and that of the emergence. I have, however, found no striæ upon any rock surfaces in the Second District. These, however, if made, would hardly remain in the soft rocks of the Waverly or of the Coal Measures, which are readily disintegrated under atmospheric influences. If found, however, they might have been made by the ice-rafts where they ground along the bottom or impinged against the slopes of the hills, or by the movements of shore ice. Pres. Orton reports such glacial striæ in the high lands west of the Scioto, in Highland county, which he considers the work of a great continuous northern glacier. The great current in which the great ice-rafts floated appears to have moved in a southerly direction a little west of south, the eastern limit being in the western part of Muskingum county, and Ashland, on the Ohio River. East of this general line I have found but a single bowlder on high ground, that in Washington county. This line was not the eastern limit of the water, but the limit of the floating ice.

The Drift phenomena of the Second District connect themselves, without any perceptible change, with those of the great general Drift of the North There is nothing wanting except striation of surface rocks, and these may have once existed. Local glaciers on the highest unsubmerged lands, the moving ice-rafts, and doubtless vast quantities of shore ice, may well explain the striæ and their varying directions. The Drift period was of immense duration, and the great northern currents, with their floating icebergs, with loads of debris from northern regions, would in time be able to cover the bottom of the shallow sea with the materials we now find, and arranged as we now find them. All geologists agree in the belief in a submergence of the land, the only difference of opinion being in regard to the question whether prior to such submergence there had been spread over the whole North a vast and continuous glacier. To such a vast continental glacier is attributed by some the mighty work of giving shape and configuration to all the surface within its range, reducing mountains and hills to plains, and digging out the basins of lakes sometimes to depths even below the level of the ocean. We have already seen that in the Second District there is no evidence that the pre-glacial or ante-drift surface was essentially different from what it now is. If there were a climate so arctic in character as to allow of the extension of a sheet of ice immensely thick almost to the Ohio River, we should expect that the same cold climate would necessitate glaciation in the Alleglany Mountains but a short distance south of the Ohio, where no traces of glaciers have been found. The average altitude of the Alleghany range is 3,000 feet. If, on the other hand, the cold were produced by marine currents coming down from the arctic region, it would have the sharp limitations characteristic of such currents at the present day. It is doubted by many geologists of high authority whether we have, even in Greenland and in the antarctic regions, any thing now corresponding to such a widely-extending glacier. There are glaciers in these polar regions occupying the valleys sloping to the sea, but not one universal glacier. If this is true, there is no analogy for such a vast glacier as is claimed, except such as may be found in local glaciers like those of the Alps, and such local glaciers are freely admitted to have existed on the higher grounds adjacent to the icy northern currents.

If, again, the cold were so great and so wide-spread as the whole glaciation of so large a part of the northern continent would call for, whence the heat for evaporating the moisture to be condensed by the cold into the snow and ice of the great glacial mantle? Prof. Tyndall has forcibly suggested this difficulty.

Again, what force or *vis a tergo* could have been exerted to impel the vast glacier across the great valley of the lakes, and up and over the high ground to the south? In all recorded movements of glaciers the ice is carried down slopes, so that gravity, if not positively aiding, could not retard the movement. If a glacial sheet extended into southern Ohio, it must have passed over the vast distance from the high lands (now reported to be only 1,500 feet high, which is not as high as the highest lands of the Ohio watershed, as reported by Dr. Newberry) between the lakes and Hudson's Bay, across a general depression, in which lie the lakes, and up over the watershed dividing the waters of the lakes and the Ohio River. The Duke of Argyll, President of the Geological Society of London, has well said in his recent annual address: "We know that the descent of a glacier, even down the steep declivities of Mont Blanc, is retarded by such an enormous amount of friction that the coherence of its substance is overcome; the base of it is, as it were, torn from its superincumbent mass, and the progress of the base is reduced to one-half of the rate at which the surface moves. We know that this is the result in a case where the force of gravity is at its maximum, and none of its momentum has been lost. We know, also, that in no part of the existing world is the phenomenon presented of ice streams moving for great distances even over level ground, still less ascending steep gradients, and this, too, at a great distance from the declivities which give impetus to forward motion. * * * I can not help thinking that there is a fundamental fallacy in comparing the movement of ice masses down the slopes of a mountain with any movement of such masses which is possible on level ground or against opposing slopes. In the one case gravity is an assisting, in the other case it is a resisting, force. In the one case, the heavier the mass of ice the easier and faster will be its motion; in the other case, every additional ton must add to the difficulty of effecting movement. In the one case, thrust and gravity act together; in the other case, thrust must act alone, with gravity and friction to counteract it. * * * * It would be altogether illogical to suppose that because these molecular changes (by variations of temperature acting on the molecular structure of the ice) are able to overcome friction when they are powerfully assisted by the gravity of the mass lying on a steep slope, therefore they are equally able to overcome friction with no such assistance from gravity, but, on the contrary, with gravity exerting all its force in favor of rest and against motion of any kind."

In Canada and along the old sea margin, as at Portland, Maine, the Drift clays contain marine shells of existing arctic forms. Principal Dawson, of Montreal, who has studied the Drift phenomena of Canada with rare ability and painstaking, has enumerated from the Drift, of plants, 10 species; radiata, 24; mollusca, 140; articulata, 26; and vertebrata, chiefly fishes, 5. In the West no marine forms, so far as I know, have been found in our Drift clays, but I doubt whether the search has been sufficiently extensive and minute. Plants, however, are not uncommon. The living marine forms dredged from the depths of Lake

Superior indicate that at one time the lakes may have been filled with salt water from the arctic regions.

The terraced valley Drift is known to extend far down the Ohio River. Profs. E. W. Hilgard and F. V. Hopkins, in their geological researches in the lower Mississippi valley, find in the Orange sand a wide out-spread of gravel, pebbles, and occasionally small bowlders, which they connect with the Drift of the northern States. Prof. Hopkins quotes the fact of the elevation at which bowlders were found on high lands in the Second Geological District of Ohio, as reported in the Report for 1869, as showing that if these bowlders were transported by floating ice-rafts, as he believed, and not by a vast, continuous northern glacier, the whole district of the lower Mississippi was submerged in the Drift era, and by these submerging waters the Drift materials he finds in the South could readily have been transported. He gives a table of the elevations of the higher lands in the path of such a great southern current to prove that such high lands have all been beneath the water, and so were not insuperable barriers to such a current.

Prof. Hilgard writes: "The gravel is composed of northern rocks disposed in belts, of which one occupies the main axis of the embayment, while others mark outlets now closed; and the extensive denudation and violent plowing up of the more ancient formations clearly prove the occurrence of an immense flow of waters southward, which, in the main channels, moved pebbles of many pounds weight, while between them the deposition of the finer materials took place in the more quiet waters. That these events were not of a local character, that, on the contrary, the phenomena observed in the southern States are but the necessary consequences and complements of the Drift phenomena of the North, hardly requires discussion; but it is time that these facts were more generally understood and taken into the account by American geologists, and that the Ohio should cease to be proclaimed as the southern limit of the Drift."

Westward of the State of Ohio the Drift is found in most of the western States. The State of Iowa I have crossed on four different east and west lines of railroad, and examined a large number of railroad cuts, and every where I find evidences of Drift deposited and arranged by the action of currents of water. Similar Drift phenomena appear under the "Bluff" formation in the north-western part of Missouri, as reported by Prof. G. C. Broadhead in the recent report of the geological survey of that State. These many facts attest the submergence of a vast area, and doubtless for a vast period of time, during which the bowlders and foreign rocks were brought in, and the bottom of the comparatively shallow sea was subject to such changes as currents and grounding ice would naturally produce. Further north, in higher latitudes of the continent, there were doubtless many glaciers, and these may have moved in the same channels for such long periods of time as to have performed a very considerable work of erosion in deep furrows and striæ.

CHAPTER LI.

REPORT ON THE GEOLOGY OF WASHINGTON COUNTY.

This county is situated upon the Ohio River, the river constituting its southern and eastern boundary. It is bounded on the north by the counties of Monroe, Noble, and Morgan, and on the west by Morgan and Athens. It is divided into two proximately equal parts by the Muskingum River, which, entering the county in the north-west corner, flows, with many windings, in a general south-east direction, and enters the Ohio at Marietta.

The length of the Ohio River along the southern and eastern border of Washington county is very nearly fifty-four miles. In this distance the stream falls thirty-two feet, giving an average fall of about seven inches per mile. But this fall is not evenly distributed through the whole distance, for the river consists of a series of alternating pools and shallows, and in the latter the chief fall is found. According to the Government surveys, there are in the aggregate about twenty-four miles of pools, in which the water is seven feet or more deep. The remaining thirty miles are made up of comparative shallows and ripples.

It appears to be the law of all streams of much length to form for themselves an uneven bed. This would be so if flowing upon rock beds, if the strata were of unequal hardness; and this is always the case when flowing in alluvial beds. To change the natural character of the current of the Ohio so as to give a proximate uniformity of depth in low-water seasons, is a problem of the highest importance to the commercial interests of the West.

The elevation of the Ohio above tide-water at the upper end of the county, one and one-fourth miles above Matamoras, is 588.3 feet, and the elevation where the river leaves the county at the lowest point of Belpre is 556.3 feet. If we take the survey for the New York and Erie Canal, the elevation of Lake Erie is 565 feet above tide-water. This determination may properly be preferred over railroad surveys, since, generally, surveys for canals are made with more minute accuracy than railroad surveys.

The point on the Ohio where the elevation is 565 feet above tide-water, or at the exact level of Lake Erie, is 2.9 miles above the mouth of Little Kanawha at Parkersburg. The surveys of the New York and Erie Railroad make the elevation of Lake Erie 569 feet, or four feet higher. How this discrepancy is to be explained I do not know, but the results of the earlier survey are, I think, generally accepted. Prof. Arnold Guyot gives 565 feet as the elevation, and Col. Chas. Whittlesey, of Cleveland, who has carefully collected the various surveys, gives the same. Col. Chas. Ellet—probably taking his data from the surveys of the Muskingum River Improvement and of the Ohio canals—gives the elevation of the mouth of the Muskingum above tide-water as 571 feet, while the Government surveys of the Ohio River give it as 569.821 feet, a difference of 1.179 feet. If we accept the figures of the Government survey, and, also, 565 feet as the elevation of the Lake, then the mouth of the Muskingum is 4 821 feet above the level of the Lake.

The surface drainage of the county is very complete. The principal affluents of the Ohio within the county besides the Muskingum are the Little Muskingum River, Duck Creek, and the Little Hocking River. Wolf Creek, which drains a considerable area in the north-west part of the county, is a tributary of the Muskingum, and empties into the latter a little above Beverly.

The drainage system of the county presents some very interesting facts. The Ohio River, Little Muskingum, Duck Creek, and the Muskingum all converge toward a common center, the last three uniting with the former in Marietta township. The Ohio, which flows in a channel nearly parallel with the Little Muskingum, is deflected north-westerly by the West Virginia hills, and meets the other streams mentioned. The slopes of nearly half a circle find their lowest point at a common centre in Marietta township.

The Little Muskingum drains the south-western part of Monroe county, and entering Washington county near the north-east corner of Ludlow township, flows through Ludlow, Independence, Lawrence, Newport, and Marietta townships to the Ohio. Its branches also drain portions of Jolly and Grandview townships. All of Liberty township, except the north-west corner, is drained by Fifteen-Mile Creek, a branch coming in from the north. Duck Creek flows nearly south through Washington county, and drains a comparatively limited area lying in Aurelius, Salem, Fearing, and Marietta townships. The Pawpaw branch extends into the north-west corner of Liberty, and Whipple's Run rises in Fearing. There is within the county no western tributary of Duck Creek of any considerable size, the watershed or dividing ridge between the Duck Creek and the Muskingum being generally very near the former stream.

The northern tributaries of the Muskingum within the county are all small. Bear Creek, Cat's Creek, and Big Run are the chief, and drain Adams and the western part of Salem township. On the western and southern side of the Muskingum its principal tributaries are two—Rainbow Creek and Wolf Creek; the former flowing eastward, and entering the Muskingum in Muskingum township, and the latter, with its several branches, flowing northward, and draining Watertown, Palmer, Wesley, and the northern portions of Fairfield, Barlow, and Warren, and small parts of some other adjacent townships. The slope drained by the waters of Wolf Creek, in this county, is proximately a north-western one, and directly opposite the general slope of southern Ohio.

In the south-western part of the county is the Little Hocking River, the east branch of which rises in the southern part of Warren, just back of the Ohio River hills, and flows south-westerly through Dunham and Belpre, to unite with the west branch in the extreme western part of the latter township. The west branch drains the southern part of Fairfield and Decatur, flowing in a general south-easterly direction toward the Ohio River.

Thus it will be seen that the county presents a great variety of surface slopes. In the eastern half of the county the slope is south-western and southern, while in the western, *i. e.*, west of the Muskingum, it is chiefly northern and south-western. While the general drainage of south-eastern Ohio is to the south-east, the large streams, like the Muskingum and Hocking, flowing in a direction proximately at right angles to the direction of the Ohio, yet in Washington county we have almost every variety of direction.

What originally determined the flow of streams in these different directions it is impossible now to determine. In some parts of the State the dip of the strata determines the direction of drainage, but this can not be the case to any large extent in Washington connty.

East of the Muskingum River the rocks show many undulations of dip, with some well-marked uplifts, such as those on Newell's Run and Cow Run; but these original elevations have not served to deflect the direction of streams. Cow Run has cut its valley directly through the Cow Run uplift from east to west, and Newell's Run has singularly enough eroded its valley longitudinally in the very axis of the Newell's Run uplift. Similar facts appear in West Virginia, where, in the southern continuation of the Newell's Run uplift, the erosion has removed many hundreds of feet from the top of the anticlinal, and the present streams cut through it in all direetions.

If it is remembered that the area now constituting Washington county has been high and dry land ever since its Carboniferous era, excepting a temporary submergence in the Quaternary period, it will be seen that there has been time enough for the removal of the summits of all the anticlinal ridges by the simple action of such eroding agencies as are now at work degrading the hills. It is true that the direction of streams is, for limited distances, determined by the character of the strata of rocks in which they flow, the softer strata yielding a passage, while the harder resist. This will explain many of the crooked ways of our streams, which would be otherwise utterly inexplicable. But this cause could not have determined the general direction of the streams in Washington county.

Soil.—The immediate valleys of the Ohio and Muskingum are very rich and productive, and equal in fertility to any lands in the State. There are in the county about fifty-four miles in length along the Ohio River, and about thirty-two miles along the Muskingum. This county has, therefore, a large aggregate area of the finest alluvial soil. In these valleys alone we find the sandy Drift terraces, which are generally at an elevation of from seventy to eighty feet above the streams. While the soil of the terraces is not so rich as that of the lower alluvial ground, it is, nevertheless, generally fertile, and being a warm and early soil and easily cultivated, it is the favorite one for many crops. There is in the gravel and among the pebbles of these terraces a considerable quantity of limestone, which adds greatly to the fertility. The valleys of Duck Creek and Little Muskingum are generally much narrower, and show no Drift terraces. The alluvial soil in these valleys is composed of sedimentary materials derived from the Carboniferous strata of this county and of Noble and Monroe. From the nature of the strata, we should not expect, as a rule, a soil as rich as in the longer valleys of the Ohio and Muskingum, where there is a larger variety of soil-producing materials in the strata traversed, and especially more of limestone. The soil on the hills and hill-sides in the county is determined in quality by the nature of the strata composing the hills. It is richest where there is an abundance of limestone, and poorest when derived from disintegrated sandstone. In some cases I have found strata of highly soluble limestone of great fertilizing value situated half way up the hill-sides, while above are sandrocks and sandy shales. Yet the more sterile sandstone soil is often cultivated and the rich limestone soil neglected. It has been estimated that the alluvial valley of the Muskingum is three-fourths of a mile wide. If so, there would be 15,360 acres of land in the immediate valley. If we estimate the average width in both bottom and terrace land of the north bank of the Ohio at one-half mile, we have

17,280 acres, and a total in the two valleys within the limits of Washington county of 32,640 acres. The largest deposits of limestone strata are perhaps those found along Wolf Creek, but they are so low in the valley—indeed, often in the bed of the stream—that they produce little fertilizing effect. In Adams, Salem, and Liberty townships there are valuable deposits of highly soluble limestone, which are of the utmost agricultural importance, and give to many farms a rich and almost self-perpetuating soil. Such limestones are not altogether wanting in several other townships, but are most abundant in the townships named. The smoothest lands in the county, and those most attractive to the eye, excepting the more immediate river valleys, are found on the slope drained by the branches of Wolf Creek, in the townships of Barlow, Watertown, Palmer, etc. They are not, perhaps, the richest, for there is a deficiency in limestone; but they lie beautifully, and in their gentle undulations and gradual slopes are in marked contrast with the abrupt hills so common in other parts of the county. Taken as a whole, the soil of Washington county is in quality above the average of that of the counties of southern Ohio. Even its most rough and forbidding hills have, by the frugal and industrious German population, been rendered productive and attractive.

General Geological Features.—The county lies wholly within the Coal Measures, and in the upper portion of the series. There are no other geological formations represented within the county, if we except the surface materials which constitute the Drift terraces of the Muskingum and Ohio valleys, which are of Quaternary age. There is in Barlow, on the northern slope of the Wolf Creek waters, the probable evidence of an ancient lake bed, which is also, doubtless, Quaternary in age. The Drift terraces constitute a uniform series of ancient gravel banks and sand bars, formed at a time when the Ohio and Muskingum Rivers were at a far higher stage than now. The materials of these terraces were brought from the north, from areas once covered by large deposits of sand, gravel, bowlders, etc. Duck Creek and Little Muskingum are not sufficiently far north to reach these Drift areas, and, consequently, no true Drift terraces are found upon them. On the Little Muskingum and Duck Creek I have noticed some terraced banks, but they show none of the extra-limital materials found in the Drift terraces, and were made by the deposit of the proper river sands where the current of these streams met the back-water of the Ohio, at the time when the waters of the latter were probably eighty or one hundred feet higher than now. In the Drift gravel in the Ohio and Muskingum terraces we find a great variety of pebbles and small bowlders, very interesting in their lithological and palæontological characters. In addition to granites, quartzites, and greenstones, and all forms of the harder rocks found north of the lakes, we have the fossils of all the fossiliferous strata lying to the north. These are found best preserved when imbedded in cherty limestone. With time and patience, one could obtain in these Drift gravel banks a very good cabinet of minerals and fossils. It is not uncommon to find considerable accumulations of rounded pebbles of bituminous coal and small bowlders of our Coal Measure sandrocks. Bowlders of the Waverly sandstone and of the Corniferous limestone are very common. Away from the Drift terraces I have never found in Washington county but a single Drift bowlder, and this I picked up on the high divide between the Muskingum and Duck Creek, about three hundred feet above these streams. There is a possibility that it may have been carried up from the banks of the Muskingum by human agency. If not thus brought, it was doubtless dropped from floating ice at a time of submergence, when at other points in the State large numbers of Drift bowlders were dropped on higher ground than this.

Passing from the Drift and surface geology, we find the stratified rocks of the county all belonging to the Coal Measure formation. It is common to divide our Ohio Coal Measures into two divisions, Upper and Lower, the dividing line being that of the Pittsburgh seam of coal. But the Pittsburgh and Wheeling seams are the same, according to the Pennsylvania geologists, and I have, by careful tracing through the several counties, identified the Pomeroy and Wheeling seams as the same. If, therefore, the Pomeroy seam be taken as the base of the Upper Coal Measures, nearly all of Washington county lies in the upper series. The Pomeroy seam is found in large development west of the Washington county line on Federal Creek and its branches in Rome, Berne, and Ames townships, and in Marion and Homer townships, in Morgan county. But the seam dips to the eastward, and is not seen any where in the west half of Washington county. But in the undulations and uplifts in the eastern part of the county it appears on Duck Creek and Little Muskingum, and in the Newell's Run uplift in Newport township. The most extensive seam of coal in the county is the one found eighty-five to one hundred feet above the Pomeroy seam, which has a wide range in Adams, Aurelius, Salem, Liberty, Fearing, Lawrence, Newport, etc. This is the upper Salem coal, or the "sandstone seam," so called from the fact that in Salem it generally lies under a heavy sandrock. It is generally of sufficient thickness for profitable mining, and is of good quality. There is a seam of coal about one hundred feet higher in the series, found in many parts of the county, which is generally thin, but serving a purpose for local use. It is seldom sufficiently thick to warrant extensive mining. There is in Washington county an adequate supply of coal. It only needs the proper facilities for distribution. Unfortunately, all the seams of coal in the hills bordering the Ohio River are thin. The Pomeroy and the one about ninety feet above it are brought up in the Newell's Run uplift, but are too thin near the Ohio River for extensive and profitable mining. Upon the Muskingum the Coal Run seam, which is the one above the Pomeroy seam, is in fair development. When mined with discrimination, the better coal of the seam is of very fair quality and suitable for all general uses. This coal meets a want on the river which could not otherwise be well supplied. A large supply of coal may be obtained above Lowell, on the waters of Cat's Creek and Big Run. The Cat's Creek seam extends through the hills, and is found well developed on the head waters of Bear Creek, a stream which enters the Muskingum a mile below Lowell. All these locations of coal will be noticed more in detail in the reports on the different townships.

Iron ores have been found only in limited extent in the county, seldom in quantity to warrant mining. The traditional mines of lead and silver ores are every where, although I could never find them, and never saw any body who had found them. The poor Indian, who never used either of these metals until he obtained them from the white man, is generally charged with the working of these mines.

Salt, in the form of rich brines, may be found in many parts of the county by sufficiently deep boring. Many oil wells have struck ample supplies of brine.

Petroleum is found in considerable quantity in several townships east of the Muskingum.

DECATUR TOWNSHIP.

This township is in the western part of the county, and adjoins the Athens county line. It is drained chiefly by the west branch of Little Hocking River. excepting the north-western corner, which is drained by the heads of Big Run, a branch of Federal Creek. The township is hilly, but the soil is of fair quality.

In order to understand the geology of this township, it may be well to enter it on the north-west by the way of the valley of Big Run, for the Marietta and Cincinnati Railroad is located in this valley, and the railroad cuts will greatly aid us. At Big Run Station, in Rome township, Athens county, the Pomeroy seam of coal is below the level of the stream, where it was once reached by a shaft near the station-house. The seam of coal about ninety to one hundred feet above the Pomeroy seam is there seen in the side hill forty-six feet above the railroad track. This seam is about four feet thick, but, unfortunately, contains near the middle a stratum of fire-clay from a foot and a half to two feet thick. At Philip Totnan's, section 12, there are four feet six inches of coal, exclusive of the clay. Following the railroad east, we find this seam of coal about three feet above the level of the track. As this point is not far from the county line, we may here begin an examination of the strata seen as we ascend the railroad grade to Cutler Station. Bringing the separate portions into one section, it is as follows, in the descending order:

		Ft.	In.
1.	Coarse sandstone, in part conglomerate, forming ledges	30	0
2.	Coal and slate in cut at Cutler Station	0	6
3.	Shale, containing coal plants, Cutler Station	5	0
4.	Sandrock	6	0
5.	Shale	8	0
6.	Sandrock	20	0
7.	Shale	6	0
8.	Coal	0	6
9.	Clay	0	2
10.	Coal	0	3
11.	Clay	1	6
12.	Blue limestone	1	0
13.	Clay shale	8	0
14.	Sandstone	2	0
15.	Clay shale	3	0
16.	Not seen	30	0
17.	Sandstone	11	0
18.	Shale	7	0
19.	Limestone	1	0
20.	Shales, chiefly	13	0
21.	Sandstone, quarried	27	0
22.	Coal, upper Big Run seam (not measured).		
	Railroad track.		

It is possible that the limits of Decatur township may extend far enough west to take in the lowest coal of the above section, but it will necessarily be in or near the bed of Big Run. Where seen along the railroad, the coal seam No. 8 of the above section is very thin. This is the Hobson coal, of Wesley township, where the seam is worked. On the land of John Storts, section 17, a geological section was taken, which revealed about one hundred and thirty feet of strata, extending from a little below the level of the railroad to the bed of a branch of the Little Hocking. The section is as follows:

		Ft.	In.
1.	Heavy sandstone and conglomerate	50	0
2.	Laminated sandstone and shales	40	0
3.	Coal	0	8
4.	Slate	0	2
5.	Coal (Hobson seam)	0	10
6.	Slate " "	0	3
7.	Coal " "	1	6
8.	Underclay, and not seen	15	0
9.	Laminated sandstone	20	0
10.	Limestone	4	0

(See Map XI., No. 5.)

The limestone of the above section does not appear on Mr. Storts's land, but a mile down the creek. The coal of this section is worked at various places in a small way. On Mr. Burnett's land, north of Mr. Storts's, the coal is mined and found to be about the same as at Mr. Storts's. At Root's Mill the seam is worked. It has been obtained by stripping on Gilbert's Run, on the land of Esquire Newell, section 16, and on the land of Mr. Branderberry, fraction 23. Mr. Milton King, section 2, has dug the coal from the bed of a small tributary of Little Hocking. He found its thickness only two feet.

FAIRFIELD TOWNSHIP.

This township lies north of Decatur and east of Wesley. It is chiefly drained by the Little Hocking, but the northern region of the township is drained by a tributary of Wolf Creek. There is considerable smooth land, but it is intersected by the deep ravines of the head branches of Little Hocking. None of these ravines are eroded to a sufficient depth to reach the Cumberland seam of coal, but the Hobson coal is exposed. On the land of Pitt Goddard, fraction 7, the following section was obtained:

		Ft.	In.
1.	Laminated sandstone	12	0
2.	Not seen	9	0
3.	Blue clay, with crumbling limestone	6	0
4.	Not seen	10	0
5.	Heavy, coarse sandstone, partly conglomerate	40	0
6.	Shales and sandstones	60	0
7.	Coal, Hobson seam, reported thickness	2	0

(See Map XI., No. 4.)

No seam of coal was seen higher than this. There is little of interest to the geologist in this township. There are many excellent farms, and the farmers deserve great credit for doing so well with a soil containing comparatively little lime.

WESLEY TOWNSHIP.

This township lies directly north of Decatur, and borders Athens county on the west. The larger part of the township is drained by the branches of Wolf Creek. The south-eastern portion is drained by the tributaries of Little Hocking. A small area in the south-west is drained by branches of Federal Creek. In the central portion of the township there is a good deal of comparatively level and smooth land. This is upon the elevated area from which the streams radiate. In the northern part of the township there is much excellent land upon the various branches of Wolf Creek. In this township we find two seams of coal. The lower of the two is the upper seam on Big Run, or what I have generally called the Cumberland seam, from the town of Cumberland, Guernsey county, where the seam is mined. The upper seam in Wesley is about one hundred feet higher than the Cumberland seam. I have called it the Hobson coal, it being seen upon the farm of Stephen Hobson, section 36. The lower, or Cumberland, seam is probably only to be found in the north-west portion of the township. It is low in the bed of Coal Run. On the land of Henry Barnes, section 6, both seams of coal are seen, in the following geological section:

		Ft.	In.
1.	Shale	4	0
2.	Cannel slate	1	0
3.	Coal, Hobson seam	0	8
4.	Not seen	45	0
5.	Limestone	2	0
6.	Not seen	10	0
7.	Limestone and interstratified shales	8	0
8.	Buff limestone	4	0
9.	Shale	1	0
10.	Limestone	0	10
11.	Shale, with nodules of limestone	8	0
12.	Blue shale	16	0
13.	Coal, Cumberland seam, reported	1	0

(See Map XI., No. 2.)

The lower coal has only been obtained by stripping in the bed of Coal Run. Possibly a part of the seam has here been eroded, and if the coal were mined by a drift it might be found considerably thicker. This geological section reveals considerable limestone. If so much limestone were placed well up on the hills, its fertilizing effect would be much greater than where it now is, so low in the valley.

On the land of Henry Wagner, on Coal Run, we find the lower, or

Cumberland, seam of coal in larger development. The following is the section:

		Ft.	In.
1.	Limestone in layers, with some interstratified shale	25	0
2.	Blue shale	15	0
3.	Coal, the upper part slaty	0	8
4.	Slate parting	0	2
5.	Coal, Cumberland seam	2	0
6.	Underclay	1	6

(See Map XI., No. 1.)

On the land of Stephen Hobson, section 36, we find the following section:

		Ft.	In.
1.	Heavy, disintegrating sandstone	40	0
2.	Not seen	60	0
3.	Shale, somewhat ferruginous	2	6
4.	Slaty coal	0	3
5.	Black slate	0	4
6.	Coal, Hobson seam	2	8
7.	Underclay	2	0
8.	Not seen	36	0
9.	Limestone	4	0

(See Map XI., No. 3.)

The coal is not the best, but it answers a good purpose for local use. The limestone found thirty-eight feet below the coal is said to burn into excellent quicklime.

A geological section was taken on the land of Wilson Graham, section 24, which revealed the following strata:

		Ft.	In.
1.	Heavy, coarse sandstone	30	0
2.	Not seen	12	0
3.	Sandstone	10	0
4.	Black slate	1	6
5.	Clay	1	0
6.	Shale	12	0
7.	Limestone	5	0
8.	Blue shale, with nodules of siderite ore	25	0
9.	Coal	1	0
10.	Slate	0	3
11.	Coal, Hobson seam, reported	2	0
12.	Underclay	1	0
13.	Limestone	3	0

PALMER TOWNSHIP.

This township lies north of Fairfield and east of Wesley. It is entirely drained by the tributaries of Wolf Creek. Much of the land is smooth and attractive, and many of the farms are in a fine state of cultivation. There is less limestone in the hills than would be desirable. There are some layers of it, but they generally lie too low to fertilize large areas. The rock strata are chiefly sandstone and shales. The only coal seen is the Hobson seam, the geological position of which is about one hundred feet above the Cumberland seam, and about one hundred and ninety feet above the Pomeroy seam. This coal was seen on the land of S. S. Smith, section 18, but no measurements could be made to determine the thickness of the seam. About one hundred and twenty feet above the coal was found a deposit of iron ore from two to three feet thick. (See Map XI., No. 6.) The ore is apparently a bog ore, but Mr. Gilbert reports that it appears to be imbedded in shale. Like most bog ores, it is rich in manganese, but the analysis showed it to be very lean in iron. The metallic iron, as determined by Prof. Wormley, is only 9.72 per cent., while the manganese is 5.90 per cent. This ore is said to cover a considerable area in this neighborhood. A geological section was taken on the farm of John Breckenridge, on Whitewater Creek, a branch of Wolf Creek, in the northern part of the township, which is as follows:

		Ft.	In.
1.	Heavy sandstone (estimated)	50	0
2.	Clay, with limestone in concretions	6	0
3.	Limestone and shale	4	0
4.	Shales, red and blue	15	0
5.	Hard, blue limestone	1	0
6.	Not seen	10	0
7.	Laminated sandstone	15	0
8.	Heavy sandstone	20	0
	Bed of Whitewater, at Brown's Mill.		

By following down Wolf Creek we find the great limestone group of Wolf Creek coming in about twenty-five feet below the heavy sandstone, the No. 8 of the last section. The upper fifteen feet of the space is filled with a sandy shale, below which is a layer of limestone. The remaining space was not seen. It is a great misfortune for all this region that the fine deposit of limestone in the bed of Wolf Creek could not have been located high up in the hills, for it is of little fertilizing value where it now is.

Some traces of coal were seen on Mr. Breckenridge's farm in a little branch, but the exact stratigraphical position of the seam could not be determined. It may possibly be the Hobson coal, or, more probably, it is a very thin seam that comes in a little higher. In Waterford township a thin seam is seen about one hundred and ten feet above the great limestone group. This thin seam was noticed in several places in Palmer ownship. On the land of Mr. Wm. Leggett, near the middle of the township, it was one foot thick.

BELPRE TOWNSHIP.

This is the most southern township in the county. It extends for many miles along the river, and has a very large area of very fertile and valuable land. The great wealth of the soil must make amends for the dearth of valuable minerals in the hills. The geological formations through this and some adjacent townships are such as to offer very little of practical value. There are sandrocks which may be quarried, and some iron ore.

On the land of Edwin Guthrie, section 28, we find the following geological section, which reveals considerable iron ore:

		Ft.	In.
1.	Shale, with kidney ore in nodules near top	5	0
2.	Ore (1)	0	4
3.	Shale	2	0
4.	Ore (2)	0	3
5.	Shale	1	8
6.	Ore (3)	0	4
7.	Shale	1	0
8.	Ore (4)	0	3
9.	Shale	2	6
10.	Ore (5)	0	6
11.	Shale	2	0
12.	Sandstone, quarried	15	0
13.	Sandy shale	20	0
14.	Sandstone	25	0

(See Map. XI., No. 14.)

Samples of all the ores, except the nodular ore at the top, were taken for analysis by Prof. Wormley. The numbers begin with the upper layer.

Numbers 1, 2, and 3 gave only 12.13, 18.03, and 18.00 per cent. of metallic iron respectively. The detailed analyses of Nos. 4 and 5 are as follows:

	No. 4.	No. 5.
Specific gravity	2.916	2.924
Combined water	7.20	5.20
Silicious matter	16.40	21.68
Iron sesquioxide	44.86	60.44
Alumina	3.60	0.00
Manganese	2.00	8.00
Phosphate of lime	1.50	0.54
Carbonate of lime	22.18	2.08
Carbonate of magnesia	1.43	2.04
Sulphur	trace	trace
Total	99.17	99.98
Metallic iron	31.40	42.31
Phosphoric acid	0.70	0.25

No. 5 is a good ore, and worthy of some practical investigation. The layer is thick enough to be worked under favorable circumstances, and being near the Ohio River, it might be shipped to furnaces down the river. The other ores are less rich in iron, and No. 4 has more phosphoric acid than ore should have.

The probable place of the Hobson coal is below the heavy sandrock at the base of the geological section, and not far from the level of the Ohio River. It is probably too thin to be of any practical value.

One-half mile above the mouth of Little Hocking the following section was taken:

		Ft.	In.
1.	Shale	9	0
2.	Sandstone	20	0
3.	Shale and laminated sandstone	12	0
4.	Blue shale, ferruginous	4	0
5.	Coal, Hobson's seam	1	2
6.	Not seen to Ohio River	20	0

(See Map XI., No. 12.)

Near the mouth of Little Hocking Mr. M. R. Hill and Mr. Waterman have opened the same seam of coal as that given above, but have taken out but little. The seam is quite too thin to make the mining profitable.

There is another thin seam of coal higher in the hills, of which we sometimes find traces, but it is of no practical worth. We sometimes find in the Ohio River hills clay shales which contain considerable limestone of valuable fertilizing quality. The limestone is in small concretions, and is often sufficiently abundant to give the shale a whitish appearance.

The Drift terraces along the Ohio constitute an interesting feature in the surface geology of this township; they are high and well defined, and upon them are some fine earth-works of the old Mound-builders.

Although Blennerhasset's Island belongs to West Virginia, yet, being very near the Ohio shore, it may be properly alluded to. This island is one of the most beautiful of the river islands, and is connected with scenes in the early history of the General Government which make it of no little historical interest. Mr. Wirt's speech at the trial of Mr. Blennerhasset for complicity with the designs of Aaron Burr, which were supposed to be treasonable, has become classic, and the island he so well pictures is often visited by strangers.

BARLOW TOWNSHIP.

This township is north of Durham and west of Warren. The southern part is drained by the branches of Little Hocking, and the north part by the branches of Wolf Creek. In the central and northern part the land is pretty smooth, and the hill-slopes are quite gradual. There are many excellent farms, which show thorough cultivation. No important minerals were found in sufficient quantities to warrant practical development. The only coal is the Hobson seam, which was noticed at several points on the Wolf Creek waters, although no where thick enough for profitable mining. On the land of William Bell, in the north-western part of the township, is an exposure of the coal in the bed of the stream. The section is as follows:

		Ft.	In.
1.	Sandstone	12	0
2.	Shale	3	0
3.	Coal, Hobson seam, reported	1½ to 2	0

(See Map XI., No. 10.)

Probably little attention has been paid in Barlow to the matter of opening seams of coal, since, as yet, the forests afford sufficient fuel. Careful search might be rewarded in finding at some point the coal thick enough to warrant working. In this township there are beds of shale of considerable thickness, which contain small concretionary lumps of limestone in large quantities, so as to give the shales great value for fertilizing purposes. These shales are popularly called "marls." A horizon of this marl is found about eighty feet above that of the coal seam before alluded to. A similar marl is seen near Barlow village and vicinity, which is probably higher in the geological series. About one hundred and forty feet above the same coal is a stratum of red, or chocolate-colored, shale, containing nodules of iron ore. The nodules seen were thoroughly oxidized, and changed from the original blue carbonate into hematite. The quality of the ore is good, but it would be difficult to obtain sufficient quantity for the supply of furnaces.

Many years ago the late Jesse Lawton, Esq., who took a very intelligent interest in geology, discovered on his farm, near the village of Barlow, the evidences of the existence of an ancient lake bed, and called the attention of the late Dr. S. P. Hildreth, of Marietta, who was connected with the former geological survey, to it. Several years since I spent a day with Mr. Lawton in examining the same region. What I saw went to confirm the opinion of Mr. Lawton. I quote from Dr. Hildreth's geological report for 1838 what he says on the subject: "On Mr. Lawton's farm, in Barlow township, Washington county, in the midst of the marl region, is a locality of fossil fresh-water shells of the genus Unio. They are imbedded in coarse sand or gravel, cemented by ferruginous matter. The specimens are casts, replaced by an argillaceous oxide of iron. The spot in which they are found has once evidently been the bed of an ancient lake or pond. It is now a beautiful valley of a mile or more in width by four miles in length, surrounded by low hills. On the south side a small branch drains the superfluous water into the Little Hockhocking. In digging wells for domestic use in this tract, beds of sand, gravel, and plastic clay are passed to the depth of thirty feet, containing imbedded branches of trees, leaves, and fragments of wood, of recent and living species. Similar valleys and levels are found in the uplands of the western part of the county, lying between the head waters of the creeks, and are a kind of table-land. From the frequency of these flat lands between the head waters of the Little Hocking and the South Branch of Wolf Creek, it is quite possible that at some remote period the waters of Wolf Creek were discharged into the Ohio River instead of the Muskingum. This opinion is strengthened from the fact that the head branches of the South Fork now rise within two miles of the Ohio, and run northerly, parallel with and opposite to the course of the Muskingum for twelve miles, and join that river twenty miles from its mouth. The remains of its ancient beds would form pools and ponds of standing water, furnishing fit residences for the fresh-water shells, whose fossil remains are now found there. Great changes, evidently, have been made in the direction of all our water-courses before they found their present levels."

WATERTOWN TOWNSHIP.

This township lies north of Barlow and south of Waterford. The north half of its western line borders Morgan county. It is chiefly drained by Wolf Creek, except its eastern side, which is drained by the head waters of Rainbow Creek. The township is less hilly than most in the county, and the land is generally finely situated for agricultural purposes. Like most of the townships west of the Muskingum River, the rock strata, by the disintegration of which the soil is formed, are chiefly shales and sandstone, with probably little limestone. There is a heavy deposit of limestone in the bed of the West Branch of Wolf Creek, but it must be removed and applied artificially to the land. How far this has been attempted, either in the form of limestone or as a quicklime, I do not know. High in the hill near the Muskingum dam, above Beverly, there are two or three layers of limestone. These may extend through the hills of Watertown. The only seam of coal observed is the one near the village of Watertown. On the land of William G. Woodford the following section was taken:

		Ft.	In.
1.	Shale	6	0
2.	Sandstone	4	0
3.	Shale	5	0
4.	Bituminous, ferruginous shale, with coal plants	2	0
5.	Coal, somewhat slaty	2	0
6.	Underclay	1	0

(See Map XI., No. 9.)

This seam is supposed to be the Hobson seam. Its place is probably about one hundred feet above the Cumberland or Coal Run seam, but no measurements were possible. Careful exploration might perhaps reveal it at some point in greater thickness.

WATERFORD TOWNSHIP.

This is the north-western township of the county. It is divided into two proximately equal parts by the Muskingum River, which, touching its south-western corner, flows northward, constituting the western boundary; thence, with many a curve, in a general south-east direction through the township. There is, therefore, within the township limits a very unusual area of the rich river bottom land. No part of Ohio can show richer land or finer farms. The township is chiefly drained by small tributaries of the Muskingum. The south and west branches of Wolf Creek unite near the south line, and the united waters empty into the Muskingum just above Beverly. Olive Green Creek, a stream of considerable importance in Morgan county, enters the Muskingum within the limits of this township just below the Morgan county line.

Many of the hills bordering the Muskingum River are high and bold. A hill above Beverly, near the dam, presents a fine cliff on the river side very favorable for examination, while from its summit a view of unusual beauty is obtained. In the cliff are good exposures of the higher strata, while in the bed of Thompson's Run, a few rods higher up the river, a complete section of the limestone group was obtained. The following strata were seen in the cliff:

		Ft.	In.
1.	Sandy shale, light and dark colored (not measured).		
2.	Sandstone	12	0
3.	Shale	6	0
4.	Limestone	0	8
5.	Shales, red and blue	10	0
6.	Limestone	1	3
7.	Shaly sandstone	10	0
8.	Limestone	0	8
9.	Shaly sandstone	4	0
10.	Sandrock (not measured).		
11.	Shales, light colored (not measured).		
12.	Limestone, irregularly bedded (not measured).		
13.	Red shale, with nodules of iron ore (not measured).		
14.	Heavy sandrock, its cracks incrusted with crystallized limestone (not measured).		
15.	Limestone group (not measured).		

The incrustations on the sandrock above referred to are very white and beautiful. At some time the clearest of water, charged with carbonate of lime in solution, percolated through the cracks in the sandrock, and the lime accumulated on the sides of the cracks. Had the same water dropped into a cavern there would have been formed stalactites of remarkable purity and beauty. The following is a detailed section of the limestone group:

		Ft.	In.
1.	Limestone, blue and hard	1	0
2.	Blue clay shale	1	0
3.	Hard blue limestone	1	0
4.	Limestone, yellowish	8	0
5.	Hard blue limestone	4	0
6.	Blue clay	0	8
7.	Limestone, upper part blue, yellow at bottom	4	0
8.	Blue clay	4	0
9.	Hard blue limestone	1	0
10.	Blue clay	1	0
11.	Hard blue limestone	1	6
12.	Blue clay	0	6
13.	Sandy limestone, with casts of mud cracks on the under side	0	8
14.	Blue clay	1	0
15.	Blue limestone	1	4
16.	Blue clay, thin limestone near top	6?	0
17.	Space not exposed (estimated)	10 to 15	0
18.	Sandstone	12	0
	Level of Muskingum River.		

Without doubt many of the layers of limestone would make excellent quicklime. The thin layer of sandy limestone, No. 13, contains on its under side fine casts of sun-cracks made by the drying of the clay underneath when it was surface mud. Some fine slabs showing these casts were taken to the cabinet of Marietta College many years ago. The place of the Coal Run seam of coal was supposed to be in the space No. 17, not exposed. No traces of the coal were seen. In the river bank opposite Beverly is a fine exposure of limestone. The following section was taken on the bank of the Muskingum, on the Dana farm, below Beverly, the part below the water having been given me several years since by Boylston Shaw, Esq., who made a boring for Mrs. Dana:

		Ft.	In.
1.	Limestone	8	0
2.	Light blue clay (not measured).		
3.	Limestone	4	0
4.	Blue clay (not measured).		
5.	Limestone	0	10
6.	Blue clay	0	6
7.	Blue limestone	1	0
8.	Blue clay	0	10
9.	Limestone	1	6
10.	Blue clay	3	6

		Ft.	In.
11.	Blue limestone	1	8
12.	Blue clay shale	11	0
13.	Coal	1	0
14.	Clay parting	0	10
15.	Coal	3	8

(See Map XI., No. 7.)

Mr. John Hubbell has a shaft on the same farm to reach this coal. I suppose the seam to be essentially as reported by Mr. Shaw in the above section. Immediately above the coal fifteen feet of blue shale are reported, and above this fifteen feet of limestone. The place of the Hobson seam is about one hundred feet above the coal last mentioned. A thin seam in this horizon was seen in the hill-side by the road-side north of Coal Run village, under a heavy white sandrock. A section at this point is proximately as follows:

		Ft.	In.
1.	Heavy white sandrock (not measured).		
2.	Shale (not measured).		
3.	Coal (very thin).		
4.	Sandstone and shale	40	0
5.	Limestone	1	8
6.	Not exposed, except some limestone near top	30 to 40	0
7.	Coal (Coal Run seam).		
	Interval to Muskingum River (estimated)	10	0

The heavy white sandrock may be worthy of attention as a material for glass-making. Selected portions would certainly be fine enough. Some of it would, I think, answer an excellent purpose for hearthstones for furnaces. The upper coal seam is of no value here, and probably nowhere in this region. In some of the townships south-west it is the only seam found, but it is too thin for profitable mining.

Several years ago portions of the skeleton of a huge mammoth were dug up in the village of Beverly. Several large teeth in excellent preservation were found, and much of the skull; but the latter being somewhat crumbling, after being kept for a time was thrown into the street and crushed under wagon-wheels. As no skull of the mammoth has ever been obtained in this country, so far as I know, the destruction of this skull was a very serious loss to science. One of the teeth is preserved in the cabinet of Marietta College. A fine specimen of a shoulder-blade of a mammoth was obtained by Dr. Bowen, of Waterford township, from another location farther up the river, which he generously deposited in the same cabinet. I have known of portions of quite a number of different individuals of this extinct species of elephant which have been found in Washington county. While the mammoth roamed here in considerable numbers, I have not known of the finding of any bones of the mastodon. In some parts of the West, on the other hand, the bones of the mastodon are found almost exclusively. These animals were contemporaries. Did they have distinct and separate haunts?

WARREN TOWNSHIP.

This township lies east of Barlow and south of Union townships. It is bounded on the south-east by the Ohio River. It is drained by the waters of Wolf Creek on the north and west, by Little Hocking on the south-west, by Indian Creek on the north-east, and by several small streams flowing into the Ohio, of which the principal are Mile Run, Scott's Run, and Bailey's Run. From the high lands on section 16 and vicinity the streams flow in almost every direction. The soil on the Ohio River is most excellent, and that of the valleys of the smaller streams productive. Many of the shales in the hills are rich in small concretions of lime, and when disintegrated form a good soil. It is probable that these concretions change in places into thin layers of limestone. No thick seam of coal could be found, but the thin Hobson seam, found in townships to the west, is often met with in its proper geological horizon. This seam is exposed in the railroad cut, under the heavy sandrock, in the Narrows below Harmar. It is here of no economic importance. Traces of a higher seam were observed, but the seam must be very thin.

The most valuable feature in the economic geology of this township is the sandstone of very superior quality for grindstones and for building purposes found in heavy ledges along the Ohio River hills. No towns in the Second District are so rich in grindstone material as Warren and Dunham. There has been an increasing traffic in grindstones from these townships for the last forty years and more. There is an almost inexhaustible supply of stone admirably adapted to this important manufacture. Almost every variety of texture and grit is to be obtained, and the prepared stones are sent all over the country. The business is capable of almost indefinite development. The following is a geological section showing the position of the sandstones, as found in the Narrows on the Ohio River, in this township:

		Ft.	In.
1.	Heavy sandrock	30	0
2.	Blue shale	9	0
3.	Heavy sandrock, extensively quarried for grindstones	25	0
4.	Sandy shale	20	0
5.	Heavy sandrock, quarried in places	36	0
6.	Shale, somewhat ferruginous	4	0
7.	Coal, Hobson seam	1	6
8.	Fire-clay and shale	4	0
9.	Interval to Ohio River	42	0

(See Map XI., No. 19.)

The proximity of the quarries to the railroad and river greatly increases the value of the location. Down the river, near the Dunham township line, the sandstone has been quarried for many years by a company under the superintendence of Mr. William McClure. The "Constitution stone" of this company is a very beautiful bluish-gray stone of fine texture, and admirably adapted to ornamental architectural work. It has been introduced into Chicago and other cities. It is a firm and durable stone, and capable of resisting great pressure without fracture. It will also resist the influence of heat, in case of fire, far better than limestones and marbles.

For miles along the Ohio River hills quarries might be opened, although stone of the very highest quality, and that adapted to special uses, either for grindstones or for building, will be found in more limited areas. Messrs. D. Briggs, Henry Cole, D. B. Caldwell, Calvin Finch, the the Ohio River Stone Company, and others, are engaged in converting the sandrock of the quarries into grindstones. The middle sandrock, or No. 3 in the geological section, is generally preferred for grindstones. At some of the quarries nearly the whole of the stratum, or twenty-five feet, is available.

DUNHAM TOWNSHIP.

This township lies directly north of Belpre. It is a long, narrow township, with three miles of the Ohio River bordering it on the east. Its surface drainage is almost entirely effected by the East Branch of Little Hocking and its tributaries, the streams flowing into the Ohio being very small.

The same thin seam of coal found in Fairfield, Belpre, etc., called the Hobson seam, is found in Dunham township. Its stratigraphical position is seen from the following section on Little Hocking, in section 16, on the farm of Harvey Ellenwood:

		Ft.	In.
1.	Sandy shale	8	0
2.	Blue clay shale	4	0
3.	Coal, Hobson seam	1	6
4.	Underclay	2	0
5.	Shale	13	0
6.	Laminated sandstone	5	0
7.	Shale	15	0
8.	Laminated sandstone	6	0

Highest mark of back-water of Ohio River. (See Map XI., No. 11.)

The black stain of the Hobson coal can be seen in many places in the township.

No well defined layers of limestone were seen, but such may exist, for some of the shales contain limestone in small concretions. Sometimes in place of such concretions we find regular strata of limestone.

Sandstone is the most characteristic rock in the hills, and formerly many of the hills were crowned with yellow pines, a tree that thrives on highly silicious soil. In the hills bordering the river large quarries have been opened in the heavy sandstone ledges, and vast quantities of stone have been removed. The stone for the piers of the railroad bridge across the Ohio at Parkersburg came very largely from a Dunham quarry. Other excellent quarries have been opened, and stone for building purposes is shipped down the river. The selected stone makes superior grindstones, and large numbers are annually made and sold. Mr. B. E. Tilton, D. Briggs, and others, are engaged in this business. The old quarries of the late Oren Newton, where grindstones were obtained forty years ago, are in this township. The sandstones of this and of Warren townships are of the most excellent quality, are convenient to river and railroad, and cannot fail in the future to be sources of great wealth.

ADAMS TOWNSHIP.

This township lies directly east of Waterford, and is traversed by the Muskingum River. The chief affluents of the Muskingum, which drain the township, are Big Run and Cat's Creek. There is considerable limestone in the hills, and the soil is generally rich and productive. There is an almost unlimited supply of coal of fair quality to be found nearly through the whole township north of the river. The dip is generally to the south, but we find the seam also gradually rising to the east on the waters of Big Run, Cat's Creek, and Bear Creek. The following section was taken on the hill below Coal Run village, near Ewart and Mills's coal bank:

		Ft.	In.
1.	Soil, etc., top of hill	10	0
2.	Laminated sandstone	6	0
3.	Shale, buff-colored	4	0
4.	Red shale	5	0
5.	Sandstone	2	0
6.	Shale, with crumbling limestone and ore	12	0
7.	Laminated sandstone	9	0
8.	Shale, with nodular limestone	17	0
9.	Laminated sandstone	3	0
10.	Shale	16	0
11.	Laminated sandstone	6	0
12.	Mostly shale	28	0
13.	Sandstone	4	0
14.	Shale	11	0
15.	Sandstone	6	6

		Ft.	In.
16.	Shale	18	0
17.	Limestone	6	0
18.	Red shale	14	0
19.	Fine-grained laminated sandstone	5	0
20.	Red shale and scattered limestone	33	0
21.	Buff and white limestone	3	0
22.	Shale	5	0
23.	Sandstone	19	0
24.	Shale	3	0
25.	Coal	1	0
26.	Clay and slate	1	6
27.	Coal	3	3
28.	Clay	5	0
29.	Limestone (reported).		

(See Map XI., No. 8.)

We see by this section that the quantity of limestone over the coal is much less than at Beverly or on the Dana farm. On the lower part of Big Run a coarse sandstone takes the place of the limestone altogether. Such changes are not uncommon, and show how difficult it is to identify the coal seams by associated sedimentary rocks. While in this case, about Beverly the waters brought in calcareous mud, now constituting limestone, at another point they brought in sand, now forming sandstone. At George W. Lyne's bank, below Coal Run village, the coal seam shows the same structure as at Ewart and Mills's bank. Mr. Lyne reports that "the thickness of the seam varies from three and a half to four feet three inches in thickness." South of the river no banks have been opened. The coal doubtless extends south, but it must be mined by shaft and the mines drained by pumping. The upper foot of coal, the part above the clay parting, is not generally taken out. There is no reason why abundant brine should not be obtained by boring, and the poorer coals be used for making salt. Mr. Lyne reports the quantity of coal mined at the Coal Run banks at from 400,000 to 500,000 bushels a year, and this quantity could be very largely increased if the demand required it. The coal, when mined with proper care, is of good quality for the generation of steam and for household use. It has a caking tendency, and needs stoking to allow it proper draft. On Big Run, the Coal Run seam of coal is found along the whole length of the stream. Six miles above the mouth, in Noble county, Mr. Jacob Cassel has obtained the coal on his land by stripping, and reports it to be from five to six feet thick. From Cassel's the dip of the coal seam is about equal to the fall of the stream. About two miles above the mouth the limestones above the coal mostly disappear, and a heavy, coarse sandrock comes in. A section on the land of Henry Ross, a mile and a half above the mouth of the stream, shows the sandrock as follows:

		Ft.	In.
1.	Heavy, coarse-grained sandrock	25	0
2.	Shale, with coal plants	4	6
3.	Coal	1	6
4.	Clay parting	1	4
5.	Coal	2	8
6.	Interval to bed of Big Run	20	0

(See Map XI., No. 13.)

Another section, taken higher up Big Run, but within the limits of Washington county, shows the stratigraphical position of some limestones and of a higher seam of coal:

		Ft.	In.
1.	Coal stain or blossom.		
2.	Not exposed	10	0
3.	Sandy shale	20	0
4.	Sandstone	5	0
5.	Shale	17	0
6.	Limestone	2	0
7.	Not exposed	41	0
8.	Limestone, in part magnesian	9	0
9.	Shale	15	0
10.	Buff and white limestone	3	0
11.	Shales, chiefly	25	0
12.	Coal, Coal Run or Cumberland seam (not measured).		
13.	Not exposed	30	0
14.	Limestone	2 to 3	0

The two coals are from one hundred and forty to one hundred and fifty feet apart. The upper one is doubtless very thin and valueless. It has been noticed, however, at one or two other points. It is better developed in some other counties.

On Cat's Creek the Coal Run or Cumberland seam of coal is seen. The following section was taken on the land of G. Brown, two miles above the mouth:

		Ft.	In.
1.	Buff and white limestone	2	0
2.	Sandy shale	27	0
3.	Coal and clay	1	0
4.	Coal	1	6
5.	Clay and bituminous shales	1	0
6.	Coal	2	5
7.	Clay	6	0
8.	Sandstone and shales	24	0
9.	White limestone	2	0

(See Map XI., No. 15.)

On the left branch of Cat's Creek, on the land of Nicholas Basil, about three miles above the mouth, the coal is thicker. The following section was taken, showing the several exposed strat in the hills:

		Ft.	In.
1.	Crumbling limestone in red shale.		
2.	Not exposed	110	0
3.	Laminated sandstone	5	0
4.	Sandy shale	16	0
5.	Hard sandstone	3	0
6.	Shale	10	0
7.	Limestone	2	0
8.	Not exposed	40	0
9.	Limestone, in part cement limestone	10	0
10.	Clay shale	18	0
11.	Buff limestone	3	0
12.	Sandstone	20	0
13.	Shale	1	0
14.	Coal, slaty at top	4	3
15.	Not exposed	10	0
16.	Sandstone	14	0
17.	Shale	4	0
18.	Limestone	2	0

(See Map XI., No. 16.)

The same seam of coal is to be found on all the branches of Cat's Creek, and, continuing under the hills, reappears on Bear Creek, in Salem township.

Adams township has, therefore, a very large supply of coal, well adapted to all ordinary uses. It will be the basis of a large manufacturing industry when capital and enterprise are introduced. At present there is no adequate market for it, and coal cannot be profitably mined without large markets. The water-power at Lowell is very considerable, but for many classes of manufacturing fuel in large quantities is indispensable. A railroad in the Muskingum valley would be of almost incalculable value to this part of the State, and would naturally attract capital to the coal field in Adams township. The soil of the township is excellent, abundant limestone of a highly soluble and fertilizing kind being found in all the hills. The alluvial soil of the Muskingum valley is also extremely fertile, so that a large manufacturing population could be fed from home productions, and the farmers would have the advantage of a constant and remunerative home market.

UNION TOWNSHIP.

This township lies directly south of Adams and east of Watertown. It is drained chiefly by the waters of Rainbow Creek. Much of the soil is good, and some of the limestone strata found north in Adams extend into the hills of Union, but they show a tendency to thin out toward the south. The only coal observed is always thin. It is supposed to be the Hobson seam, the place of which is about one hundred feet above the Coal Run or Cumberland seam. At one place, not far above the mouth of Rainbow Creek, this seam is found, and is reported to be only eight inches thick. This township, since the formation of Muskingum township, has lost the larger part of the Muskingum River, formerly within its limits, with the rich adjacent bottom lands.

MUSKINGUM TOWNSHIP.

This township lies north of Marietta, and includes the Muskingum River as far north as the mouth of Bear Creek. It, consequently, contains a large area of the immediate valley of that river. Its eastern boundary generally takes the summit of the ridge dividing the waters of the Muskingum and Duck Creek. The soil on the top of this ridge is not remarkable for its natural fertility, being composed largely of disintegrated sandstone and shales. In the northern part of the township some of the limestone found in the hills of Adams township serve a valuable purpose in fertilizing the soil. These are seen in the hills near the mouth of Bear Creek. The following section was taken on the road leading from the Lutheran Church, on the ridge, down to Bear Creek, near the north line of the township:

		Ft.	In.
1.	A black stain of black slate or coal.		
2.	Shales, chiefly	59	0
3.	White limestone, probably in two or three layers	3 to 5	0
4.	Sandstone and shales, not seen in detail	77	0
5.	White limestone, possibly not in place	1	0
6.	Not all well seen, but chiefly sandstone and sandy shales	100	0
7.	Buff limestone	1	3
8.	Blue limestone, in bed of Bear Creek.		

The section can be only proximately correct, as the dip was not known, and no allowance could be made for it. The place of the Bear Creek or Cumberland coal is about seventy-five feet above the buff limestone, but no trace of it was found. The dip of the strata on Bear Creek is sharply to the south. On the land of John Spears, a half a mile above the mouth of Bear Creek, a section was taken as follows:

		Ft.	In.
1.	Blossom of coal, Hobson seam.		
2.	Not well exposed, but contains several layers of limestone	48	0
3.	Limestone	2	0
4.	Not exposed	45	0

		Ft.	In.
5.	Blossom of coal, Cumberland or Bear Creek seam.		
6.	Not exposed	50	0
7.	Limestone (not measured).		
8.	Not exposed	10	0
9.	Heavy sandstone	25	0
10.	Coal below bed of stream, once dug a little.		

Bear Creek. (See Map XI., No. 17.)

On the hill, back of the house of B. F. Dyar, section 7, in this township, we find the Hobson coal exposed. It has in two and one-half miles from the place of the last section dipped about sixty feet. Mr. Dyar's section is as follows:

		Ft.	In.
1.	Nodules of iron ore, hematite.		
2.	Shales and sandstones	34	0
3.	Sandstones, chiefly	20	0
4.	Not exposed	12	0
5.	Coal, Hobson seam	0	8
6.	Clay parting "	0	2
7.	Coal "	1	6
8.	Underclay	2	0
9.	Crumbllng limestone	2	6
10.	Not exposed	40	0
11.	Limestone	8	0
12.	Interval, not seen to Muskingum River	65	0

(See Map XI., No. 24.)

A section was taken on the north side of March Run hill to obtain the interval between a thin seam of coal once mined by Frank Norman, and the heavy limestone deposit near the foot of the hill. This was found to be ninety-seven feet. The limestone, with the shales between the layers, is nine feet thick. Underneath are four feet of shale. A composition section showing all the strata on both sides of the hill is as follows:

		Ft.	In.
1.	Red shales on top of slate.		
2.	Crumbling limestone and shale	2	0
3.	Mostly shale	51	0
4.	Sandstone	3	0
5.	Red shale	36	0
6.	Coal once dug, now covered.		
7.	Hard limestone near the top, rest unseen	20	0
8.	Sandstone	15	0
9.	Bluish clay, with a layer of nodules of ore	10	0
10.	Limestone	1	0
11.	Cay shale	5	0
12.	Sandstone	4	0

		Ft.	In.
13.	Not exposed	28	0
14.	Sandstone	10	0
15.	Not seen	4	0
16.	Limestone, with shales	9	0
17.	Shale	7	0
18.	Coal once exposed, Hobson seam.		

The place where this lower coal was seen is by estimate forty feet above the level of the Muskingum River. It is probably ten or fifteen feet higher than the same seam in the Narrows below Harmar. Neither of the seams of coal in the above section was exposed for measurement.

On the land of Jacob Sutter, on Second Creek, a seam of coal is found with the following associated strata:

		Ft.	In
1.	Sandstone	12	0
2.	Red shale	5	0
3.	Not seen	13	0
4.	Hard blue limestone	0	10
5.	Shale	1	6
6.	Black slate	0	9
7.	Coal	1	6
8.	Clay	0	4
9.	Coal	0	6
10.	Not seen	2	0
11.	Sandstone	2	0
12.	Shale	10	0
	Bed of Second Creek.		

I suppose this to be the Hobson seam. In the bed of Second Creek abundant nodules of rich iron ore are found. These have been gathered and used for the puddling furnaces in the Marietta rolling-mill. Many years since I traced these nodules to their origin in a stratum of blue clay, from which they had been washed. While examining the region in the prosecution of the State Survey, the clay seam was found to be buried, and its exact place was not identified and no measurement taken, but I have no doubt that it is the same blue clay which carries nodular ore seen on March Run hill, about seventy feet above the level of the Hobson coal. Under a bridge over Second Creek, on the plank-road, near the east line of the township, is a thin seam of limestone containing scales of fishes and some small univalve shells.

SALEM TOWNSHIP.

This township lies east of Adams. Its drainage is entirely by the waters of Duck Creek and its tributaries, excepting the western margin, which is drained by Bear Creek. Duck Creek, in this township, is remarkable for its crookedness. This township is hilly, but the hills are capable of cultivation, and the soil is generally excellent, rendered so by the limestone found more or less abundantly in the hills.

In determining the geological facts of this township we shall best begin on the western margin, having already described Adams township. The Cat's Creek seam of coal—the Cumberland seam—is the same as the Bear Creek seam. The seam varies in thickness on Bear Creek. On the west side of one-hundred acre lot No. 53, the coal was formerly mined, and measured five feet, with a slate parting of one inch two feet above the bottom.

Here the coal was of excellent quality for household and all ordinary uses. Coal of similar good quality was found higher up the creek, on the land of Mr. Jackson, and considerable quantities were obtained by "stripping" in the bed of the stream, and carried in wagons to Marietta. To the south and south-west the seam becomes thinner, and the coal is more slaty. At the Bowen mine the seam measures three feet six inches. To reach this mine a tram-road was built up the creek from the Muskingum River. It is to be regretted that this road does not extend higher up the creek, so as to reach a thicker and better development of coal.

A sample of Bear Creek coal was analyzed by Prof. Wormley, with the following result:

Specific gravity	1.325
Water	2.00
Ash	5.24
Volatile combustible matter	33.76
Fixed carbon	59.00
Total	100.00
Sulphur	3.33
Sulphur remaining in coke	1.86
Per cent. of sulphur in coke	2.82
Iron in ash	0.39
Permanent gas per pound in cubic feet	3.97

The sulphur is more than is desirable, and more than the appearance of the coal would indicate. This is explained by the fact that only a small part of it is combined with iron in the form of bi-sulphide. The amount of fixed carbon is large, and the amount of permanent gas is also large. The coal kindles readily, and burns freely, with a brilliant flame, and has high heating power. The best of the Bear Creek coal is of excellent quality for household use. With proper facilities for purification, the coal would answer for gas-making. It was once tested in the

31

laboratory of the Manhattan gas works, New York, with favorable results as to the quantity of gas, and as to its high illuminating power.

A combined section of the strata seen on the upper part of Bear Creek is as follows:

		Ft.	In.
1.	Blossom of coal	2	0
2.	Not exposed	2	0
3.	Limestone	2	0
4.	Not exposed	15	0
5.	Limestone	4	0
6.	Not exposed	60	0
7.	Sandstone	4	0
8.	Shale	6	0
9.	Coal	3	0
10.	Slate parting	0	1
11.	Coal	2	0
12.	Not exposed	27	0
13.	Sandstone	8	0
14.	Shale	6	0
15.	Laminated sandstone	10	0
16.	Shale	2	0
17.	Limestone layers, white and buff	6	0

(See Map XI., No. 22.)

About forty feet above the upper coal, of which only a faint trace was seen, is a stratum of blue limestone.

The strata on Bear Creek dip regularly to the south. On the lower part of the stream, before it leaves Salem township, we find in its bed a well-known stratum of earthy, buff limestone, with which are associated other limestone layers, forming a group which has quite an extensive range in the eastern part of Washington county. Under this group lies the lower Salem coal, found in many places on Duck Creek. On Whipple's Run it is changed to cannel coal. Some of the limestones and the associated shales are fossiliferous, containing, on Bear Creek, teeth of fishes and comminuted shells. A layer of slate below the coal is also fossiliferous. This limestone group on Bear Creek, in the south-west corner of Salem township, passes under the dividing ridge and is seen in the bed of Duck Creek, near Mr. Flanders's, about half a mile above the Cedar Narrows bridge, in Fearing township. From this point it is readily traced in the banks of the creek and adjacent side hills up to Salem, and up the East Fork to the Noble county line. The coal under it is seldom more than three feet thick, and it is generally less. This seam is the equivalent of the Pomeroy seam and of the Pittsburgh seam. It has been traced from Pomeroy through Athens and Morgan counties into Washington county. On the West Fork of Duck Creek the limestone group with the coal gradually thins out to the north and disappears—at least it was not seen in the vicinity of Caldwell, in Noble county.

On Pawpaw Creek, a branch of the East Fork of Duck Creek, the limestone group is seen for several miles. It is also seen on Coal Run, a branch of Pawpaw, coming in from the north. The coal accompanying this group has been mined in small quantities at several points, two or three banks having been opened near the village of Salem.

A section taken in the hill back of Salem village is as follows:

		Ft.	In.
1.	Sandstone and shale	5	0
2.	Blue limestone		0
3.	Buff limestone	2	0
4.	Limestone and shale	2	0
5.	Clay	3	0
6.	Coal	2	6

(See Map XI., No. 21.)

On Pigeon Branch of Whipple's Run, on the Moses Blake farm, near the south line of Salem township, the coal is for the most part cannel, and has been mined to some extent and taken to Marietta. It burns freely in the grate, but the percentage of ash is too great to make it a desirable fuel. To the north this coal reverts to the usual type of bituminous coal. Such changes are not uncommon, and show that cannel coal is only a local modification of a seam of bituminous coal. A sample of the bituminous coal of the "limestone seam," taken from the Coal Run Branch of Pawpaw Creek, was analyzed by Prof. Wormley, with the following result:

Specific gravity (dried at 212°)	1.224
Ash (light gray)	6.20
Volatile matter	38.20
Fixed carbon	55.60
Total	100.00
Sulphur	2.18

Coke very compact, with metallic luster.

The buff limestone, which forms one of the layers of the limestone group, was also analyzed, with a result as follows:

Silicious matter	19.10
Alumina and sesquioxide of iron	8.65
Carbonate of lime	47.70
Carbonate of magnesia	19.40
Combined water	2.50
Undetermined	2.65
Total	100.00

This is a double carbonate of lime and magnesia, with such proportions of silica and alumina as would indicate some value as a waterlime. It is worthy of practical investigation. The most important seam of coal in Salem township is the upper one, which is here locally called the "sandstone seam," because of the heavy sandstone generally found above it. This sandrock is not entirely persistent, for in some places it does not appear, at least not in a heavy body. This seam of coal is one of wide extent, being found in a large number of counties in the Second Geological District. Its place is generally from eighty-five to one hundred feet above the Pomeroy seam. It has no better development than on the waters of Duck Creek. It has already been referred to as the Bear Creek seam of coal. There the coal, in all its physical structure, is somewhat different from that of the coal of the same seam on the East Fork of Duck Creek, and on the West Fork at Macksburg, Newburg, etc. This is due to the different conditions under which the coal was deposited. The same seam shows much the same characteristics on the farm of Samuel J. Hazen, near the head of Whipple's Branch of Pigeon Run. The coal here is four feet thick, with three inches of black slate under it and ten inches of similar slate over it. Above the latter slate is a mass of blue clay mottled with red. Here no heavy sandrock appears over the coal. In former years considerable coal from the Hazen bank was taken by wagons to Marietta. It has a pretty large percentage of ash, but in other respects is a good coal. To the north the seam may be traced, in varying thickness, to the north line of this township. Its finest development is probably on the East Fork and in the hills between the two forks. I have seen few openings on the lower part of the West Fork, but where I have found the coal it is thinner; but it thickens again in Aurelius and to the north. The coal is well seen on the farm of Vincent Payne, on Coal Run Branch of Pawpaw Creek, where the seam presents the following structure:

Coal, upper bench	2 ft.	6 in.
Clay parting	0 "	11 "
Coal, lower bench	3 "	7 "

Making a total of coal of six feet one inch. A sample of this coal was analyzed by Prof. Wormley, but I think it not a fair representative sample, from the exceptionally large ash. The coal was dried at 212°, and no record is given of the loss of moisture:

Specific gravity	1.352
Ash	12.95
Volatile matter	37.50
Fixed carbon	49.55
Total	100.00
Sulphur	3.26

On the farm of Mr. Payne are two well-marked seams of limestone, one one hundred and forty-four feet above the coal, and the other fifty-six feet higher. Each of these limestone deposits exerts a fine fertilizing effect upon the hill-sides. The upper one appeared to have great enriching power, so that the soil, almost to the summits of the hills, is very productive. Grasses, grains, and fruit grow luxuriantly. A geological section seen on this farm is given in Map XI., No. 20.

Crossing the ridge to the farm of Moses True, Esq., we find the coal well developed. Here the coal has been mined, and small quantities have formerly been taken to Marietta. The quality of Mr. True's coal, as tested in the parlor grate, is excellent. It is a caking coal, and for this reason needs more attention than coal of the dry, non-cementing class. Many years ago I burned a load of it with great satisfaction. In that part of the bank from which that coal came were layers of interlaminated cannel of excellent quality, which added to the value of the coal for grate use. This seam is believed to continue in fine thickness through all the high lands extending east into Liberty township. On one of the branches of Pawpaw Creek, in the north-western corner of Liberty, the coal is reported seven feet thick. All the farms which take the high hills on both sides of the East Fork contain this coal. It has been opened on nearly all the farms—on H. C. Hovey's, Ephraim Gould's, Jas. Alden's, etc. In this region the aggregate quantity of coal is very great. On Crooked Run, a branch of Duck Creek, north of Mr. True's, the seam is seen, and at the proper place below it is the coal of the limestone group, measuring thirty-two inches. This lower coal is also well seen by the road side on the farm of Mr. Hovey. Every where this coal, so far as it could be seen, appears to be of good quality. Through all this region the heavy sandrock over the upper or main seam of coal makes a conspicuous landmark. It often forms bold ledges, and on some of the small streams the water pours over it in falls of great beauty. Salem township perhaps exceeds any other in the county in its supply of coal. The day is not far distant when this coal will be needed. To all uses except the highest, which forbid much sulphur, the coal is well adapted. For household use, for the generation of steam, and for rolling mills, the coal will answer a good purpose, but not for the blast furnace nor for gas-making. It is possible that at some points the coal will afford good merchantable coke. I think some of the coal from the East Fork—such, for example, as was formerly mined by Mr. Moses True—would make a firm coke. How far the sulphur of the coal would pass off in coking, and, consequently, how much would remain in the coke, can only be determined by experiment. The coal is every where accessible, and generally every advantage can be taken of the dip for drainage and easy delivery of the coal to the mouth of mines. The general dip is to the south, but this is locally modified; indeed, the strata all through the east half of Washington county are more or less undulating. At one point in the township the level line or line of no dip was found to be north 60° east. This would give the dip at this point south 30° east.

Petroleum.—Several years since this township laid claim to the possession of good oil territory. On Pawpaw Creek several alluring little wells were obtained, enough to quicken the pulse of the oil fever. That there is considerable oil in the region there is no doubt; and if the price would justify small wells, the Pawpaw region might be worked. Among the many minor undulations which have caused subterranean fissures, and thus made it possible for the oil, probably in the form of vapor, to rise and accumulate, one such undulation, as an anticlinal, probably crosses Pawpaw Creek in lots 55 and 145 and in that neighborhood. Most of these undulations are so slight as not to make their detection on the surface possible except by a very careful instrumental survey. Toward the north line of the township, on the East Fork, some quite deep wells were bored and a little oil obtained, but not in remunerating quantities.

Salt.—It is almost certain that brine of good strength may be obtained almost any where in this township by boring wells. On the West Fork, in Aurelius township, and in Noble county, brine has been obtained in the oil wells. In Noble county salt works have been established. Should the making of salt be found a profitable industry, I have no doubt that immense quantities could be made in Salem. Fuel at the minimum cost could be obtained for the evaporation of the brine.

AURELIUS TOWNSHIP.

This township lies directly north of Salem, on the West Fork of Duck Creek. It differs from Salem little in the general character of its soil, and the geological features are essentially the same. The lower Salem coal, "the limestone seam," was no where seen in good development, and probably it thins out to the northward; but the upper and larger seam of coal is to be found. On the land of Hugh Jackson, near the south line of the township, this coal has been opened and mined. Where our measurement was taken the seam presented the following structure:

	Ft.	In.
Coal	1	9
Fire-clay	3	4
Coal	3	4

(See Map XI., No. 18.)

This is an unusual thickness of the middle clay, and makes the mining of the coal difficult. Further north the lower bench of coal attains a thickness of six feet, and the seam is found every where at its proper horizon in the hills bordering the creek. The tendency of the coal is to grow thinner westward and thicken to the north-east, but there are doubtless many local exceptions. The Ohio Coal Company has opened a valuable mine in the hills east of Macksburg, where the seam is six feet thick. The mine is probably in Enoch township, in Noble county. The coal is shipped to Marietta by railroad. The coal is of good quality for domestic use and for the generation of steam. It has also been used largely and with acceptance in the Marietta rolling-mill. It is a coal of good heating power. It is easily mined, and can be furnished in Marietta at very reasonable rates. The people of Marietta have found the great advantage of a regular railroad supply of coal from Duck Creek coal field over the precarious supply of the Ohio River. Manufactures of all kinds in which cheap fuel is a principal factor can be established.

Salt.—Besides the abundant coal, an unlimited supply of good brine for the manufacture of salt can be obtained in this part of the Duck Creek valley. On the flat below Macksburg a coarse sandrock containing brine is reported to be struck in the oil wells at ninety feet below the surface, but a more copious supply is obtained in another sandrock three hundred and eight feet below the surface. Deeper borings should strike the Upper Waverly sandrock, from which abundant supplies of brine are obtained at Pomeroy and other parts of the State.

The record of a deep well bored by Mr. Blauvelt, given hereafter, shows that the upper Waverly contains brine. It is always difficult to determine the strength of brine in any of these wells unless the fresh water, which enters almost all wells, be tubed off. If extensive mining of the coal should be carried on in Aurelius, the fine, or slack coal, which is not merchantable, could be profitably used in boiling salt. At many places in the State refuse coal is exclusively used in the salt works.

Petroleum—Aurelius township has heretofore furnished large quantities of excellent petroleum. One of the earliest wells bored in 1860, on the land of James Dutton, Esq., yielded many thousand barrels of heavy lubricating oil. It was only fifty-six feet deep. The daily yield at first must have been, from the reports, from one hundred to two hundred barrels. This well caused no little excitement, and many other wells were bored, many of which yielded remunerative returns. The Buell well, named from the Hon. B. P. Buell, of Lowell, one of its owners, has produced oil steadily for seven or eight years, and yet averages five barrels a day. The Mattison well is reported to have yielded an average of fifteen barrels a day for eight months. Other wells yielded considerable quantities. But most of this oil was produced before the Marietta, Pittsburgh, and Cleveland Railroad was constructed, and the expense to wagon it over bad roads caused the business to languish. Now the railroad is finished, the excessive product in Pennsylvania, and the extremely low price, render, for the time being, operations of this kind uninviting.

But I have no doubt that there are large quantities of excellent oil in the subterranean fissures in Aurelius awaiting the drill and the pump, and it will be a source of wealth to those who will conduct their business wisely and economically. A well has recently been bored by Mr. Rice, a little east of the Buell well, which yields one hundred and fifty barrels a day, and another larger well has still more recently been obtained in the same neighborhood. During the great oil excitement the speculation in oil lands was the principal thing, and the production of oil was of secondary consequence; and quite too often the superintendence was intrusted to persons of no knowledge or experience, who sometimes wasted in a most extravagant manner the funds of their companies. Duck Creek valley was a theater of the wildest speculation. But wells like the Buell well, although small, have been managed in a prudent way, and have yielded handsome returns upon the investment.

A deep well was bored near Macksburg by Mr. J. C. Blauvelt, agent, who has kindly sent me the following record of the strata passed through:

		Feet.
1.	Soil to the bed rock	17
2.	Sandrock containing heavy oil (28° gravity)	96
3.	Interval not reported	89
4.	Soapstone (clay shale)	185
5.	Coal, 2 feet thick	188
6.	Soapstone	190
7.	Limestone and bastard rock	260
8.	Sandrock	340
9.	In this sandrock struck salt water at 420 feet, a gas vein at 436 feet, and oil at	460
10.	Smut rock containing black carbonaceous matter	480
11.	Oil show	732
12.	Black sand	786
13.	Oil show	796
14.	Gray rock	828
15.	Black sand	840
16.	White sand	855
17.	Gray sand	870
18.	Salt water	874
19.	Fine white sand	906
20.	Coarse blue sand	1,010

		Feet.
21.	Oil and gas	1,020
22.	White sand	1,028
23.	Coarse blue sand	1,034
24.	Fine white sand	1,044
25.	Black sand	1,077
26.	Slate	1,079
27.	Slate	1,114

Mr. Blauvelt gives the record of another well bored by him within two hundred yards of the deep well, as follows:

		Feet.
1.	Soil to the rock	30
2.	Sandrock (first sandrock)	58
3.	Blue sandrock	250
4.	Sandrock	269
5.	Soapstone	280
6.	White sandrock (second sandrock)	310
7.	Oil	375
8.	Coal	378

In the deep well the sandstone, four hundred and forty-one feet thick, struck at a depth of six hundred and thirty-eight feet, is, I have no doubt, the Waverly. The thirty-five feet of slate at the bottom of the well may be the top of the Ohio black slate (Huron shale), or, possibly, it is a slate interstratified with the Waverly near the bottom. A slate sixteen feet thick is found in the lower Waverly on the Ohio River, in Scioto and Adams counties.

Iron Ore.—Iron ore of excellent quality is often found in this and adjacent townships. It is always in nodular form, and is derived from the disintegrated clay shales in the hill sides, from which it is washed out. Sometimes very large nodules are found. It is often difficult to trace the ore to its original bed, but where I have succeeded in doing this the nodules are too few to warrant drifting into the shales for them. Doubtless other and better localities will be found where drifting may be profitably done. The following is an analysis, by Prof. Wormley, of a sample of the ore from the farm of James Dutton, in this township:

Specific gravity	4.554
Water combined	1.20
Sesquioxide of iron	78.90
Alumina	7.70
Silica and insoluble matter	10.60
Sulphuric acid	0.25
Phosphorus	0.00
Total	98.65
Metallic iron	55.48

This is a rich ore, and would make an iron adapted to Bessemer steel. If it can be found in adequate quantity it will be of inestimable value.

FEARING TOWNSHIP.

This township is situated on Duck Creek, by the waters of which it is drained. The largest of the affluents of Duck Creek in the township is Whipple's Run, which rises in the north-western part of Lawrence township. The land is hilly, but in the valleys and on the hill-sides the soil is good. As a rule, the soil is less fertile on the ridges. There is less limestone in the hills than in Salem township, on the north. The so-called limestone coal, the equivalent of the Pomeroy seam, is found in the northern part of the township, near the mouth of Whipple's Run, and in that vicinity. Here it has been mined to some extent for neighborhood use, and formerly it was taken by the plank-road to Marietta. On Whipple's Run the coal is part cannel, while three-quarters of a mile below, where it was taken in low water in the bed of Duck Creek, near Mr. Flanders's, it is reported to have been entirely bituminous. This seam of coal in this vicinity well illustrates the changes which sometimes take place in the character of the coal in short distances. In the bed of the creek it is the usual bituminous variety, while as we go north a part of the seam is changed into cannel—perhaps in some places it is all changed, but when we reach the neighborhood of Salem village it is found to be bituminous again. If we adopt the better theory of the origin of cannel coal, there was here a portion of the old coal marsh, in which a part of the vegetation was so changed, probably by maceration in water, as to lose its structure and become a mere mass of vegetable mud or muck. This muck, when buried and compressed and bituminized, forms the cannel coal. Unfortunately with this vegetable mud there was commingled other mud in the form of clayey sediments, and thus the cannel coal now contains a larger quantity of ash than could come from coal formed of pure vegetable muck.

ANALYSIS OF CANNEL COAL OF WHIPPLE'S RUN.

Specific gravity	1.500
Water	1.00
Ash	26.00
Volatile combustible matter	31.00
Fixed carbon	42.00
Total	100.00

Gas per pound in cubic feet, 2.73.

Ash, gray. Coke, pulverulent.

Several years ago, when coal-oil was distilled from cannel coal, and before wells were bored for petroleum, a small experimental oil distillery was established on Whipple's Run, and some oil was made from this cannel coal. The coal was not very rich in oil, and the location was remote from market. Soon after, however, petroleum was obtained in great quantities from wells, and all the "coal-oil" distilleries, however well situated, were obliged to succumb.

The "limestone coal" dips pretty rapidly to the south, passing below the bed of Duck Creek, near Mr. Flanders's, and is not seen again in the township. At the Cedar Narrows bridge the limestone group, with its coal seam, was passed through in boring for oil, at a reported distance of thirty feet below the surface. The group reappears in Lawrence township, brought up in the Cow Run uplift, and in Newport in the Newell's Run uplift. We should expect that the upper coal, the "sandstone seam" of Salem, would be found over a large area in this township. Its place is about eighty-five to ninety feet above the lower. Traces of it are seen, but it is generally very thin. It is found just north of the township line in Salem, where Mr. S. J. Hazen has mined it in the hill at the head of Pigeon Branch of Whipple's Run. It should be found on the main run, it being very easy to ascertain its proper horizon from the limestone group and the lower coal. A stain of the coal of the seam was once observed in a bank of the railroad a mile or two below Cedar Narrows bridge. The exact point was not noted, but it was where the southern dip would naturally bring it. No coal was seen on the west side of Duck Creek except a trace of the "sandstone seam." On the west side of the ridge, between Duck Creek and the Muskingum, on the land of B. F. Dyar, in Muskingum township, the coal of the Hobson seam was found one hundred and fifteen feet above the bed of the Muskingum. The place of the seam is about one hundred feet above the "sandstone seam." But this seam was not noticed on New Year's Run, on the eastern side of the ridge. At Stanleyville we find in the bank of the creek, below the mill, a considerable body of limestone ten or twelve feet thick, and a few feet over it a very thin seam of coal. Under the limestone is a considerable body of red clay shale fifteen or twenty feet thick, with a layer of limestone eight inches thick near the middle. This red shale rests upon a heavy sandrock, which forms the bed of the run. It is difficult to determine the exact stratigraphical position of the Stanleyville limestone, because there is no certain geological horizon or datum line with which to connect it. On the Muskingum River, at Mr. Dyar's, in a north-west direction from Stanleyville, there is a body of somewhat similar limestone eight feet thick, sixty-five feet above the Muskingum River. If our determinations there are accurate, the place of this limestone is about fifty feet above the horizon of the "sandstone" seam of coal. The same limestone is seen on the north side of March Run Hill, toward the foot of the hill. If this limestone continues eastward to Duck Creek with the usual dip, it would appear on Duck Creek at Stanleyville. The same Stanleyville limestone is seen on some of the eastern tributaries of Duck Creek. On Killwell Run, on the farm of Lewis Dowling, the limestone is well seen. Here the following section was taken:

		Ft.	In.
1.	Chocolate-colored shale, with coal plants.		
2.	Sandstone	3	6
3.	Slate, blue and brown	6	0
4.	Sandy, calcareous nodules	0	6
5.	Shale	0	5
6.	Coal	0	6
7.	Clay	0	5
8.	Coal	0	10
9.	Fire-clay	3	6
10.	Sandy shale	0	6
11.	Sandstone	0	6
12.	Blue clay	1	3
13.	Limestone, not measured, probably	10 to 12	0
	Bed of stream.		

Passing over the ridge to the south-east into Lawrence township, we find on Little Eight-Mile Run, about a third of a mile from its mouth, a similar body of limestone. The "sandstone seam" is found at Guyton's Mill, at the mouth of Little Eight-Mile Run, on Little Muskingum, under the heavy sandrock. No measurement was made of the interval, but I should think the limestone to be about fifty or sixty feet above the "sandstone coal." These observations would tend to verify the other.

MARIETTA TOWNSHIP.

This township is situated on the Ohio River, and embraces within its limits the mouths of the Muskingum and Little Muskingum rivers and Duck Creek. The shape of the township is such as to give a very large frontage on the Ohio, and, consequently, a large area of the rich soil of the immediate valley. The valleys of Duck Creek and Little Muskingum are much narrower. The township is generally hilly, as are almost all townships bordering on the Ohio River. The city of Marietta is built in part upon a Drift terrace, and in part upon the alluvial ground bordering the Ohio and Muskingum rivers. The terrace is a high and beautiful one, affording a dry soil, and is admirably fitted to be the site of a town. Terraces of about the same level are seen upon the opposite side of the Muskingum, a mile and a half above Harmar, and on the West Virginia side of the Ohio. A very extensive terrace is found in the upper part of Marietta township, above the mouth of the Little Muskingum River. All these terraces tell a tale of very high water in these rivers, and of the formation of large sand banks and sandy flats. The terrace in the city of Marietta contains an interstratified layer of blue clay, which appears on Putnam street. It is said to form the retentive bottom of the well of Col. John Mills, and reveals itself by springs at several points. This terrace, at the confluence of the Muskingum and the Ohio rivers, presented attractions to the ancient Mound-builders, and the extent and character of the earth-works they have left show that they once had here a populous fortified town. The views from Harmar Hill, College Hill, and other high points around Marietta, are almost unequaled for their beauty.

There is very little of interest or of economic importance in the geology of this township. A thin seam of coal is found in the hills, but it has never been found thick enough for profitable mining. It is seen on College Hill, and was passed through in the well of the Hon. W. F. Curtis. It is seen on the roadside a little east of town. Probably the same seam of coal is in the hills between Duck Creek and the Muskingum River. The latter has been opened on the county infirmary farm, and at several points near the Muskingum River. If it is the equivalent of the seam under the heavy sandrock below Harmar—the Hobson seam—the place of which is about one hundred feet above the Cumberland, or upper Salem coal, it rises gradually to the east, affected, perhaps, by the Cow Run uplift. On the hill, perhaps a mile or a mile and a half east of the Farmers' bridge over Duck Creek, it is, by barometer, one hundred and forty-six feet above the bridge. It is very difficult to determine the exact stratigraphical position of this coal, since it is almost impossible to connect it with any known stratum or any ascertained datum line from which measurements can be made. Sandstones, shales, and even the non-fossiliferous limestones, are so variable that little dependence can be placed upon them for accurate determination. There are in the township large deposits of sandstone, but it must be selected with some discrimination, if it is to be used for building purposes. On College Hill an old quarry was extensively worked in the earlier history of the town. Of late years the favorite building stone has been obtained in quarries in Harmar and in Warren. In the hills we find much of the dark, chocolate-colored clay shales, which often contain considerable lime. Some of these shales contain impressions of ferns. At the foot of College Hill such impressions are very abundant.

LAWRENCE TOWNSHIP.

This township lies south of Liberty and east of Fearing townships. The Little Muskingum River runs diagonally through the township from the north-east to the south-west. The principal tributaries on the north are Fifteen-Mile Creek and Morse Run, while those on the south, or south-east, are Archer's Fork, Bear Run, and Cow Run.

We have seen that in Liberty township, as well as Salem, the strata have a decided southern dip; but we find in this township a marked change, produced by the forces which elevated the Cow Run uplift. This uplift, which will be more particularly noticed hereafter, passes northward, gradually diminishing or flattening, but showing on Morse Run and its branches the well-marked characteristics of an anticlinal. The strata, followed from the north, are seen gradually to rise on the back of this anticlinal swell, at the same time dipping on either side of it to the east and west.

On Fifteen-Mile Creek, at Burning Spring, the anticlinal feature is scarcely perceptible, but there is doubtless such an undulation as has caused subterranean fissures, from one of which the gas of the Burning Spring emanated. Such fissures also generally contain oil, and some good wells have been obtained in this region; but so slight are the surface indications of the subterranean disturbance, that it is impossible to determine beforehand just where the greatest fissurings of the rocks, and, consequently, the more probable locations for oil wells, may be.

F. W. Minshall, Esq., of Marietta, who to an unusually full and discriminating knowledge of the geological relations of the petroleum of Washington county adds large experience in the practical production of oil, informs me that he has not been able to find any well-marked anticlinal in the region of Burning Spring, on Fifteen-Mile Creek.

A very carefully conducted series of levelings with instruments more accurate than Locke's level or the Aneroid barometer, might possibly show where the undulations are the sharpest, and where the oil would be most probably found, if at all. It is, however, doubtful whether any very valuable results would be secured. In a region of so very slightly disturbed condition, there is no authentication of oil territory so good as the wells themselves. Further south, on Cow Run, the anticlinal, or "break," as it is popularly termed, is very manifest, and intelligent oil men have long been guided by it.

On Little Morse Run we find the traces of the Cow Run uplift, for there is an apparent westward dip. This is seen on the land of D. Baker, section 27. Here the upper Salem, or Cumberland, seam of coal is found. A geological section here is as follows:

	Ft.	In.
1. Heavy sandrock (not measured).		
2. Blue clay	1	6
3. Coal	0	1
4. Clay	0	3
5. Coal	1	4
6. Underclay, shales and sandstone to the bed of Little Morse Run	22	0

Another section on the same stream was found to be quite similar, and at no point was the coal thick enough for profitable mining. To the east the coal grows thicker. On the land of Amos Dye, 2d, between Little Morse Run and Morse Run, we find the coal in four distinct layers separated by clay. The section here is as follows:

		Ft.	In.
1.	Coal	0	3
2.	Not seen, except sandstone at bottom	40	0
3.	Blue clay	2	0
4.	Coal	0	4
5.	Blue clay	1	8
6.	Coal	0	4
7.	Blue clay	1	0
8.	Coal	1	4
9.	Blue clay	2	1
10.	Coal	1	4
11.	Clay (not measured).		

The upper, thin coal is unusual, but traces of it are found in other townships. On the main run, sometimes called, I think, the East Fork, the seam is found to be from three and one-half to four and one-half feet thick, and is here mined with success to supply coal to the oil works on Cow Run. At the bank of Diarca Dye the coal seam at the outcrop is three and one-half feet thick, with a very coarse sandrock directly over it. At the bank of Wm. Carmichael, section 22, it is four feet thick. At Esquire Martin's bank it is four feet. On John Pepper's land it measures four and one-half feet. On the land of Mrs. Woemer the coal is reported to be nine feet below the bed of Morse Run. Generally there are a few feet of clay shale between the coal and the overlying sandrock, but there are exceptions to this. South of Morse Run the strata along the center of the uplift rise rapidly, and the coal under the heavy sandrock becomes much thinner. About one-fourth of a mile above Mr. Reynolds's, on the Little Muskingum, this coal is only ten inches thick, and one hundred and forty feet above the bed of the river. Here the dip on either side of the anticlinal axis is very marked, but it is generally better seen on the western side. On Cow Run the "sandstone coal" is two hundred and forty-five feet above the bed of the run. Cow Run crosses the uplift in a nearly east and west course, and has eroded its channel to the usual depth of all the streams of the region, as determined by the natural drainage. We find, therefore, in the center of the uplift on Cow Run strata not seen elsewhere (except in the Newell's Run uplift, in Newport township), for they are quite below the general stratigraphical range of the county. If we may consider the lowest point geologically, *i. e.*, the center of the uplift in the valley two or three rods above the Perkins oil well No. 1, and form a section upward, we shall find the strata in their order. If to the rocks not seen directly there we add the higher ones found in their proper geological position in the hills to the east, we shall have a complete and very interesting section, as follows:

		Ft.	In.
1.	Yellow shale	25	0
2.	Coal, Hobson seam	1	4
3.	Clay, "	0	4
4.	Coal, "	0	8
5.	Clay	1	0
6.	Black bituminous slate	0	10
7.	Coal	0	1
8.	Clay	0	3
9.	Limestone	4	0
10.	Not exposed	18	0
11.	Heavy sandrock	60	0
12.	Shale	10	0
13.	Coal, "sandstone" or Cumberland seam (not measured).		
14.	Not exposed	75	0
15.	Blue limestone	4	0
16.	Buff limestone	2	0
17.	Limestones and shales	10	0
18.	Coal, Pomeroy seam (not measured).		
19.	Not exposed	98	0
20.	Blue limestone	5	0
21.	Not exposed	40	0
22.	Bed of Cow Run.		

(See Map XII., No. 28.)

The upper coal, which is stratigraphically three hundred and thirty feet above the bed of Cow Run in the center of the uplift, is found about two miles east, and the actual level, by barometer, shows it to be only one hundred and nineteen feet above, so rapidly have the rocks on the eastern slope dipped to the east. The western dip is also well marked. In the center of the uplift the buff limestone group, with its coal, is one hundred and fifty-three feet above the bed of the run. This group dips below the bed of Cow Run about three-eighths of a mile west. If to this we add eighteen feet for the fall of the stream, we have the whole dip in this distance one hundred and seventy-one feet.

The heavy sandstone over the "sandstone" or Cumberland coal is brought down to the bank near the mill-dam on the Little Muskingum, just below the mouth of Cow Run. Under this rock the coal has been dug. The upper coal of all, the Hobson seam of the western part of the county is found further down the creek, and probably continues through Marietta township, it being, possibly, the seam found on the county infirmary farm. While there are, then, eastern and western dips, there is also the marked northern dip already referred to. If we stand on the hill on the south side of Cow Run, in the center of the uplift, we find by leveling across to the north side, a distance of about a quarter of a mile, that the corresponding strata—the buff limestone, for example—are forty feet lower on the north than on the south side. Hence the axis of the arch of the uplift dips rapidly northward, and of course the arch soon flattens down and is lost in small undulations, generally too small to be easily detected. The arch also, doubtless, flattens down to the south, for on Eight-Mile Run, so far as I have examined, the anticlinal is not very strongly marked, and all efforts to obtain oil there in any considerable quantity have failed. The following is a record of strata in a well—the Greenback well—bored by Messrs. Curtiss and Minshall within the Cow Run uplift. The top of the well is about one hundred and forty feet below the Pomeroy seam of coal:

		Ft.	In.
1.	Alluvial	22	0
2.	Red and blue shales	74	0
3.	Fossiliferous limestone	1	6
4.	Yellow shale	18	0
5.	Coal (no measurement).		
6.	Not given	20	0
7.	First sandrock, oil rock of Newton well	30	0
8.	Clay ("mud rock"), with nodular iron ore	4	0
9.	Not known in detail, thin coal near the bottom	377	0
10.	Sandrock ("cap rock"), with black grains	30	0
11.	Sandrock, second oil rock	100	0
12.	Sandy shale, dark colored	30	0
13.	Shales and sandstones	125	0
14.	Black bituminous layer, thin.		
15.	Shales and sandstones	130	0
16.	Fine white sandrock	33	0
17.	Conglomerate, pebbly white quartz	22	0

The oil has been chiefly derived from the two sandrocks, Nos. 7 and 11. The Newton well—the first one bored on Cow Run—obtained its oil from a fissure in the first sandrock, while many more recent wells extend down to the lower sandstone. The oil is found in fissures, and these fissures in our oil fields of Ohio and West Virginia are to be found along anticlinal lines. Not at all points within the uplift, or "break," do we find oil. There are many dry wells where oil was most confidently expected. But generally, at Cow Run, while one is not sure in the most promising places, yet it is quite certain that he must follow pretty closely certain lines. Any considerable variation from such general lines will necessitate failure. The first well was bored here by Mr. John Newton and his associates in 1860. They were first drawn to this region by an oil spring, it is said. This well continued productive for eight or ten years, and yielded many thousands of barrels of oil. Many other excellent wells have been obtained. The field is a very small one—perhaps not much more than half a mile along the axis of the uplift, and probably less than that on a line at right angles to the axis. Some years eighty thousand barrels have been produced. No oil field in Ohio has been so valuable as this. The Cow Run uplift is entirely disconnected from the great West Virginia oil uplift, which crosses the Ohio River a little above the mouth of Newell's Run, Newport township. It is an entirely independent uplift, doubtless, however, produced at the same time and by the same forces which produced the one on Newell's Run, and, indeed, caused all the undulations of the Coal Measure rocks in south-eastern Ohio. When the uplift took place there were more or less subterranean cracks formed, extending to great depths. In these fissures the oil from below coming up in the form of vapor, from the distillation of bituminous materials underneath, accumulated. The cracks in the sandrocks remained open—for the walls would not be disintegrated by water—and retained the original oil, while the cracks in strata of clay shales, or "mud rocks," would, as water entered them, be filled with the mud of the disintegrating shales, and thus ultimately the oil would come to be found chiefly in sandrocks. Whether there are now any unclosed fissures extending down to the prime sources of oil, so that the supply is constantly accumulating, is doubtful. Wells are often pumped with some success after having been once exhausted, but the oil is doubtless brought in from the connecting fissures in the same sandrock, and not from great depths below. The fact that we find nearly all the oil imprisoned in fissures in sandrock would imply that it is old oil.

There is a group of limestones on the bank about thirty feet above the Little Muskingum, at the mouth of Fifteen-Mile Creek. When there many years ago it was reported there was a seam of coal about thirty feet above the limestone, while about one hundred feet above the limestone was another seam under a sandrock, supposed to be the equivalent of the upper Salem, or "sandstone seam." During the progress of the survey I had no opportunity to revisit the location.

On Bear Run a thin seam of coal—reported fifteen inches thick—was seen on the land of Mr. Atkinson, section 2. This may possibly be the Hobson seam, but its exact stratigraphical position could not be determined without a laborious investigation of the dip in this part of the township, which the slight value of the coal seam did not warrant. It is proximately in the line of the Newell's Run uplift, but it will be seen, in the discussion of the geology of Newport township, that this uplift flattens very rapidly to the north.

LIBERTY TOWNSHIP.

This township lies east of Salem and north of Lawrence townships. The north-western part is drained by Pawpaw Creek—a branch of Duck Creek—and the remaining portion is drained by tributaries of Little Muskingum River. The land is hilly, but the soil is generally good, there being often considerable limestone in the hills.

The Salem "sandstone seam" of coal—the Cumberland seam—extends quite generally through the township. It is almost every where of good working thickness, and will afford an almost unlimited supply of fuel. The quality of the coal is fair. The seam shows the usual clay parting, which is quite variable in thickness. Over this coal is generally seen the same heavy sandrock which is seen in Salem, on the East Fork of Duck Creek. The seam is readily traced from the bank of Moses True, Esq., along the waters of Crooked Run, where we also see the limestone group with the lower or Pomeroy seam of coal, thirty-two inces thick, into the high ridge which divides the waters of Crooked Run from Pawpaw Creek. On the east side of this ridge, in the extreme north-west corner of Liberty, on a little branch of Pawpaw, we obtained the following geological section:

		Ft.	In.
1.	Limestone (not measured).		
2.	Sandstones and shales (not measured).		
3.	Clay	3	0
4.	Coal	1	0
5.	Clay	1	0
6.	Limestone	5	0
7.	Sandstone and shale (estimated)	37	0
8.	Heavy sandrock	50	0
9.	Clay shale	1 to 2	0
10.	Coal not seen in detail (reported)	6	0
11.	Fire-clay and clay shale	6	0
12.	Sandstone	10	0
13.	Limestone (not measured).		

(See Map XI., No. 27.).

The upper seam of coal in the above section is the Hobson seam of the western part of the county. The lower and thicker seam is the sandstone seam, or the Cumberland seam. On the land of Wm. Hamilton, near Germantown, in section 23, the following geological section was taken:

		Ft.	In.
1.	Heavy sandrock (exposed)	22	0
2.	Blue shale	8	0
3.	Coal, Cumberland seam	2	6
4.	Clay, " "	2	0
5.	Coal, " "	2	10
6.	Clay and shale	5	0
7.	Limestone	2	0

Bed of Pawpaw Creek. (See Map XI., No. 23.)

This is the Cumberland seam. In another coal bank, near by, the dividing clay is only ten inches thick. On the land of Edward Doyle, section 16, the geological section is as follows:

		Ft.	In.
1.	Heavy sandrock (exposed)	30	0
2.	Shale	5	0
3.	Coal, Cumberland seam	2	0
4.	Clay, " "	1	0
5.	Coal " "	2	3

On the farm of Henry Barnhardt, in section 8, in this township, a more complete geological section was taken, as follows:

		Ft.	In.
1.	Heavy sandrock, exposed	20	0
2.	Shale	1	0
3.	Coal, Cumberland seam	2	0
4.	Clay, "	0	8
5.	Coal, "	2	0
6.	Underclay	2	0
7.	Not exposed	48	0
8.	Limestone	2	0
9.	Sandy shale	20	0
10.	Limestone and magnesian limestone	5	0

Bed of stream. (See Map XI., No. 25.)

At other openings of the coal in this section the seam presents about the same measurements as at Mr. Barnhardt's. The same coal is mined along the banks of Fifteen-Mile Creek, in sections 7 and 9. In section 1, on the land of Lewis Linchcomb, the following geological section was taken:

		Ft.	In.
1.	Sandrock	15	0
2.	Shale	6	0
3.	Coal, Cumberland seam	1	8
4.	Clay, "	1	2
5.	Coal, "	1	3

Near the south line of the township, in section 7, on Fifteen-Mile Creek, I noticed many years ago a thin seam of coal, associated with a group of limestones, about forty or fifty feet below the Cumberland seam. The coal is of no value, but it indicates the horizon of a seam which in Belmont county is worked. The general dip of the strata is to the south in this township, but there are undulations which often vary the direction. The dip is sometimes forty to fifty feet per mile.

NEWPORT TOWNSHIP.

This township lies upon the Ohio River, having Marietta township on the west, and bordering Lawrence and Independence townships on the north. It has a long distance of frontage upon the Ohio, and, consequently, contains a large area of the rich alluvial and terrace land of the immediate valley. The Little Muskingum flows for two miles and a half through the extreme north-western corner, and a considerable area of the western part of the township is drained by Eight-Mile Run and Long Run, both branches of that river. There are several small streams flowing into the Ohio, of which, perhaps, the more important are Bell's, Newell's, and Dana's runs. The dividing ridge between the Ohio and Little Muskingum is high, and the sides are often furrowed with ravines of very steep banks, and of rapidly increasing depth. The small streams in these ravines are slowly eating away the ridge.

A mile back of Newport village is an interesting depression, extending like a chord across the arc formed by the curve of the Ohio. During the era of the high water of the Drift period the river, or a portion of it, flowed through this depression, and deposited Drift sand and gravel. The hill to the south once constituted an island. The river now flows on a rock bed.

The western part of the township shows little of interest in its geological structure. The hills are composed largely of shales and sandstones, and belong to a series above the horizon of the Pomeroy and Cumberland seams of coal. The Hobson seam should be in the hills, but it is doubtless thin. The most remarkable feature in the geology of the township is what is termed the Newell's Run uplift, a continuation of the great West Virginia uplift. I first called the attention of geologists and others to this line of uplift in an article in the *American Journal of Science*, July, 1860, having traced on foot the line, across valleys and over ridges, from Burning Spring, Wirt county, West Virginia, north into Newport township, Ohio. It was found to be a line of gas springs, oil springs, and of the few wells at that time obtained. Since that time valuable oil wells have been found at many places within, but none without, this so-called "break." This anticlinal, toward the north, becomes a broad and flattened arch, and gradually dies away. The same is true, as I have been informed by General A. J. Warner, of Marietta, to the south, beyond Burning Spring, on the Little Kanawha River. The center of the uplift on the Newport side is at or very near the mouth of a little tributary of the Ohio called Conley's Run. This is a little above the mouth of Newell's Run. In the immediate bank of the Ohio we find by far the lowest rocks, geologically considered, in the county, for the bottom of this uplift is, geologically, about one hundred and sixty-five feet lower than the bottom of the Cow Run uplift. The sandrock in which the old Newton well, on Cow Run, found its oil, is here seen in the Ohio River bank. The following section gives the lower strata near the mouth of Conley's Run:

		Ft.	In.
1.	Fossiliferous limestone	1	6
2.	Yellow shales	18	0
3.	Slaty coal	0	8
4.	Clay and coal	0	6
5.	Fire-clay, light-colored	0	6
6.	Coal	0	6
7.	Not exposed	20	0
8.	Sandrock, with some quartz pebbles, first oil rock of Cow Run	25	0
9.	Iron ore adhering to sandrock	0	6
10.	Blue clay shale, with nodules of iron ore	1	6

Level of water Ohio River. (This is the lower part of section No. 29, Map XI.)

The limestone No. 1 of this section is doubtless the equivalent of the Cambridge fossiliferous limestone, which is seen in many counties, and has its place about two hundred and thirty feet below the horizon of the Pomeroy seam of coal. I have observed it nowhere else in Washington county; indeed, at no other point could we expect to find it except in the Newell's Run uplift. The thin coal found eighteen feet below this limestone is found in other counties, always holding the same relation to the Cambridge limestone. It is always thin, and of no practical value. There is often a thin seam of coal a few feet above the limestone, but it was not seen in the uplift. No very good exposures of the strata immediately above the limestone, however, were seen, and no careful search was made for it. It was not reported as passed through in the Cow Run wells, while the seam eighteen feet below was found in its true place. On the farm of Mr. Joseph O'Neal, between Conley's Run and the mouth of Newell's Run, a well was bored by F. W. Minshall, Esq., the top of the well being four feet below the Cambridge limestone. The following is a record of the strata passed through:

		Ft.	In.
1.	Sandstone	15	0
2.	Coal, etc	1	6
3.	Sandrock, believed to be the first oil rock of Cow Run	44	0
4	Red and blue shales	210	0
5.	White sandrock, with a strong flow of brine from near the bottom	100	0

		Ft.	In.
6.	Soft blue shale	25	0
7.	Shale, with strata of black bituminous slate	75	0
8.	Coal, black slate, and fire-clay	10	0
9.	Hard sandrock, "cap rock"	20	0
10.	Sandrock, believed to be the second oil sandrock of Cow Run	45	0
11.	Black slate	10	0
12.	Sandrock, a little oil in the lower part	45	0

There is a large flow of brine from the sandrock No. 5, forced up from three to four times a day by gas. The coal—No. 8 of the section—is one of the lowest coals of the Coal Measures. Probably the two lower sandrocks belong to the Upper Waverly. It is remarkable that in the four hundred and fifty-four feet above this coal no other seams should have been found, for this space includes the proper geological horizons of some of the most important seams of coal in the State—such as the Sheridan, Nelsonville, Jackson Hill, and Anthony seams. It is evident from the record of this well, and, indeed, from many other wells near the center of our great coal basin, that seams so important along the western margin of the coal field have not extended to the middle of the field. The conditions favorable to the growth and accumulation of the vegetable materials for seams of coal appear not to have existed.

On the hill back of Mr. O'Neal's farm we find, one hundred and thirty-six feet above the Cambridge fossiliferous limestone, another body of hard blue limestone, about six feet thick. This is the limestone seen in the bed of Newell's Run, at the forks of the stream, near Basil Williamson's house. This limestone is ninety-eight feet below the Pomeroy seam of coal, here associated with the buff limestone group. About forty feet above the limestone, a little above Williamson's, on Newell's Run, is a very thin seam of coal. We find traces of this seam in other counties. It is probably the equivalent of the Jeffers coal in Gallia county. The center of the uplift is found a little east of Williamson's, on Kerr's Run—a branch of Newell's Run—where the lower limestone is eighteen feet above the bed of the run. There is here, therefore, a western dip.

On the land of Samuel Kerr, on Kerr's Run, in section 5, we find the Pomeroy seam of coal, with the overlying limestone group, in the bed of the stream. A geological section taken here is as follows:

		Ft.	In.
1.	Heavy coarse sandrock, in places conglomerate	60	0
2.	Shale	10	0
3.	Coal, Cumberland seam, seen on Newell's Run	1	9
4.	Not exposed	45	0
5.	Heavy sandrock, laminated with false bedding	25	0
6.	Clay shale	5	0

		Ft.	In.
7.	Blue limestone	4	0
8.	Buff limestone	2	0
9.	Blue limestone and shales	10	0
10.	Coal, Pomeroy seam (not measured).		
11.	Underclay, "		
	Bed of Kerr's Run. (This is the upper part of section No. 29, Map XI.)		

At this point we are well on the eastern slope of the uplift. From a point three-eighths of a mile below, on the stream, it was found that the dip in this distance was one hundred and two feet. This is not the measure of the greatest dip, for the valley here runs in a north-west and south-east direction.

On ascending a branch west from Williamson's the western dip is very marked. This is seen on the land of H. Pegg. Besides the eastern and western slopes of the uplift, we find, as at Cow run, that the top of the anticlinal arch gradually sinks down and dies away to the northward. Near the center of the uplift, on the Ohio, the same limestone which is seen eighteen feet above the bed of Kerr's Run, also near the center of the uplift, is two hundred and two feet above the water of the Ohio. It is probably not more than a mile in a straight line. If we allow eighty feet for the fall of Kerr's Branch and Newell's Run, we have one hundred and twenty-two feet of northern dip. North of Williamson's, as we ascend Newell's Run, the dip of the strata to the north was ascertained to be proximately one hundred and twelve feet per mile. This carries the Pomeroy coal, with its associated limestone group, below the stream, and higher up the Cumberland seam under the heavy sandrock goes under. The latter coal has been opened and mined a little. It measures twenty-one inches in thickness. Higher in the hills, at the head of the run, is the Hobson seam of coal, the place of which is ninety to one hundred feet above the Cumberland seam.

The axis of the Cow Run uplift in Lawrence, if produced south, would be about three and a half miles west of the center of the Newell's Run uplift. Wells bored for oil in Newport have not generally been successful. The anticlina arch is so broad and flat that it is very difficult to determine beforehand just where the largest subterranean fissuring of the rocks may be. Wells have been bored in the center and on either slope, some of them very deep, but no large reservoirs of oil have been struck. At some points in West Virginia, by a careful study of the "break," as it is called, I was enabled to predict, upon the position of the rocks on the surface, where the large oil fissures must almost necessarily be found, and these predictions were ab ındantly verified. But in Newport the same "break," or uplift, so flattens and fades away that I have found it impossible to make similar predictions. And yet I have no doubt that there are beneath the surface large quantities of oil.

East of Newport village, on the bank of the river, we find the Cumberland seam of coal under a heavy sandrock. In the Narrows, below the village, this sandrock is four hundred feet above the water of the river. Nowhere in Newport have I seen the coal under the sandrock of much promise. The Pomeroy seam is still thinner, and, probably, nowhere worthy of mining.

INDEPENDENCE TOWNSHIP.

This township lies east of Lawrence and north of the eastern part of Newport. It touches upon the Ohio River in the south-eastern portion. The eastern part is drained by Sheet's Run and several others which empty into the Ohio; and the western chiefly by Archer's Fork of Little Muskingum. The township is quite hilly. There is no valuable development of coal, although the Cumberland and Hobson seams are found in their proper horizons, but always thin. In section 3, on the land of John Goodrich, on the run, about two miles above the Ohio, was found the Hobson coal. The whole section here is as follows:

		Ft.	In.
1.	Coarse heavy sandrock	30	0
2.	Not exposed	22	0
3.	Sandrock, laminated in places	40	0
4.	Shale	27	0
5.	Sandrock	10	0
6.	Sandy shale, with nodules of iron ore	3	0
7.	Shale	3	0
8.	Coal, Hobson seam	1	3

(See Map XI., No. 32.)

On the land of Joseph Chris, section 13, on Davis Run, the Cumberland seam of coal was found. The following is a geological section there:

		Ft	In.
1.	Sandrock	15	0
2.	Shale, and not seen	25	0
3.	Sandrock	10	0
4.	Shale	40	0
5.	Coarse sandrock	24	0
6.	Sandy shale	6	0
7.	Blue shale	6	0
8.	Slate, with streaks of coal	1	0
9.	Coal, Cumberland seam	1	0
10.	Clay, " "	1	6
11.	Coal, " "	0	8

(See Map XI., No. 33.)

The same coal with that of the above section is found and mined in a small way at other places, and on other runs. A buff limestone is sometimes found, but it is not persistent, as it is in places replaced by heavy sandstone.

LUDLOW TOWNSHIP.

This township lies east of Liberty, and borders Monroe county on the north. The Little Muskingum River flows through the township, entering it near the north-west corner, and leaving it near the south-west corner. Its course is very winding. The township is entirely drained by it and its tributaries. Its geological features are essentially those of Liberty, but with less coal.

On Wingett's Run, in the western part of the township, some sections were taken, which show the Cumberland, or upper Salem, seam of coal, and the lower Salem, or Pomery seam. The following geological section was taken in section 34, on the land of Albert Ewing:

		Ft.	In.
1.	White limestone	1	0
2.	Shale	5	0
3.	Limestone, white and buff	4	0
4.	Red shale	27	0
5.	Sandrock	12	0
6.	Shale, with 5 inches siderite ore	6	0
7.	Coal, Cumberland seam	2	2
8.	Clay and slate, "	1	10
9.	Coal, "	1	8
10.	Shale chiefly	12	0
11.	Sandstone	4	0
12.	Shale	28	0
13.	White limestone	1	0
14.	Shale	4	0
15.	Buff limestone	5	0

(Map XI., No. 30.)

On the farm of Seth Adams, section 33, on Wingett's Run, both coals were seen, as follows:

		Ft.	In.
1.	Limestone (not measured).		
2.	Shale	23	0
3.	Heavy sandrock	23	0
4.	Sandy shale	6	0
5.	Coal, Cumberland seam	0	8
6.	Clay, "	2	0
7.	Coal, "	2	0
8.	Not well seen, but mostly shale	45	0
9.	Limestone	1	0

		Ft.	In.
10.	Shale	5	0
11.	Limestone	3	0
12.	Not seen	6	0
13.	Sandy shale	20	0
14.	Limestone, in part cement limestone	8	0
15.	Shale	2	0
16.	Coal, lower Salem, or Pomeroy seam	2	10
17.	Not seen	11	0
18.	Limestone	2	0

(See Map XI., No. 31.)

Another geological section was obtained on the same run, in the same section, showing the lower coal, as below:

		Ft.	In.
1.	Sandy shale	12	0
2.	Limestone, partly cement stone	7	0
3.	Shale	2	0
4.	Coal, lower Salem, or Pomeroy seam	2	10
5.	Not seen	11	0
6.	Limestone (not measured).		

The coal is opened at several points on Wingett's Run. The dip is probably from thirty to forty feet per mile to the south, but the exact direction of the greatest dip was not ascertained. From all the measurements of the upper, or Cumberland, seam of coal on Wingett's Run, it appears to be thinner and of less importance than in the townships to the west.

At Bloomfield, in section 21, the following geological section shows the lower Salem, or Pomeroy seam:

		Ft.	In.
1.	Sandrock	20	0
2.	Shale	3	0
3.	Limestone, some of it cement stone	8	0
4.	Shale	3	0
5.	Coal	1	2

(See Map XI., No. 34.)

Here the lower coal is thinner than on Wingett's Run.

GRANDVIEW TOWNSHIP.

This township lies upon the Ohio River, above Independence, and extends to the Monroe county line. The drainage is chiefly into the Ohio River by small tributaries, although a small area on the western and north-western part is drained by branches of the Little Muskingum. It has a long stretch of frontage on the Ohio River, and, consequently, contains much fertile land. Back from the river the land is quite hilly.

The geological features are quite similar to those of Independence township, with similar sandstones and shales, and with traces of the upper coals.

On the land of C. W. Talbot, section 8, a geological section was taken:

		Ft.	In.
1.	Sandrock	23	0
2.	Shale	9	0
3.	Coal	1	2
4.	Slate, with streaks of coal	2	10
5.	Coal	1	0
6.	Not exposed	150	0
7.	Blossom of coal.		
8.	Not exposed	18	0
9.	White and buff limestone (not measured).		
10.	Hard, greenish, flinty sandstone	3	0
11.	Interval to Ohio River	65	0

(See Map XI., No. 35.)

If the coal—No. 7 of the section, of which only the blossom was seen—is the Hobson seam, then the upper coal, one hundred and fifty feet higher, is the equivalent of one of the seams found in Monroe county. There should be another seam between, but the intervening strata were not exposed. It may not, however, exist here. If No. 7 is the outcrop of the Cumberland seam, then the upper seam is the equivalent of a seam found in Jackson and Benton townships, in Monroe county. The latter is the more probable grouping.

JOLLY TOWNSHIP.

This is a small township, situated directly north of Grandview, and adjoins Monroe county. It is hilly and broken. It is drained by small streams flowing directly into the Ohio River. The mineral resources of this township are quite limited, so far as could be learned. The only place where coal was seen was on the land of Eli Eddy, in section 11. The following section was taken at this point:

		Ft.	In.
1.	Sandstone	7	0
2.	Shales	7	0
3.	Coal, upper part slaty	3	6

(See Map XI., No. 36.)

The stratigraphical position of this coal, as given on the map, is perhaps not the true one, it being very difficult to decide its true place without more time than could be devoted to the work. The same seam will be found through the region in its proper geological horizon. We visited the only exposure that we could hear of.

CHAPTER LII.

REPORT ON THE GEOLOGY OF NOBLE COUNTY.

This county is quite irregular in outline. It is bounded on the north by Guernsey, on the east by Belmont and Monroe, on the south by Washington, and on the west by Morgan and Muskingum. The southern part of the county is drained by the waters of Duck Creek, which flows south to meet the Ohio at Marietta, and the northern part by the waters of Will's Creek, which flows northward and empties into the Muskingum. The soil in the valleys is generally rich and productive, and in many townships are abundant limestones, which greatly enrich the soil of the hill-sides.

The county lies wholly within the Coal Measures, and is rich in coal. The high lands almost every where contain the upper Salem, or Cumberland seam, and the Cambridge seam is known to exist beneath the surface in fine development in the northern part of the county. Some excellent iron ores have been found at different points. Brine for the manufacture of salt will be found almost every where by boring, and salt can be made cheaply with the small and refuse coals of the mines. Petroleum in considerable quantities has been obtained in the southern part of the county. Now that a railroad has been constructed through the Duck Creek valley, we may hope for a large increase of production of oil whenever the price will render production remunerative. The Marietta, Pittsburgh and Cleveland Railroad, extending through the whole length of the county from south to north, is destined to prove of incalculable benefit to the people of the county by aiding the development of their vast mineral resources.

BROOKFIELD TOWNSHIP.

This township lies in the north-west corner of the county. The land is generally high, and the water drains in several directions. In the north-west part the streams flow northward into Will's Creek, on the east they flow into Duck Creek, and in the south-western part into a tributary of the Muskingum. The high lands are unusually rich and fertile, from the abundant limestone.

The Cumberland seam of coal seen at Cumberland, in Guernsey county, a little north of the Brookfield township line, has been traced into Muskingum county, where its relations to the Pomeroy seam are ascertained. This appears on Map No. X., accompanying Vol. I. of the final report of our survey.

A mile south of the village of Cumberland we find, in Brookfield township, the Cumberland seam of coal at the mines of H. C. Hunter, Esq. In the hills south or south-east from these mines a section was taken, revealing the limestones and other strata above the coal. Other sections were taken to the east of Cumberland, showing the strata for two hundred and thirty-five feet below the coal. In a south-east direction from Cumberland the coal seam was found for three miles to rise at about the rate of thirty feet per mile. The full section taken near the north line of Brookfield township and in that vicinity is as follows:

		Ft.	In.
1.	Limestone	2	0
2.	Not exposed	19	0
3.	Limestone	1	6
4.	Not exposed	10	0
5.	Limestone	1	0
6.	Shale	15	0
7.	Limestones and shales	25	0
8.	Not exposed	10	0
9.	Sandstone	10	0
10.	Shale	10	0
11.	Coal	1	6
12.	Slate parting, one-half inch.		
13.	Coal	1	2
14.	Slate parting, one-half inch.		
15.	Coal	1	10
16.	Not seen	3	0
17.	Limestone	2	0
18.	Not exposed	31	0
19.	Sandstone of good quality, quarried	15	0
20.	Not exposed	30	0
21.	Buff limestone	1	6
22.	Not exposed	15	0
23.	Coal blossom.		
24.	Interval to Ames limestone	136	0
	(See Map XII., No. 7.)		

Four samples of coal were taken from the Hunter bank for analysis—No. 1 from near the bottom, No. 2 from upper part of the lower bench, No. 3 from middle bench, and No. 4 from top bench.

	No. 1.	No. 2.	No. 3.	No. 4.
Specific gravity	1.451	1.440	1.372	1.393
Moisture	1.80	2.20	1.90	1.90
Ash	14.00	7.60	11.00	16.50
Volatile combustible matter	32.60	34.40	34.10	32.10
Fixed carbon	51.60	55.80	53.00	49.50
	100.00	100.00	100.00	100.00
Sulphur	10.24	6.94	4.66	4.11
" left in coke	Not deter.	4.06	Not deter.	Not deter.
Per cent. of sulphur in coke	"	6.43	"	"
Permanent gas per pound in cubic feet	3.26	3.18	3.26	3.18
Color of ash	Fawn.	Fawn.	Gray.	Gray.
Character of coke	Compact.	Comp't.	Comp't.	Comp't.

The coal has too much sulphur and too large ash to be a first-class fuel.

SHARON TOWNSHIP.

This township lies south of Brookfield, and borders Morgan county on the west. It is chiefly drained by the waters of Olive Green Creek. There is considerable limestone in the hills, and the soil is generally good. The Cumberland seam of coal is found in the high hills. In section 1 the following geological section was taken:

		Ft.	In.
1.	Limestone	0	10
2.	Not exposed	30	0
3.	Coal, reported	3	6
4.	Not exposed	36	0
5.	Sandstone, quarried for buildings	10	0
6.	Not exposed	57	0
7.	Sandstone	2	0
8.	Not exposed	5	0
9.	Impure limestone, with clay	4	0
10.	Hard limestone, burned for lime	6	0
11.	Chiefly red shales	36	0
12.	Limestone	1	6

(See Map XII., No. 18.)

The coal is quite high in the hill, and had formerly been mined at this point. All the higher hills should take the coal. By barometer the height of the coal above Caldwell is about three hundred and forty feet. From Sharon the coal dips pretty rapidly to the south, reaching the Muskingum River at Coal Run; but to the east there is very little dip.

JACKSON TOWNSHIP.

This township is situated in the south-west corner of the county, and borders Washington county on the south and Morgan county on the west.

There is in this township, as in others to the north and north-west, considerable limestone in the hills, giving fertility to the soil. The coal of the Cumberland seam is found throughout this township, but it is not generally as thick as at points farther east. It is, however, well developed in some portions of the township. Going west or south-west from Newburg, we find the summit at the cross-roads about three hundred and seventy-five feet, by barometer, above the level of the Duck Creek bridge. A geological section in that neighborhood gives the following strata:

		Ft.	In.
1.	Summit at cross-roads.		
2.	Not exposed	67	0
3.	Limestone, with one layer of porous, buff color	6	0
4.	Sandstones and shales	53	0
5.	Coal, Cumberland seam	0	4
6.	Clay, "	2	0
7.	Coal "	3	6
8.	Sandstones and shales	70	0
9.	Limestone group, partly buff (not measured).		

The place of the Pittsburgh, or Pomeroy seam of coal, is below the limestone group—No. 9 of the section—but no trace of it was there seen. The Cumberland seam has been opened on the land of John McGuire, who, at the time of my visit, some years since, was mining about two hundred bushels a day for the supply of oil and salt works in the valley. At Kieth's Mills, section 18, the coal is found to have rapidly dipped to the south and south-west. Here the coal is three and a half feet thick, and about forty feet above the bed of Olive Green Creek. Twenty-four feet above the coal, three feet of buff limestone were seen. The coal is mined to a considerable extent for local use. On the land of William Taylor, section 15, the coal is six feet two inches, a fine development. On Big Run, six miles above its mouth, Jacob Cassel has obtained coal by stripping, and reports it from five to six feet thick. Further down, on section 26, the coal is only three feet to three and a half feet thick. The dip of the coal is about equal to the fall of the stream from Mr. Cassel's down to its mouth. About two miles above the Muskingum the limestones over the coal mostly disappear, and are replaced by a heavy sandrock.

OLIVE TOWNSHIP.

This township lies north of Jackson and east of Sharon. It is traversed by Duck Creek, and contains a large area of rich valley land. Caldwell, the county seat, is near the northern line of the township. The Cumberland seam of coal is found on all the high hills, but generally somewhat remote from the valley of Duck Creek.

On the land of Leonard McKee, near the east line of the township, we find the coal with two deposits of limestone above it. The section is as follows:

		Ft.	In.
1.	Group of limestone layers (not measured).		
2.	Not exposed	25	0
3.	Limestone	2 ?	
4.	Coal	0	8
5.	Clay	1	3
6.	Coal, Cumberland seam	5	0

The coal is, by barometer, a little over three hundred feet above the Duck Creek bridge at Newburg. The coal is well developed in all the hills east of Newburg, and east of Macksburg, but is reported as less thick on the highlands west of Duck Creek. On the hill west of Mr. Fulton Caldwell's, on the land of Mr. Aranda Woodford, the same seam of coal is reported to be three feet thick.

Here, by barometer, the coal is two hundred and ninety-five feet above Blake's bridge. Above the coal, perhaps sixty or seventy feet, is the usual group of buff and blue limestones.

The summit of the hill on the road near Wm. Goochnour's, two and one-half miles south-west of Blake's bridge, was found, by barometer, to be four hundred and twenty feet high. On the summit are shales, below which is a layer of iron ore, perhaps three inches thick. Below this, ten feet of red shales, succeeded by twelve and a half feet of limestones, interstratified with shale.

On the land of Mr. Caldwell, about a mile below his house, we find fifty feet of sandy shales, forming cliffs along the bank of Duck Creek. These shales rise to the north, and underneath them appears a stratum of limestone a foot or more thick, highly fossiliferous, which for some miles rises faster than the stream. At a point once called "Soak'em" it is more than fifty feet above the creek. Seven feet underneath the limestone is a thin seam of coal. A geological section at this point is as follows:

		Ft.	In.
1.	Sandy shales (not measured).		
2.	Fossiliferous limestone, Cambridge limestone	1	0
3.	Black shale, fossiliferous	7	0
4.	Coal	1	0
5.	Clay shales—yellow above, red below	22	0
6.	Clay, with nodular limestone	8	0
7.	Shale	15	0

Bed of Duck Creek. (See Map. XII., No. 30.)

This fossiliferous limestone is, I have no doubt, the Cambridge limestone, and is nowhere to be seen in the valley of Duck Creek south of

Olive township, it having dipped below the surface. It is brought to the surface again in the center of the Newell's Run uplift, in Newport township, Washington county. It has a very wide range through the Second Geological District. There aré two seams of coal which often accompany it, one a little above and the other a little below. Sometimes we find only one of these, but the regularity of the limestone and its parallelism with the leading seams of coal in the district are to be attributed to its relation to these two proximate seams of coal. Its regular position in the stratigraphical series is rather a borrowed one from the seams of coal. Being thus regular it forms a good datum line for stratigraphical measurements.

This limestone is seen at many points in the valleys in Olive township. A mile, perhaps, east of Caldwell it is in a double form, as follows:

		Ft.	In.
1.	Shale	6	0
2.	Gray fossiliferous limestone	0	10
3.	Sandstone	0	10
4.	Blue clay shale	1	3
5.	Blue fossiliferous limestone	0	8
6.	Blue calcareous shale	6	0
7.	Coal	0	4
8.	Underclay	2	0

Below Caldwell comes in a stratum of sandrock ten feet thick, which is quarried for building purposes. This is below the limestone. In the bank of a stream west of Caldwell, on the farm of Hon. A. Simmons, we find some limestones and shales, with a little iron ore. The section is as follows:

		Ft.	In.
1.	Limestone, with interstratified clays	12	0
2.	Red clay shale	9	0
3.	Nodular siderite ore	0	4
4.	Reddish clay shale, with scattered nodules of ore	10	0
	Bed of stream.		

Nothing was seen in this township of the Pomeroy seam of coal, the place of which is about ninety feet below the Cumberland seam.

At the village of Olive a salt well was bored in 1814, which, in its outbursts of gas and outflow of petroleum, presented phenomena of great interest, attracting no little attention. Dr. Hildreth, in the Geological Report for 1838, writes that "the discharges of gas are tremendous, throwing the water all out of the well to the height of thirty or forty feet. These eruptions are attended by a flow of petroleum, which for the first few years amounted to from thirty to sixty gallons at each paroxysm, and returning at intervals of from two to four days. They are now less frequent, and the discharge of petroleum is about a barrel a week." During the oil excitement from 1860 to 1865, the history of this well was often quoted in proof of the great value of this district as oil territory. No good wells have as yet been obtained in the neighborhood.

At South Olive is a small salt furnace, where a small quantity of salt is made from brine obtained from a well three hundred and twenty feet deep. A sample of the brine was obtained and taken to Columbus for analysis, but before the analysis could be made the brine had been changed by evaporation and other causes so as to make any exact determination of the original impossible. An analysis of the salt from the Olive works will be found in another part of the report, with other similar analyses.

NOBLE TOWNSHIP.

This township lies east of Brookfield and north of Olive. It is drained by the head-waters of the West Fork of Duck Creek. The fossiliferous limestone, with a thin coal below it, seen in the neighborhood of Caldwell, can be traced along the valley through this township. Near Mr. Jennings's store the following section was taken:

		Ft.	In.
1.	Yellow clay shale	15	0
2.	Dark blue clay shale, with nodules of iron ore	12	0
3.	Dark blue sandy fossiliferous limestone	4	0
4.	Coal	1	0
5.	Clay and clay shale	15	0

In the hills west a fossiliferous limestone was seen, which, by barometer, is about ninety feet above the coal in the above section. As the Cumberland seam of coal is something more than three hundred feet above the lower limestone, there are probably few hills in the township high enough to contain the coal. There may, however, be some; but no search was made for them. The lower coal is in some places thicker than at Mr. Jennings's, and it has been mined a little for local use. On a branch of Duck Creek, in the western part of the township, there is a local thickening of the seam, reaching, as reported, from four to five feet. Near the Hiramsburg Station, on the land of Mr. Gorby, we find the same fossiliferous limestone seen further south, with a thin coal above it, and some earthy iron ore. The section taken in a cut of the railroad, just above the station, is as follows:

		Ft.	In.
1.	Shales (not measured).		
2.	Earthy siderite ore, fossiliferous, from 6 inches to 3 feet.		
3.	Clay shale, fossiliferous	0	6
4.	Coal	1	4
5.	Clay and shale, not well seen	10	0
6.	Limestone, fossiliferous and ferruginous	1	6

(Map XII., No. 26.)

A sample of the ore was analyzed by Prof. Wormley, with the following result:

Water	5.00
Silicious matter	26.75
Sesquioxide of iron	11.30
Carbonate of iron	13.31
Alumina	0.80
Manganese	Trace.
Lime, phosphate	0.52
Lime, carbonate	37.30
Magnesia, carbonate	4.57
Sulphur	0.23
	99.78
Metallic iron	14.34
Phosphoric acid	0.32

Between Hiramsburg Station and Ava Station Col. Teeters, of Caldwell, to whom I am indebted for much intelligent aid, found some ore (but not, I think, in place) of a much better quality, as seen by the following analysis:

Water	12.85
Silicious matter, etc.	20.04
Sesquioxide of iron	58.27
Alumina	Trace.
Manganese	5.80
Phosphate of lime	1.30
Carbonate of lime	0.14
Carbonate of magnesia	1.21
Sulphur	0.10
	99.71
Metallic iron	41.78
Phosphoric acid	0.60

The percentage of phosphorus is not large, and the amount of metallic iron is considerable. The manganese would make the ore valuable for certain uses. Those interested should ascertain whether there is an available quantity of this ore.

At Ava Station the same fossiliferous limestone, so often referred to, was seen. At this place a test well was bored to reach the Cambridge coal, which was, by report, found about one hundred and twenty-five feet below the horizon of the limestone. The thickness of the seam was given as six feet six inches. This is the proper place for the Cambridge seam, and finding the coal verifies the conclusion previously reached from other data, that the fossiliferous limestone is the equivalent of the Cambridge limestone, which, in the vicinity of Cambridge, is about one hundred and twenty-five feet above the Cambridge coal. The existence of the Cambridge seam at Ava is a fact of the highest importance. It can be easily reached by shafts. From this point this very valuable seam will doubtless be found to extend under all the high ground to the north, which divides the waters of Duck Creek from those of Wills Creek. This gives an extensive coal field, bordering the railroad, and tributary to it, reaching from Ava to Cambridge.

BUFFALO TOWNSHIP.

This township borders Guernsey county, and has its principal drainage northward by means of branches of Wills Creek. Its south-western portion is upon the southern slope of the divide, and is watered by the head branches of the West Fork of Duck Creek. The Marietta, Pittsburgh, and Cincinnati Railroad passes through the divide between the two streams by means of a tunnel. The hills in Buffalo township are probably not high enough to take the Cumberland seam of coal, and in this region the Pomeroy seam has a slight development. The soil of the township is rich from the limestone in the hills. At the "Notch," where the railroad leaves the Duck Creek waters, the following strata were seen:

		Ft.	In.
1.	Sandstone (not measured).		
2.	Limestone	2	0
3.	Not seen	20	0
4.	Limestone	0	10
5.	Not seen	6	0
6.	Nodular limestone	5	0
7.	Not seen	25	0
8.	Blue fossiliferous shale, with nodules of siderite ore	20	0
9.	Not seen	2	6
10.	Blue fire-clay	10	0
11.	Ferruginous limestone, fossiliferous (Cambridge limestone)	2	0
	Bed of stream. (Map XII., No. 23.)		

I have no doubt that the limestone at the bottom of this section is the equivalent of the Cambridge limestone and of the fossiliferous limestone at Ava Station. This would give us the Cambridge seam of coal at a depth of about one hundred and twenty-five feet below the valley at the "Notch." At Ava Station the boring revealed the Cambridge coal, six feet six inches thick, one hundred and twenty-five feet below the limestone. We may justly infer that this fine seam extends under Buffalo township. This will give great value to the lands bordering the railroad.

It must be remembered that the larger part of the coal of the world is mined by means of shafts, sunk, often, to great depths. Here the sinking of shafts would involve comparatively little expense, and the coal could be brought to the surface directly upon the railroad. All the land would be underlain by the coal, thus saving a large area of coal which, when coal seams are in the hills, is lost from the erosion of the valleys.

SENECA TOWNSHIP.

This township of excellent land is situated in the northern part of the county, having Wayne township on the north and Buffalo on the west. Its north-west corner touches Guernsey county. It is drained by Wills Creek and its branches. A geological section was taken two miles west of Mt. Ephraim, which revealed the position of the coals and limestones. In no case were the coal seams opened so as to admit of measurement. The section is as follows:

		Ft.	In.
1.	Group of limestones	30	0
2.	Not exposed	72	0
3.	Blossom of coal (Cumberland seam).		
4.	Not exposed	4	0
5.	Limestone	2	0
6.	Not exposed	18	0
7.	Coal, not opened (10 inches seen)	0	10 ?
8.	Not exposed	60	0
9.	Dark blue limestone, laminated, containing small bivalve shells and coal plants	1	6
10.	Not exposed	18	0
11.	Blossom of coal.		
12.	Not exposed	75	0
13.	Fossiliferous limestone	1	0
14.	Not exposed	17	0
15.	Limestone, bluish	1	0
16.	Not seen	46	0
17.	Fossiliferous limestone (Ames or Salesville seam) (Map XII., No. 3.)	2	0

In section 33, in this township, the following section was taken:

		Ft.	In.
1.	Hard sandstone	13	0
2.	Blossom of coal.		
3.	Underclay	5	0
4.	Limestone	1	6
5.	Not seen	4	0
6.	Limestone and clay	7	0
7.	Clay	6	0
8.	Limestone	1	0
9.	Not seen	9	0
10.	Limestone	0	8

		Ft.	In.
11.	Clay	3	0
12.	Sandstone	2	0
13.	Not seen	6	0
14.	Limestone	0	10
15.	Red shale	14	0
16.	Limestone	1	0
17.	Not seen	15	0
18.	Compact sandstone	30	0
19.	Shale	1	0
20.	Slaty coal	1	6
21.	Clay	0	11
22.	Coal, with two 1-inch partings, Cumberland seam	3	6
23.	Clay	2	0
24.	Not seen	18	0
25.	Limestone	2	0
26.	Not seen	14	0
27.	Sandstone	12	0
28.	Not seen	82	0
29.	Limestone	2	0

(Map XII., No. 19.)

On the northern slope of the ridge between Seneca and Wills Creeks the following section was taken, revealing considerable cement limestone:

		Ft.	In.
1.	Sandy shale	8	0
2.	Not seen	54	0
3.	Shale	6	0
4.	Nodular limestone	0	8
5.	Shale	2	0
6.	Limestone	0	10
7.	Shale	14	0
8.	Not seen	14	0
9.	Coal (Cumberland seam) seen on north slope of hill.		
10.	Not seen	59	0
11.	Laminated sandstone	3	0
12.	Black slate and shale	1	0
13.	Limestone	0	8
14.	Cement limestone	4	0
15.	Shale	0	4
16.	Cement limestone	3	0
17.	Bluish limestone	3	0
18.	Not seen	77	0
19.	Flagging sandstone	4	0
20.	Shale and black slate	6	0
21.	Clay	3	0
22.	Limestone	6	0

(Map XII., No. 28.)

The coal in the above section is the "Upper Barnesville," or Cumberland seam. No measurement was made, but in this region it ought to be found thick enough for working. The cement limestones are promising. The distance from the railroad would probably make the manufacture of cement lime unprofitable at present.

Whether the Cambridge seam of coal exists in full thickness below the surface in this township, can only be known by trial borings. Such borings would not be expensive if located in the deeper valleys. The place of the Cambridge seam is proximately five hundred and ten to five hundred and twenty feet below the Cumberland seam, or two hundred and ten to two hundred and twenty below the Ames fossiliferous limestone. This limestone is seen in the township. It is about three hundred and twenty feet below the Cumberland seam of coal.

WAYNE TOWNSHIP.

This township lies on the northern border of the county. Wills Creek flows through the township in a north-west direction. The soil is generally most excellent. Probably few of the hills are high enough to take the Cumberland seam of coal, and the Cambridge seam is below the bed of Wills Creek.

A section taken near Kennonsburg shows the following limestones:

		Ft.	In.
1.	Heavy limestone in layers	18	0
2.	Not exposed	27	0
3.	White limestone	2	0
4.	Not exposed	80	0
5.	Fossiliferous limestone, Ames limestone	2	0
	(See Map XII., No. 24.)		

The relations of the Ames limestone both to the Pomeroy and Cumberland seams may be seen from Map XII., as also its relations to the Cambridge seam, which is below. There are some seams of coal which are elsewhere found in the geological range of the vertical space in the above section, but they are always thin.

BEAVER TOWNSHIP.

This is the north-eastern township of the county, and is one of the richest in agricultural resources. Its valleys are very fertile and very beautiful. The hills abound in limestone, and many of the shales are rich in lime.

On the land of Mr. Hastings, section 15, a geological section was taken, revealing the position of the coals, limestones, etc. It is as follows:

		Ft.	In.
1.	Buff limestone	1	0
2.	Shale	3	0
3.	Buff limestone	0	6
4.	Shale	27	0
5.	Blossom of coal, Cumberland seam, reported	1	8
6.	Shale	14	0
7.	Sandstone	2	0
8.	Shale	4	0
9.	Blossom of coal, reported	1	6
10.	Shale, and not exposed	60	0
11.	Sandstone	5	0
12.	Not exposed	12	0
13.	Limestone	3	0

(See Map XII., No. 27.)

The coal No. 5 of the above section is the same as the Cumberland seam, or the "Upper Barnesville" seam.

On the land of Mr. Bascom, section 16, the same seam measures four feet six inches, with one inch clay parting eighteen inches from the bottom.

Near Williamsburg a section was taken which is given in No. 22 of Map. XII. The coal is that of the Cumberland, or "Upper Barnesville" seam.

Another and more interesting section was taken two miles north of Williamsburg. It shows the place of a cement limestone:

		Ft.	In.
1.	Buff limestone and clay	5	0
2.	Clay shale	8	0
3.	Not seen	25	0
4.	Laminated sandstone	30	0
5.	Not seen	14	0
6.	Sandstone	10	0
7.	Coal	1	0
8.	Shale	1	6
9.	Coal, Cumberland seam	4	6
10.	Not seen	24	0
11.	Clay shale	1	0
12.	Coal	0	5
13.	Clay	0	4
14.	Coal	0	6
15.	Shale	0	5
16.	Cement limestone	3	0
17.	Shaly limestone	0	3
18.	Cement limestone	2	0

(See Map XII., No. 25.)

The cement limestone would doubtless answer for making cement—at least it is worthy of trial. It is too far from the railroad for profitable working, but it will be needed at some future day. The coal is of fair quality.

CENTER TOWNSHIP.

This township is situated east of Noble and north of Olive and Enoch townships. It is drained on the south by the tributaries of the east and west forks of Duck Creek, and on the north by one of the branches of Wills Creek. Much of the soil is excellent. The principal coal is of the Cumberland seam, which is every where to be found at its proper elevation in the hills. The following section was taken in section 13, in this township:

		Ft.	In.
1.	Blossom of coal.		
2.	Not exposed	53	0
3.	Limestone	2	0
4.	Not exposed	30	0
5.	Sandstone	14	0
6.	Shale	6	0
7.	Coal, Cumberland seam	2	0
8.	Clay, " "	2	0
9.	Coal, " "	0	6
10.	Slate, " "	0	1
11.	Coal, " "	3	0
12.	Not exposed	36	0
13.	Heavy sandstone	15	0
14.	Not exposed	13	0
15.	Sandstone	4	0
16.	Magnesian limestone	2	0

(See Map XII., No. 21.)

In section 20 in this township, on the land of G. W. Brown, the same seam of coal presents the following measurement:

		Ft.	In.
1.	Fire-clay	1	0
2.	Coal, with one half-inch parting	4	4
3.	Underclay	3	0

The coal is of fair quality.

MARION TOWNSHIP.

This township lies east of Centre and Seneca townships. Its northern border is upon Wills Creek, and its south-western upon Duck Creek. It is hilly, but the soil is generally good. In some of the valleys receiving the wash of the limestone of the hills the soil is most fertile.

The Cumberland seam of coal is to be found in the high hills in its proper horizon. On the land of Mr. H. McVicker, section 30, the following measurements were made:

		Ft.	In.
1.	Yellow shale	10	0
2.	Coal	2	0
3.	Shale	1	8
4.	Coal, with four inches slaty in middle	4	6
5.	Interval to creek	250	0

A little below the coal is a limestone of a highly soluble nature, which has a great fertilizing effect upon the soil.

ENOCH TOWNSHIP.

This township lies east of Olive and south of Centre townships. It is drained by Middle Creek chiefly. Much of the soil is of good quality, and the township is well supplied with coal of the Cumberland seam. This seam is found almost every where in the hill at its proper horizon. At Archer's Store, section 6, we find the coal presenting the following subdivisions:

		Ft.	In.
1.	Sandstone	1	6
2.	Bituminous shale	1	3
3.	Coal	1	8
4.	Clay	1	3
5.	Coal	2	8
6.	Slate	0	1
7.	Coal	1	0
8.	Underclay	2	0

(See Map XII., No. 29.)

On the land of John Boyd the same seam of coal is five feet thick below the clay parting. Considerable limestone is seen in the hill above Mr. Boyd's coal.

The mines of the Ohio Coal Company, in the hills east of Dexter Station, show a fine thickness of the Cumberland seam. The reported section is as follows:

		Ft.	In.
1.	Limestone and interstratified shales	30	0
2.	Sandstone and some shale	25	0
3.	Coal, upper bench, reported	3	0
4.	Clay	2 to 3	0
5.	Coal, lower beach	6 to 7	0

The coal from this company's bank is shipped largely to Marietta, where it is used for the rolling mill, for the generation of steam, and for domestic purposes. It is a cementing coal of good heating power. Coke of superior strength and hardness can be made from it. By a proper selection of the materials, and by proper methods of coking, it is quite probable that a coke of sufficient freedom from sulphur may be obtained. The firmest coke I have yet seen made from Ohio coal was produced from the coal of the Ohio Coal Company's mine.

The heavy limestone twenty-five feet above the coal is an important deposit.

STOCK TOWNSHIP.

This township lies east of Enoch, and borders the Monroe county line. The East Fork of Duck Creek passes nearly through the middle of the township. This township, like almost all in this county, is hilly, but there is limestone enough to fertilize the soil and make it productive. In its geological features the township presents no peculiarities. It contains in its hills the Cumberland seam of coal, generally in good development. A combined geological section, taken near Carlisle (the section of the coal from the land of J. G. J. Smith, section 35, and the lower limestones from the land of Reuben Yoho, one-half mile west of Carlisle), is as follows:

		Ft.	In.
1.	Clay	1	6
2.	Coal	3	3
3.	Slate	0	½
4.	Coal	2	5
5.	Not exposed	80	0
6.	Limestone	3	0
7.	Shale chiefly	32	0
8.	Sandstone	8	0
9.	Shale	1	0
10.	Limestone	1	6
11.	Shale	5	0
12.	Limestone	4	0
13.	Shale	5	0

(Map XII., No. 31.)

On the land of Mr. Smith nodules of excellent iron ore were seen one hundred and thirty-five feet below the coal. These nodules are generally rich in iron, but they are seldom found in sufficient quantity to warrant drifting for them. The coal is in fine thickness, and the slate parting is quite insignificant. The quality is fair. On the farm of A. Enochs, section 36, the coal is opened and appears well. Some ore of very superior quality was also seen on his farm. The ore was not found in place, but its stratigraphical position cannot be far from that assigned it in the following section:

		Ft.	In.
1.	Coal, Cumberland seam	4	10
2.	Interval not exposed	102	0
3.	Iron ore	0	6?
4.	Red shale	15	0
5.	Sandstone chiefly	17	0
6.	Shale	8	0
7.	Limestone	2	0

(Map XII., No. 32.)

The ore is a sesquioxide of iron but slightly hydrated, the combined water being only 4.60 per cent. The following is the analysis of the ore by Prof. Wormley:

Water	4.60
Silica	10.76
Sesquioxide of iron	80.51
Alumina	1.20
Magnesia	1.30
Lime	1.30
Phosphoric acid	Trace.
Sulphur	0.0
Total	99.67
Metallic iron	56.36

The ore is rich in iron, and its remarkable freedom from phosphorus and sulphur makes it the best possible material for an iron for conversion into steel. The location is worthy of careful investigation to determine the quantity of ore. In the slide of the hill-side were large, laminated blocks of ore six inches thick. When the ore is traced to its original stratum it may be found much thicker. It is an ore of very great promise. The coal of W. C. Bevan, section 26, is the Cumberland seam. The lower bench is reported to be four feet thick, and the upper one foot eight inches.

On the land of W. W. Collins, below Carlisle, the Cumberland seam of coal is two hundred and twenty feet above the East Fork of Duck Creek. The lower bench is about five feet thick, separated from the upper bench of ten inches by two feet of clay. A sample from the lower bench was analyzed by Prof. Wormley, with the following result:

Specific gravity	1.338
Moisture	1.10
Ash	11.30

Volatile combustible matter	35.50
Fixed carbon	52.10
Total	100.00
Sulphur	6.61
Permanent gas per pound in cubic feet	3.26
Ash	Fawn color.
Coke	Compact.

The seam of coal from Mr. Collins's dips rapidly down the East Fork of Duck Creek. A mile above the mouth of Road Fork the seam is only twenty-five to thirty feet above the stream, while three-fourths of a mile up Road Fork the seam is ninety feet above the latter stream. These facts show local undulations in the strata.

ELK TOWNSHIP.

This is the south-eastern township of the county. It lies chiefly upon the waters of the East Fork of Duck Creek, but in the southern part are some of the sources of Pawpaw Creek. The land is generally hilly, but the limestone layers in almost all the hills tend to render the soil fertile. The principal seam of coal is the Cumberland seam, which is every where to be found in its appropriate geological horizon. In section 25 the following geological section was taken:

		Ft.	In.
1.	Blossom of coal.		
2.	Not exposed	15	0
3.	Limestone	1	6
4.	Not exposed	22	0
5.	White limestone	3	0
6.	Not exposed	48	0
7.	Sandstone and sandy shale, somewhat ferruginous	12	0
8.	Blue, sandy shale	2	0
9.	Coal, Cumberland seam	2	0
10.	Clay, " "	1	8
11.	Coal, " "	3	6
12.	Underclay	5	0
13.	Limestone	2	0
14.	Not exposed	53	0
15.	Magnesian and blue limestones	5	0

(Map XII., No. 36.)

On the land of Lewis Uhlman, near Harrietsville, the same seam of coal appears in the following section:

		Ft.	In.
1.	Sandy shale	5	0
2.	Coal	2	3
3.	Clay	0	10

		Ft.	In.
4.	Coal	3	0
5.	Not exposed	60	0
6.	Buff and blue limestones	6	0
7.	Not exposed	40	0
8.	Sandrock	20	0
9.	Interval to Duck Creek	60	0

(Map XII., No. 35.)

On the land of Henry Bodie, section 18, in this township, the same seam of coal gives the following measurements:

		Ft.	In.
1.	Sandy, blue shale (not measured).		
2.	Coal	2	4
3.	Clay shale	1	6
4.	Coal	3	0
5.	Not exposed	5	0
6.	Limestone (not measured).		

Bed of Saltpetre Creek.

The coal is generally of fair quality, and will answer for all the ordinary uses, but it contains too much sulphur for the highest uses.

On the land of Edward Okey, on Road Fork, in this township, the Cumberland seam of coal is seen, with a thickness of the lower bench of four feet eight inches. Above the clay parting is the upper bench, from six inches to one foot thick. Six feet of shale separate this bench from twenty-five feet of overlying sandrock. The following analysis was made by Prof. Wormley of a sample of the coal of the lower bench:

Specific gravity	1.419
Moisture	1.10
Ash	10.20
Volatile combustible matter	32.90
Fixed carbon	55.80
Total	100.00
Sulphur	3.48
Permanent gas in cubic feet	3.01
Ash	Gray.
Coke	Compact.

On Road Fork, one mile below the woolen factory, we find the coal well developed, as is seen by the following section:

		Ft.	In.
1.	Sandstone	25	0
2.	Shale	5	0
3.	Coal, Cumberland seam	2	0

		Ft.	In.
4.	Clay, Cumberland seam	1	4
5.	Coal, " "	4	6
6.	Not seen	27	0
7.	Limestone	8	0
8.	Not seen	15	0
9.	Fine-grained sandstone	3	0
10.	Shale	8	0

(Map XII., No. 34.)

Mr. Richard Vosper, at the mouth of Road Fork, mines the Cumberland seam, which is reported to be four feet six inches thick.

JEFFERSON TOWNSHIP.

This township borders Washington county, lying north and east of Aurelius. Its outline is very irregular. The West Fork of Duck Creek flows through a corner of it, but it is chiefly drained by Middle Creek. The upper Salem, or Cumberland, seam of coal is found every where in the hills, in its proper horizon. Valuable mines have been opened by the Ohio Coal Company in the western part of the township, where the lower and principal bench of the coal is from five and a half to six feet thick, and the upper is reported to be three feet thick. A branch railroad extends from Macksburg east into this township, reaching this seam of coal, where a working of six feet is obtained. The coal is of good quality, well adapted to household use, to the generation of steam, and to the rolling mill. A fine exhibition of the same seam of coal is found on the land of David McKee, Esq , on Buffalo Run, east of Newburg, not far from the line dividing this township from Enoch township. Here the lower bench of coal measures six feet eight and a half inches. In this region the hills are very high, and there will be found a large area of available coal. The same seam is found in the eastern part of the township, but it may not be equally thick. In the valley of Middle Creek some petroleum has been obtained, although not in large quantities. This is a fertile valley.

Considerable petroleum has been obtained in the Duck Creek valley, in this township, and more will be obtained when the prices render the production profitable. Brine for the manufacture of salt may be obtained by boring, and cheap fuel for its evaporation is abundant in all the hills.

CHAPTER LIII.

REPORT ON THE GEOLOGY OF GUERNSEY COUNTY (SOUTH HALF).

That portion of this county included in the Second Geological District lies south of the Central Ohio Railroad. The townships examined are Adams, Westland, Spencer, Jackson, Cambridge, Center, Valley, Richland, and Millwood. The railroad runs within the southern border of Wills township, and a few geological sections were taken there.

The southern part of the county contains much good soil, and is rich in coal. The most valuable seam is the Cambridge seam, which is now largely mined. The Cumberland seam is found in some townships, as are one or two other seams of less importance. The existence of so much coal within easy reach of the Central Ohio, and the Marietta, Pittsburgh and Cleveland railroads will make this one of the most important mineral counties in the State. Some valuable iron ore has been discovered. Brine may be obtained by boring, and salt can be cheaply manufactured with the small and refuse coals of the mines. Both coal mines and salt works may be located upon the railroads. In this way the three essential elements of profitable salt-making, viz., abundant brine, cheap fuel, and cheap transportation, are secured. There is little doubt that some of the coal will, with proper treatment, make coke suitable for smelting iron ores. The rich Lake Superior ores could be brought as return freight in cars carrying coal to Cleveland or other lake ports, and the blackband ore is found within the limits of the county, and in the adjacent county of Tuscarawas. Iron works of various kinds must hereafter spring up in this region, as, indeed, other kinds of manufacturing enterprises in which cheap and abundant fuel is a prime element.

ADAMS TOWNSHIP.

This township lies on the west side of Guernsey county, and north of Westland township. It is drained by the waters of Crooked Creek, a branch of Wills Creek. A section was taken on the land of Horatio Grummond, section 23, as follows:

		Ft.	In.
1.	Shale	8	0
2.	Cannel coal, reported thickness	1	6
3.	Not exposed	79	0
4.	Sandstone	3	0
5.	Shale and black slate, nodules of ore	6	0
6.	Coal, 3½ feet seen, reported	6	0

(See Map XII., No. 1.)

The lower coal of this section was thought to be the equivalent of the Cambridge seam, and the equivalent of the Alexander seam in Muskingum county. The coal was formerly mined on the farm of Mr. Grummond, but the old mine was not in a condition for complete measurement. The cannel coal, eighty-eight feet above, is in the horizon of a thin seam of coal seen at many points.

Near Cassell's Station, on the Central Ohio Railroad, section 22, the following section was taken:

		Ft.	In.
1.	Interval to top of hill not measured.		
2.	Fossiliferous limestone	15	0
3.	Not seen	110	0
4.	Sandstone	6	0
5.	Dark shale, ferruginous	3	0
6.	Blackband iron ore	3	0
7.	Coal (Cambridge seam)	3	6
8.	Not seen to level of railroad track	10	0

(See Map XII., No. 15.)

The following analysis of the blackband ore of the above section was made by Prof. Wormley:

Specific gravity	3.052
Water and volatile matter	11.55
Iron, carbonate	33.72
Iron, sesquioxide	8.34
Silicious matter	38.72
Alumina	00.00
Manganese	2.30
Lime, carbonate	2.30
Magnesia	2.49
Sulphur	0.16
Total	99.58
Metallic iron	22.12
Sulphur	0.16
Phosphoric acid	trace.

This ore, when roasted, will lose its water, volatile or bituminous matter, the carbonic acid of the carbonates of iron and lime, and all, or nearly all, of its slight amount of sulphur. There is hardly enough bituminous matter in this ore to serve as a fuel in roasting it. A sample of the blackband ore from Newcomerstown, obtained by Mr. Gilbert for comparison, yielded 24.00 per cent. of metallic iron. Both ores are very free from sulphur and phosphorus. From more recent visits to Cassell's Station, I am led to think the average of the blackband better than the sample analyzed.

CAMBRIDGE TOWNSHIP.

This township contains Cambridge, the county seat of the county. A section was taken on the high and isolated hill a little south-west of the town, as follows:

		Ft.	In.
1.	Blossom of coal.		
2.	Not exposed	15	0
3.	Fossiliferous limestone, seen	1	0
4.	Not exposed	10	0
5.	Laminated sandstone	7	0
6.	Shale	40	0
7.	Blossom of coal.		
8.	Clay	1	0
9.	Sandstone	15	0
10.	Shale	24	0
11.	Blossom of coal.		
12.	Clay	4	0
13.	Shale	36	0
14.	Limonite ore	0	2
15.	Blossom of coal.		

(See Map XII., No. 6.)

In this section No. 15 is the Cambridge, or Scott's coal; No. 11, the equivalent of a seam found forty-two feet above Scott's bank; No. 7, the equivalent of the cannel coal at Horatio Grummond's, in Adams township; and No. 1, the equivalent of the Anderson coal, near Campbell's Station. This section, therefore, is a key by which the intervals may be judged elsewhere. A section was taken on Tunnel Hill, west of Cambridge, from the highest coal, on the very summit, to the level of the railroad track. The exposures were chiefly in a slide in the hillside, in the approach to the tunnel on the west side of the hill:

		Ft.	In.
1.	Shale and soil	8	0
2.	Coal, seen	1	0
3.	Not seen	12	0
4.	Limestone, highly fossiliferous, reported	8	0

		Ft.	In.
5.	Not exposed	59	0
6.	Dark brown shale	20	0
7.	Yellow shale	10	0
8.	Sandstone passing down into shale	30	0
9.	Ore—siderite and limonite	0	7
10.	Nodular limestone	6	0
11.	Shale	5	0
12.	Laminated sandstone and shale	32	0
13.	Coal	1	3
14.	Fire-clay	3	0
15.	Shaly sandstone	10	0
	Level of railroad track.		

In this section the strata in the slide could not be measured, and the thickness was estimated. No trace of the Cambridge seam of coal was sen. A section was made in the village from the bed of Wills Creek, at the site of the old mill, up to a seam of coal in Mr. Isaac Morton's field, on the hill-side above, as follows:

		Ft.	In.
1.	Heavy, coarse sandstone, seen	10	0
2.	Coal, varying from 1 ft. 3 in. to	2	0
	Not all seen, but the lower part a very heavy sandrock, with vast concretionary masses of "blue core" rock	39	0
4.	Level of the railroad.		
5.	Interval to bed of creek, lower part shaly sandstone	27	0
6.	Coal, once mined by stripping in low water in Wills Creek (reported) (Map XII., No. 5.)	2	9

The upper coal in this section is believed to be the equivalent of the Cambridge coal, or Scott's coal. It is generally covered with shale. The same seam is found under the floor of the shop of Louis Schreier, on Main street. It has an elevation of thirty-seven feet above the railroad track at the station.

A level from this coal strikes a bench on Tunnel Hill a little above the tunnel. A trace of .coal was found on this bench. Every where in the immediate vicinity of the town of Cambridge the Cambridge seam is very thin, and this fact has created the chief difficulty in identification. Two or three miles south of Cambridge the seam becomes thick enough for mining, and presents in that region a fine development. In this neighborhood the following section was taken at the coal bank of Andrew Nicholson:

		Ft.	In.
1.	Sandstone	12	0
2.	Clay shale, laminated	4	6
3.	Coal	3	10
4.	Clay parting	0	1¼
5.	Coal	1	0
6.	Underclay	3	0

This is the Cambridge seam. The quality is seen from the following analyses by Prof. Wormley of samples from near the bottom, middle, and near the top:

Specific gravity	1.318	1.283	1.272
Water	4.20	3.90	3.80
Ash	6.10	3.80	3.00
Volatile combustible matter	31.60	29.70	34.70
Fixed carbon	58.10	62.60	58.50
	100 00	100.00	100.00
Sulphur	1.26	1.04	1.11
Sulphur left in coke	0.42	0.65	0.83
Cubic feet fixed gas per lb. coal	3.54	2.98	3.58
Color of ash	Gray.	Gray.	Yellow.
Coke	Compact.	Compact.	Compact.

This is an excellent coal. The average percentage of ash is 4.30. The average of the fixed carbon is 59.73, which is quite large. The sulphur is less than in the larger part of the coals of the State, the average being 1.13. Of this there remains in the coke 0.633. The coke is compact. The coal belongs to the caking variety, and requires a good draft for its best combustion. The coal is evidently a strong coal, of high heating power, and when burned under favorable conditions must do excellent service. It is the best representative of the Pittsburgh type of coal I have seen in the State. A section was made at the bank of Joseph Stoner, as follows:

		Ft.	In.
1.	Clay slate, with coal plants	10	0
2.	Coal	3	7
3.	Clay parting	0	2
4.	Coal	1	0
5.	Underclay	4	0

This coal resembles that at the Nicholson bank. In both banks the vertical joints, or polished planes, are numerous. This, however, is a characteristic of the Cambridge seam generally.

CENTER TOWNSHIP.

This township lies directly east of Cambridge. There are several mines opened in the Cambridge seam of coal in this township and in the eastern part of Cambridge. There was time to examine only a part of these. The coal is generally quite uniform in thickness and quality. The following section was taken on the land of Mr. E. M. Scott:

		Ft.	In.
1.	Limestone, fossiliferous	3	0
2.	Not exposed	88	0
3.	Coal, with shale roof	1 to	3

		Ft.	In.
4.	Not seen	26	0
5.	Laminated sandstone	6	0
6.	Clay slate	10	0
7.	Coal	4	7
8.	Clay parting	0	2
9.	Coal	1	4
10.	Underclay	2	6
11.	Sandy shale (not measured).		

(Map XII., No. 9.)

This coal is extensively mined by Mr. Scott, and shipped by the Central Ohio Railroad. It is used for household purposes, for steam-making, for locomotives, and in rolling mills. It is an excellent coal.

At the mining works of Fordyce & Co., about a mile west of the Scott bank, large quantities of this coal are mined and shipped by railroad, and considerable is made into coke in coke ovens. The Cambridge coal is always quite bituminous and somewhat caking in character. It is highly esteemed by those who prefer a coal of this class to the dry burning coals.

The following is a record of salt well No. 2, bored by Mr. Scott:

		Ft.	In.
1.	Level of the Cambridge seam.		
2.	Soil, etc.	18	0
3.	Gray sandrock	32	0
4.	Not known	10	0
5.	Coal	1	6
6.	Fire-clay	3	0
7.	Limestone	1	6
8.	Soapstone	6	0
9.	Shale and fire-clay	26	0
10.	Black slate	10	0
11.	Shale	12	0
12.	Coal	0	10
13.	Soapstone	40	0
14.	Coal	1	2
15.	White fire-clay	20	0
16.	Blue sandstone (oil rock)	44	0
17.	Black shale	31	0
18.	Limestone	0	11
19.	Shale	14	0
20.	Iron ore, very hard	1	6
21.	Shale	69	0
22.	Hard black rock	6	0
23.	Shale	83	0
24.	Stratum charged with sulphuret of iron	3	0
25.	Interval not recorded	215	7
26.	White sandrock	40	0

In this well salt water was found at the depth of five hundred and ninety feet, and again at six hundred and fifty feet. Mr. Scott's well No. 1 struck brine at the depth of one hundred and eighty feet and at six hundred and twenty feet.

A mile east of the Scott mines the Cambridge seam of coal is mined at the "Williams's bank" by a shaft. The coal seam is reported to be in the bed of Leatherwood Creek. The top of the shaft is upon the slope of the hill, high enough to secure easy delivery of the coal upon the railroad.

The following analyses were made by Prof. Wormley of four samples of coal from this mine, representing the seam as follows:

No. 1, 6 inches from top; No. 2, 1 foot 8 inches from bottom; No. 3, center of seam; No. 4, to 10 inches from bottom.

	No. 1.	No. 2.	No. 3.	No. 4.
Specific gravity	1.294	1.299	1.295	1.336
Water	2.50	3.10	3.00	3.00
Ash	4.34	7.32	6.99	3.98
Volatile combustible matter	31.59	27.90	32.69	35.60
Fixed carbon	61.57	61.68	57.37	57.42
	100.00	100.00	100.00	100.00
Sulphur	2.48	2.94	3.96	1.06

The coal from this mine is shipped somewhat exensively by the Central Ohio Railroad to different parts of the State. Much of it has been sent to Toledo. It is an èxcellent coal for most uses. It is quite probable that the samples analyzed came from a part of the mine where the percentage of sulphur was unusually large. The coal is acceptably used in locomotives and in rolling mills, and is valued for domestic uses.

WESTLAND TOWNSHIP.

This township is south of Adams, and borders the county of Muskingum. A section was obtained near Claysville, as follows:

		Ft.	In.
1.	Laminated black slate	3	0
2.	Coal (Cumberland seam)	3	3
3.	Not exposed	4	0
4.	Limestone	0	8
5.	Not exposed	15	0
6.	Laminated sandstone	4	0
7.	Not exposed	56	0
8.	Limestone	0	8
9.	Not exposed	23	0
10.	Laminated sandstone	4	0
11.	Yellow clay shale	63	0
12.	White clay	0	6
13.	Limestone, ferruginous and fossiliferous	2	0

(See Map XII., No. 8.)

In this township, on the Central Ohio Railroad, about half way between Concord and Cambridge, a seam of coal ten feet above the heavy fossiliferous limestone was once worked, but no measurements could be made. It is probably thin.

In this township, but not far from the border of Muskingum county, on the Central Ohio Railroad, the following section was taken:

		Ft.	In.
1.	Fossiliferous limestone (Ames limestone).		
2.	Not seen	58	0
3.	Laminated sandstone	10	0
4.	Shale	18	0
5.	Blossom of coal.		
6.	Shale	10	0
7.	Limestone, fossiliferous (Cambridge)	12	0
8.	Hard clay and nodular limestone	5	0
9.	Shale	3	0
	Level of railroad track.		

SPENCER TOWNSHIP.

This township lies in the south-western part of Guernsey county. It is drained for the most part by Buffalo Creek, a branch of Wills Creek. The only coal worked is the Cumberland seam. The blossom of the Pomeroy seam was seen, but so far as could be learned the seam is not mined. It is probably quite thin. The following section contains the Cumberland coal seam found on the land of Mr. H. C. Hunter, a mile from the town of Cumberland, on the road to Caldwell:

		Ft.	In.
1.	Limestone	2	0
2.	Red shale	19	0
3.	Limestone	1	6
4.	Shale	10	0
5.	Limestone, crumbling	1	0
6.	Not exposed	15	0
7.	Whitish limestone in layers in red clay shale	25	0
8.	Not exposed	10	0
9.	Sandstone	10	0
10.	Shale	10	0
11.	Coal (Cumberland seam)	1	6
12.	Slate, " "	0	$0\frac{1}{2}$
13.	Coal, " "	1	2
14.	Slate, " "	0	$0\frac{1}{2}$
15.	Coal, " "	1	10
16.	Clay	3	0
17.	Blue limestone	2	0
18.	Not seen	31	0
19.	Laminated sandstone	5	0
20.	Heavy sandrock, quarried	10	0

(See Map XII., No. 7.)

Mr. Hunter's bank is said to be just south of the township line of Spencer and in Brookfield township, Noble county. The analysis of the coal will be given in connection with that township.

Two miles east of Cumberland the following section was obtained:

		Ft.	In.
1.	Buff limestone	18	0
2.	Laminated sandstone and shale	30	0
3.	Coal (Cumberland seam) reported	4	6
4.	Not exposed	81	0
5.	Black fossiliferous, earthy limestone	1	6
6.	Not exposed	15	0
7.	Blossom of coal (Pomeroy seam).		
8.	Not exposed	136	0
9.	Limestone (Ames limestone), fossiliferous	1	6

The Pomeroy seam of coal has its place generally about one hundred and forty feet above the Ames limestone, and the place of the Cumberland seam of coal is from ninety to one hundred feet higher. The coal about Cumberland is high in the hills, and, consequently, there is less area of the seam. The coal is used for household purposes and for the generation of steam.

The large amount of limestone high up in the hills fertilizes the soil, and as an agricultural region this is one of the best. Cumberland is an important and thriving village.

JACKSON TOWNSHIP.

This township lies directly south of Cambridge, and is drained by Wills Creek and its tributaries.

The Cambridge seam of coal is every where seen in the northern part of the township, but disappears below the surface to the south. The presumption is that it extends continuously through this and Valley townships, for it is found by boring at Ava Station, in Buffalo township, in Noble county, where it is reported as six feet six inches thick. There may be thin places and even breaks in the continuity of the seam in so great a distance. This can only be ascertained by borings. There is no doubt, however, that there is a large area of this valuable coal field, through which the Marietta, Pittsburgh and Cleveland Railroad passes. The coal has long been mined for local use in the vicinity of Bysville.

On the land of J. Jennings the coal measures three feet three inches. At J. Long's, lot 6, it measures four feet two inches. Near Bysville, in section 6, the following section was taken:

		Ft.	In.
1.	Limestone (Ames limestone), fossiliferous	2	0
2.	Not exposed	130	0
3.	Blossom of coal.		

		Ft.	In.
4.	Not seen	15	0
5.	Shale	55	0
6.	Sandstone	10	0
7.	Shale	13	0
8.	Coal (Cambridge seam), reported	4	2

(See Map XII., No. 2.)

The entrance to the mine near which this section was taken had fallen in, and no measurement was possible. On section 13, on the land of Robert Murray, the following section was taken:

		Ft.	In.
1.	Sandstone and conglomerate	15	0
2.	Shale	6	0
3.	Coal	4	0
4.	Slate	0	0½
5.	Coal	1	9

(See Map XII., No. 16.)

The coal at this point apparently works larger than is usual for this seam. The general quality is excellent.

About a mile south of Bysville the Cambridge seam was found, by boring, to be twenty feet below the level of Wills Creek, and reported to be five and a half feet thick.

VALLEY TOWNSHIP.

This township lies south of Jackson. The valley of Wills Creek extends through it, and by this stream and its tributaries the whole area of the township is drained. The whole township lies above the Cambridge coal, unless possibly a small part of the low valley in section 21 and in that vicinity may be low enough to reach the coal. A geological section was taken about a mile and a half south-east of Point Pleasant, as follows:

		Ft.	In.
1.	Shale	25	0
2.	Limestone, fossiliferous	1	0
3.	Yellow shale	65	0
4.	Limestone (Ames limestone), fossiliferous	4	0
5.	Shale, with white clay at bottom	25	0
6.	Sandstone	26	0
7.	Shale	23	0
8.	Coal (Anderson seam)	3	0
9.	Clay and shale	12	0
10.	Siderite ore, fossiliferous	0	6
11.	Mostly sandstone	36	0
12.	Whitish limestone	1	0

(See Map XII., No. 20.)

The coal in this section, called the Anderson seam, from the owner of a bank near Campbell's Station, is mined to a limited extent. The fossiliferous iron ore is doubtless the geological equivalent of the Cambridge fossiliferous limestone found in the hills west of the town of Cambridge. Near Hartford the following section was taken:

		Ft.	In.
1.	Limestone (Ames limestone), fossiliferous	1	0
2.	Not seen	18	0
3.	Blossom of coal.		
4.	Not exposed	26	0
5.	Sandstone	20	0
6.	Shale	4	0
7.	Coal (Anderson seam)	2	6
8.	Not exposed	72	0
9.	Blossom of coal.		

(See Map XII., No. 17.)

The Anderson seam of coal has been mined to supply a local demand. The seams of coal of which only the blossoms were seen are elsewhere generally quite thin, but they should be investigated.

There is a strong antecedent probability that the Cambridge seam of coal extends under all this township, and can be reached by shafts of inconsiderable depth.. The only trial boring reported is one a little north of Point Pleasant. Here, at a depth of fifty feet below the valley, the Cambridge seam was reached, and reported to be six feet thick.

RICHLAND TOWNSHIP.

This township is situated east of Jackson. It is drained by Wills Creek and its tributaries. The following section, taken at Senecaville, shows many of the strata which make up the hills:

		Ft.	In.
1.	Limestone	2	0
2.	Blossom of coal (Pomeroy seam).		
3.	Shale	27	0
4.	Limestone	4	0
5.	Shale	6	0
6.	Limestone	1	0
7.	Shale	15	0
8.	Limestone	1	0
9.	Red shale	20	0
10.	Not exposed	55	0
11.	Shale	15	0
12.	Limestone (Ames limestone), fossiliferous	1	6
13.	Shale	18	0
14.	Coal	1	8
15.	Clay	3	0

		Ft.	In.
16.	Not exposed	8	0
17.	Nodular limestone (not measured).		
18.	Not exposed	21	0
19.	Sandstone	20	0
20.	Coal (Anderson seam)	1	4

(See Map XII., No. 14.)

The coal, No. 14, in this section has been dug to a very limited extent, but not very profitably. It was reported that, in boring for salt water at Senecaville, a seam of coal three feet thick was passed at a depth of from seventy to seventy-five feet below the lowest coal seam in the above section. At about eighty feet lower, the Cambridge coal should have been passed, if it has not thinned out in this direction. Good brine is reported to have been obtained.

A section was taken on the land of John Anderson, section 8, as follows:

		Ft.	In.
1.	Coal, with shale roof	2	1
2.	Clay	1	0
3.	Coal	1	1
4.	Not exposed	18	0
5.	Fossiliferous limestone	2	0

(See Map XII., No. 11.)

The fossiliferous limestone is the equivalent of that found on the hills west of Cambridge.

The following analysis has been made of the Anderson coal by Prof. Wormley:

Specific gravity	1.294
Water	1.70
Ash	6.00
Volatile combustible matter	35.70
Fixed carbon	56.60
Total	100.00
Sulphur	3.13
" left in coke	1.75
Percentage of sulphur in coke	2.79
Color of ash	gray.
Character of coke	compact.
Fixed gas per pound in cubic feet	3.12

WILLS TOWNSHIP.

This township lies north of the eastern part of Richland. The Central Ohio Railroad passes along its southern boundary. At Campbell's

Station, section 1, a well was bored in search of coal. The following is a reported record of the boring, furnished by Mr. Thomas Ritchie:

		Ft.	In.
1.	Clay shale	66	0
2.	Coal	0	2
3.	Black slate	3	0
4.	Coal	0	2
5.	Clay (not measured).		
6.	Sandstone	44	0
7.	Coal, reported thickness	3	0
8.	Underclay	5	0

The Anderson seam of coal, found less than a mile from this point, is forty-six feet above the top of this boring. Below the Anderson coal is the Cambridge fossiliferous limestone. By these strata we can judge of the distance down to the Cambridge, or Scott's coal. This makes the lowest coal reached in the experimental well to be the Cambridge seam.

MILLWOOD TOWNSHIP.

This township lies upon the east line of the county. A section was taken on the land of Mr. John Brill, near the village of Salesville:

		Ft.	In.
1.	Sandstone, quarried and used for grindstones		0
2.	Not exposed	92	0
3.	Shale	3	0
4.	Coal (Pomeroy seam)	4	2
5.	Underclay	2	0
6.	Limestone, reported	0	10
7.	Not seen	20	0
8.	Shale	50.	0
9.	Not exposed	88	0
10.	Sandy limestone (Ames limestone), fossiliferous	1	0

(See Map XII., No. 12.)

The following analysis of a sample of Mr. Brill's coal was made by Prof. Wormley:

Specific gravity	1.269
Water	3.80
Ash	7.80
Volatile combustible matter	36.50
Fixed carbon	51.90
Total	100.00
Sulphur	2.48
Sulphur left in coke	0.97
Fixed gas per pound in cubic feet	3.46
Color of ash	light gray.
Coke	compact.
Percentage of sulphur in coke (as coke)	1.63

The coal is of fair quality, but there is too much sulphur in it for the blast furnace or for the best gas.

On the land of F. Lynn, section 25, in Millwood township, the following section was taken:

		Ft.	In.
1.	Buff, sandy limestone	1	0
2.	Not exposed	38	0
3.	Fire-clay and white sandstone	2	0
4.	Coal	3	0

A section was taken near Millwood village, on the land of Mr. Webster:

		Ft.	In.
1.	Shale	12	0
2.	Coal	0	3
3.	Slate	0	1
4.	Coal (Pomeroy seam)	1	0
5.	Slate, " "	0	1
6.	Coal, " "	3	0
7.	Underclay and clay shale	10	0
8.	Limestone	2	6
9.	Not exposed	64	0
10.	Laminated sandstone, used for flagging	10	0
11.	Shale	34	0
12.	Laminated sandstone and shale	40	0
13.	Sandy, fossiliferous limestone (Ames limestone)	1	0
14.	Reddish shale	20	0

(See Map XII., No. 13.)

The coal is mined for all local uses.

CHAPTER LIV.

REPORT ON THE GEOLOGY OF BELMONT COUNTY (SOUTH HALF).

Only the south half of this county is included in the Second Geological District, the Central Ohio Railroad constituting the northern boundary line. The townships specially reported upon are Warren, Goshen, Smith, Richland in part, Pultney, Mead, York, Washington, Wayne, and Somerton. Several townships north of the railroad were visited for the purposes of comparison and verification of the order of stratification further south. In the prosecution of the work of the survey in this region I have been greatly aided by Mr. Nathan Bundy, of Barnesville. To an extensive knowledge of the surface features of the county, obtained in the practice of his profession as a surveyor and civil engineer, he has added during the progress of the geological survey much careful study of the geology, in the stratigraphical order and distribution of the seams of coal, limestones, etc. Extremely careful and cautious in gathering his facts, and never confused in his generalizations, his assistance, so generously given, has proved invaluable.

The surface of the southern part of Belmont county is generally hilly. The soil is unusually rich and productive, and the fertilizing effect of the limestones is seen in large and rewarding crops from upland and valley. In some of the western townships the limestones found further east are replaced by sandstones and shales, and there are, consequently, areas where the soil is less productive. Fruit of all kinds may be easily grown, especially upon the higher lands. The agricultural features of the county have been so fully and ably set forth by Hon. Isaac Welsh, in a prize essay published by the State Board of Agriculture in 1868, that I refer all interested in the subject to it.

Belmont county is drained, for the most part, by streams flowing directly into the Ohio River, viz., Captina, McMahon, and Wheeling creeks. The north-west corner of the county is drained by Stillwater Creek, which flows to the north-west, and empties into the Tuscarawas River, in Tuscarawas county. A very limited area in the western part of the county has its drainage westward by Leatherwood Creek to Wills Creek, thence to the Muskingum River. The divide, or water-shed, between the Muskingum and Ohio waters in the county extends northward through Somerton township into Warren, and thence more easterly through Goshen township, nearly to Burr's mills, and thence northward to the north line of the county. The Central Ohio Railroad, after following the valley of the Leatherwood from Cambridge eastward, enters Belmont county in the extreme south-western corner of Warren township, and from that point rapidly climbs to the summit of the ridge, or divide, at Barnesville. From this point the road keeps along the ridge at about the same general elevation to Belmont, in Goshen township, where the head of McMahon Creek is reached, and then follows that stream to the Ohio River. The highest point of the divide in Belmont county visited by me is a knob on Mr. A. Millison's farm, just above a heavy railroad cut, called, I think, Gregg's Cut, about five miles east or north-east of Barnesville. The summit of the knob is about one hundred feet above the level of the railroad. By Locke's level the summit appeared to be a little higher than any other point in sight. Some of the hills along the Ohio River are very high, but they were not measured for altitude.

The general geological range through the south half of Belmont county is in the Upper Coal Measures, extending down to the Pomeroy seam of coal, which, having been traced through from Meigs county, is believed to be the same as the lower Barnesville coal, which is also the Wheeling or Bellair seam. In the south-west corner of Warren township we obtained a section in the valley of Leatherwood reaching one hundred and twenty feet below the lower Barnesville or Bellair seam, but in the lower space no seam of coal was found. Toward the mouth of McMahon Creek an exposure of forty-five feet below the same seam was obtained, but no other coal was seen. The Bellair or Wheeling seam is the most important one in the southern part of the county. It is the thickest, and the one usually worked. Another well-developed seam of coal lies from eighty-five to one hundred feet higher, and is known on the Ohio River as the upper Bellair, and at Barnesville as the upper Barnesville seam.

After much investigation I am convinced that these seams are identical. On the west side of the Barnesville ridge the upper Barnesville seam is separated from the lower seam by a somewhat greater distance than are the two corresponding seams near the Ohio River. This is especially true where the limestones are replaced by heavy sandrock. Mr. Nathan Bundy made a careful measurement of the vertical distance between the two coals on Leatherwood, in Warren township, and found it one hundred and five feet. In the valley of Stillwater Creek, north-east of Barnesville, the distance is only ninety feet. On

McMahon Creek the interval between the two seams ranged from eighty to ninety feet.

The upper Bellair, or upper Barnesville, seam is one of wide distribution in the Second Geological District. It is the Cumberland seam of Guernsey, Noble, and Washington counties, and is traced through Morgan into Athens, where it is pretty well developed on Big Run, in Rome township. It was not seen in Meigs county.

My associates on the survey in the First Geological District have classified the coals on the Ohio River, in this county, in the descending order, as follows:

Coal No. 10, No. 9, No. 8*c*, No 8*b*, No. 8*a*, No. 8 (Bellair, or lower Barnesville).

We trace the same seams in the same order through all the high lands of the Barnesville region. We could find no coalescing of seams in going from the Ohio River west, by which 8*a*, 8*b*, 8*c*, and 9 unite with 8. Mr. Bundy and myself have found all these on the west side of the Barnesville ridge. For example, 8*a* is seen faintly in a railroad cut west of Barnesville; on the turnpike north of Barnesville; on the turnpike between Flushing and Rock Hill; on "Belmont Ridge," in Flushing township, and at other points. It even extends through several counties. No. 8*b* is distinctly seen at all the above-named localities. No. 8*c* is the upper Barnesville seam, and is the Cumberland seam, which can be followed through Guernsey, Noble, Washington, Muskingum, Morgan, and Athens counties, always holding the same relation to No. 8, or the Pomeroy seam. No. 9 is constantly found in western and north-western Belmont. Traces of it are seen farther west. It is doubtless the Hobson seam of Washington county.

In Belmont county there are about sixteen miles of Ohio River border in the Second Geological District, *i. e.*, below the mouth of McMahon Creek. The total fall of the Ohio River in this distance is 11.066 feet, or about an average of 8.28 inches per mile. The fall is, however, unequally distributed between the ripples and pools; the former having 10.41 feet, and the latter 0.656 inches. There are 4.327 miles of ripples and 11.673 miles of pools, seven feet deep in low water.

WARREN TOWNSHIP.

This township is located in the western part of the county, and is traversed by the Central Ohio Railroad. The township is drained by the waters of Captina Creek, flowing into the Ohio, on the south-east, by Stillwater Creek, which flows into the Tuscarawas, on the north, and by

Leatherwood, a branch of Wills Creek, on the west. The central part of the township, which constitutes the divide, or water-shed, between the several streams, is high, and with its fertile soil and salubrious air presents many attractions. This ridge is becoming somewhat celebrated for its fine fruit. The railroad, as it ascends to the high ground from the Leatherwood valley, presents admirable opportunities for making a section of the strata, which are well exposed in the various cuts. The lowest strata in the section are found near the heavy embankment, or fill, across the Leatherwood valley. The history of this fill shows well the peculiar difficulties which railroad companies often meet with in using the clays found in our Coal Measures. When saturated with water they are like a mortar-bed in the embankment, and slide away, and more material must be added to the top. Unfortunately, there is no gravel in all this region nearer than the banks of the Ohio River. No traces of Drift were seen in southern Belmont county, nor in Monroe county, except the modified or terraced Drift along the Ohio River, and none of any kind in Guernsey. A section of the strata seen in the railroad cuts from Barnesville west is as follows:

		Ft.	In.
1.	Laminated sandrock on top of hill (not measured).		
2.	Shale	8	0
3.	Blossom of coal.		
4.	Dark clay	4	0
5.	White limestone	1	0
6.	Not seen	29	0
7.	Sandstone	4	0
8.	Buff clay	3	0
9.	Black slate	2	0
10.	Coal (tunnel seam)	1	2
11.	Shale (place of tunnel)	19	0
12.	Sandstone	5	0
13.	Shale	0	6
14.	Coal	0	4
15.	Slate	0	3
16.	Coal	0	4
17.	Clay	0	6
18.	Coal	0	4
19.	Slate	0	2
20.	Coal	0	2
21.	Slate	0	6
22.	Coal	0	4
23.	Clay	0	6
24.	Laminated sandstone	0	3
25.	Brown shale	2	0
26.	Black slate	1	3

		Ft.	In.
27.	Coal	0	6
28.	Fire-clay, blue	10	0
29.	Hard sandrock, ferruginous	1	3
30.	Sandstone	4	0
31.	Limestone, etc., estimated 13 feet, but probably thicker	13	0
32.	Brown shale	6	0
33.	Buff clay	3	0
34.	Limestone and shale, with three feet cement limestone	19	0
35.	Blue shale	2	0
36.	Sandstone and shales	5	0
37.	Limestone and shales	8	0
38.	Coal	1	0
39.	Clay	1	6
40.	Coal (upper Barnesville, or Cumberland seam)	3	0
41.	Slate, " " " "	0	1
42.	Coal, " " " "	1	0
43.	Clay	3	0
44.	Sandrock	35	0
45.	Not seen	4	0
46.	Buff limestone	1	0
47.	Not seen	4	0
48.	Blossom of coal.		
49.	Clay	3	0
50.	Limestone and shale	4	0
51.	Cement limestone	3	0 ?
52.	Limestone and shale	9	0
53.	Blossom of coal.		
54.	Clay	2	0
55.	Shale, with nodules of siderite ore	9	0
56.	Laminated sandstone	4	0
57.	Shale, with coal plants at bottom	15	0
58.	Coal (lower Barnesville, or Pomeroy seam)	4	4
59.	Clay	3	0
60.	Dark blue limestone	3	0
61.	Not seen	9	0
62.	Buff sandy limestone	4	0
63.	Buff shale	6	0
64.	Dark clay shale	20	0
65.	Hard blue sandstone (local)	3	0
66.	Chocolate-colored clay shale	15	0
67.	Not seen	15	0
68.	Chocolate shale, with nodules of ore	30	0
69.	Hard, laminated sandstone	5	0
70.	Not seen	9	0
	Bed of Leatherwood. (See Map XIV., No. 2.)		

This section includes a vertical range of about four hundred feet.

A general outline section was taken on a branch of Stillwater Creek, east of the railroad station, which is approximately as follows:

		Ft.	In.
1.	Coal blossom.		
2.	Not exposed	30	0
3.	Coal blossom.		
4.	Not exposed	53	0
5.	Limestone	1	0
6.	Cement limestone, estimated	9	0
7.	Not seen	22	0
8.	Coal, upper Barnesville seam (not measured).		
9.	Not seen	40	0
10.	Limestone	2	0 ?
11.	Cement limestone	5	0 ?
12.	Not seen	46	0
13.	Coal, lower Barnesville seam (not measured).		

(See Map XIV., No. 1.)

The larger spaces in this, and in all the sections, were measured by an aneroid barometer, and can be considered as only approximately accurate. The weather, by its changes, always affects the instrument. It is also often very difficult to make the exact corrections for dip. Mr. Nathan Bundy first called my attention to the upper cement in the last section, and made the suggestion that it might be the equivalent of the cement limestone stratum at Warnock's Station, on the railroad. The verification of this suggestion served as a key to unlock the stratigraphical puzzle of Belmont geology.

The cement limestone last referred to, *i. e.*, the one twenty-two feet above the upper Barnesville seam of coal, was analyzed by Prof. Wormley, with the following result:

Silicious matter	17.78
Alumina, with trace of iron	1.40
Carbonate of lime	62.50
Carbonate of magnesia	17.48
Total	99.16

The cement works of Messrs. T. C. Parker & Sons, in section 21, a little north of Barnesville, use a cement limestone found between the upper and lower Barnesville seams of coal. The stratum is five feet five inches thick, and is apparently quite homogeneous. It is not mined in open quarry, but by means of a drift-way. With the aid of Mr. Parker and of his foreman, I selected a representative sample of the stone, which was analyzed by Prof. Wormley, with the following result:

Silicious matter	29.80
Alumina, with trace of sesquioxide of iron	13.80
Carbonate of lime	41.20
" magnesia	15.36
Total	100.16

In a business prospectus issued by the Messrs. Parker I find the following analysis of the cement limestone, made by Dr. E. S. Wayne, of Cincinnati:

Carbonate of lime	72.10
" magnesia	11.15
Silica	8.47
Alumina	4.85
Iron	3.10
Loss and moisture	0.33
Total	100.00

This result is so entirely different from Dr. Wormley's analysis that I am led to believe that, by some accident, Dr. Wayne was not furnished with a representative sample of the proper cement rock. There can be no doubt that, theoretically considered, the sample analyzed by Dr. Wormley is the better stone for a hydraulic cement. The Messrs. Parker make, on an average, eighty barrels of ground cement a day, each barrel containing two hundred and eighty pounds. The works have a capacity for one hundred barrels a day. Coal for burning the lime and for generating steam for grinding the cement is obtained from the lower Barnesville, or Bellair seam, opened in the vicinity of the works. The manufacture of cement was commenced by Mr. T. C. Parker in 1858, and continued until the beginning of the war, in 1861. It was resumed successfully in 1868. The cement has a high reputation, and was used with approval in the construction of the great railroad bridge over the Ohio River at Bellair.

The coal from both upper and lower Barnesville seams is used, and numerous mines are opened in the many valleys in the township. A shaft has recently been sunk near Barnesville, to reach the upper seam. This is for convenience chiefly, in order to save the expense and trouble of bringing the coal to town from the neighboring valleys. The lower seam furnishes a more resinous and cementing coal than the upper, but both coals are of fair quality. For the generation of steam, for household use, for rolling mills, and, indeed for the great majority of uses, the coals are valuable, and the supply is practically inexhaustible.

Following the line of the railroad east of Barnesville, we find in a railroad cut on the land of Wm. Stanton, section 10, a thin seam of coal only two inches thick, which was believed to be the same as the highest coal found at Barnesville, about forty feet above the tunnel seam. The section in this cut is as follows:

		Ft.	In.
1.	Sandrock	15	0
2.	Clay	0	4
3.	Coal	0	2
4.	Brown clay shale	1	0
5.	Limestone, irregular	1	6
6.	Dark-brown shale	5	0
	Level of railroad track.		

About a mile further east, in a railroad cut on the farm of the late Ezekiel Bundy, Esq., a seam of coal one foot thick is seen, which was believed to be the same as the Barnesville tunnel seam. The section in the cut is as follows:

		Ft.	In.
1.	Shaly sandstone	8	0
2.	Black slate	0	4
3.	Coal	1	0
4.	Clay shale	3	0
	Level of railroad track.		

On the same farm an old excavation for coal was visited. Coal was once obtained here by the late Mr. Bundy for family use. This seam is twenty-seven feet below the seam in the railroad cut.

SOMERTON TOWNSHIP.

Most of this township lies upon the high ground which constitutes the water-shed between the Ohio River on the east and Wills Creek waters on the west. The soil is of fair quality, but the heaviest beds of limestone lie in the valley of Captina Creek, too low, at least, to have much fertilizing influence upon the soil of the hill-sides. At Temperanceville, in the extreme western part of the township, Beaver Creek has eroded its valley below the lower Barnesville, or Wheeling, seam of coal, and the seam is mined in that neighborhood. The following is a geological section in the vicinity of the village of Somerton:

		Ft.	In.
1.	Blossom of coal.		
2.	Not seen (estimated)	20	0
3.	Blossom of coal.		
4.	Not seen	42	0
5.	Blossom of coal.		
6.	Not seen	23	0

		Ft.	In.
7.	Shale	8	0
8.	Laminated sandstone	4	0
9.	Shale	5	0
10.	Coal	2	5
11.	Clay	2	6
12.	Laminated sandstone	5	0
13.	Shale	3	0
14.	Laminated sandstone	2	0
15.	Shale	8	0
16.	Limestone, sandy	1	3
17.	Shale	16	0
18.	Sandstone	4	0
19.	Shale	6	0
20.	Blossom of coal.		
21.	Shale, with nodules of limestone	18	0
22.	Limestone	0	10
23.	Clay	2	0
24.	Hard sandstone	8	0
25.	Shale and laminated sandstone	9	0
26.	Buff, nodular limestone	1	0
27.	Shale	5	0
28.	Buff limestone	1	0
29.	Shale and laminated sandstone	18	0
30.	Limestone	4	0
31.	Clay (not measured)	3	0 ?
32.	Interval to top of shaft (not seen)	5	0
	Shaft at steam mill.		
33.	Sandstone	14	0
34.	Cement ? limestone	1	8
35.	Reported flint	1	10
36.	Cement ? limestone	1	3
37.	Whitish sandstone	25	0
38.	Sandrock, found by boring	29	0
	(See Map XIV., No. 4.)		

The sandrock, No. 38 of the section, found by boring, is not given on the map. Mr. Eli Yocum, proprietor of the steam mill, reports a thin seam of coal twenty-five feet below the seam he mines, *i. e.*, No. 10 of the above section. It does not appear on the map. If our grouping in the map be correct, the Wheeling seam of coal should have been found in boring.

GOSHEN TOWNSHIP.

This township lies directly east of Warren. The Central Ohio Railroad traverses it from east to west, not far from the north line of the township. The drainage of the township is chiefly to the south and south-east into the waters of Captina Creek. In the extreme north-east is McMahon Creek, and in the north-west is a branch of Stillwater Creek. The tributaries of Captina Creek do not have the rapid descent from the high dividing land which characterizes the other streams, and hence nowhere, so far as I could learn, have they excavated their valleys deep enough to reach the two principal Barnesville seams of coal, except in the extreme southern part of the township, where the upper Barnesville seam is mined. A section was taken in the deep railroad cut, section 28, in which was found a seam of coal two feet thick, which was believed to be the equivalent of the highest seam at Barnesville, or the one forty feet above the tunnel seam. The strata revealed in this interesting cut are as follows:

		Ft.	In.
1.	Yellow shales, with strata of limestone, seen on knob above the cut on A. Millison's land	37	0
	Top of cut.		
2.	White limestone (supposed thickness)	1	6
3.	Yellow shale	13	0
4.	Black shale	3	0
5.	Coal	0	5
6.	Shale, and thin layers of limestone	4	0
7.	Sandy and clay shale, top yellow, bottom dark	13	0.
8.	Coal	0	2
9.	Black shale and slate	6	0
10.	Coal	2	0
11.	Clay	1	0
12.	Black clay slate, with many thin layers of nodular siderite ore	12	0
13.	Blue clay, not laminated	4	0
14.	Sandstone	4	0
	Railroad track, two feet above the bottom of the sandrock.		
	(Map XIV., No. 3.)		

The hill above the cut is the highest in this part of the county.

In a railroad cut about one-fourth of a mile east of the deep cut last mentioned, we find the same two-feet seam of coal. The section is as follows:

		Ft.	In.
1.	Shaly sandstone, with black shale below (not measured).		
2.	Coal	2	0
3.	Underclay	1	6
4.	Black clay shale, with nodules of siderite ore in layers	12	0
5.	Sandrock, with blue, sandy clay, very irregularly bedded	10	0
	Level of railroad track.		

There are probably eight feet of dip of the strata between the last cut and this.

In the next railroad cut, about a quarter of a mile further east, we find a mere trace of coal, which probably represents the seam in the tunnel at Barnesville. The following is the section in this cut:

		Ft.	In.
1.	Shaly sandstone, with yellow shales below	8	0
2.	Nodular sandy limestone	2	0
3.	Bluish shale, yellow at top	12	0
4.	Black bituminous slate, with thin streak of coal	2	0
5.	Hard, ferruginous limestone	0	6
6.	Blue clay shale	3	0
	Level of railroad track.		

At Fairmount Station, or Burr's Mill, the same group as the last is seen in a railroad cut. The only representative of the Barnesville tunnel seam is a black, bituminous shale, immediately over a ferruginous limestone. The whole section is as follows:

		Ft.	In.
1.	Shaly sandstone	6	0
2.	Yellow shale at top, with black, bituminous shale below	4	0
3.	Ferruginous limestone	0	7
4.	Clay (unstratified) shale, blue at top, chocolate-colored below	12	0
	Level of railroad track.		

The unstratified clay shale corresponds remarkably with that seen in the tunnel cut at Barnesville.

In the second cut, east of Burr's Mill, the same group was found as before, but with a larger development of limestone. It is given below:

		Ft.	In.
1.	Yellow shale	5	0
2.	Shaly sandstone, changing below into yellow shale	9	0
3.	Ferruginous limestone	0	10
4.	Black, bituminous slate, no true coal seen	1	6
5.	Ferruginous limestone in nodules, often wanting	0	4
6.	Blue unstratified clay shale, with soft blue sandstone below	14	0
7.	Brown shale	6	0
8.	Buff limestone	1	0
	Level of railroad track.		

This cut was estimated to be about six hundred feet long, and extends in a north-east and south-west direction. The exposed strata in the cut dip to the north-east in this short distance about twelve feet, by a proximate leveling with Locke's level. The railroad track is not far from level.

In a valley crossed by an embankment, a little east of this cut, a coal seam was found which had been worked by stripping. This coal could not be measured, not being well exposed. It is probably too thin for drift mining. This seam is thirty-six feet below the level of the railroad track. It is probably the equivalent of the first seam below the tunnel seam at Barnesville.

In the cut a half mile west of Belmont Station a streak of black, bituminous matter was seen, with yellow shales above and below. It is fourteen feet above the level of the railroad track. This faint representative of coal was supposed to be the equivalent of the highest seam at Barnesville—that is, the one about forty feet above the tunnel seam. At Belmont Station cut, the eastern descent of the road being greater than the dip of the strata, this black, bituminous stratum is over thirty feet above the track. About ten feet below the track, at the east end of the cut, is a seam of coal. This seam was believed to be the Barnesville tunnel seam. This belief is strengthened by finding in the valley farther east, at the proper distance below, viz., about thirty feet, a seam of coal corresponding to the one at Barnesville first below the tunnel seam.

A section one half mile east of Belmont Station is as follows:

		Ft.	In.
1.	Coal (the Belmont or Barnesville tunnel seam).		
2.	Interval down to railroad track, composed of sandstones and shales	18	0
3.	From railroad track to next coal	12	0
4.	Coal (not measured).		
5.	Not exposed in detail	27	0
6.	Limestone	3 to 5	0

If we have brought the identifications along accurately from Barnesville to Belmont, we are prepared to trace the group eastward. It should be remarked, before leaving Goshen township, that the coal seams are generally thin, and the coal is worked only to a very limited extent. In the vicinity of the railroad stations, coal is generally procured from the cars, brought from the mines towards Bellair. In section 14, in this township, Mr. Gilbert obtained the following geological section:

		Ft.	In.
1.	Blossom of coal.		
2.	Interval not exposed	100	0
3.	Blossom of coal.		
4.	Interval not exposed	36	0
5.	Sandstone	2	0
6.	Shale	2	0
7.	Coal	2	6
8.	Clay and ferruginous shale	6	0
9.	Shaly limestone	1	6

If we may consider the lowest coal in this section as the equivalent of the lower seam at Lewis's Mill, *i. e.*, the coal first below the Barnesville tunnel seam, the next coal above, of which only the blossom was seen, will be in the horizon of the tunnel seam, and the blossom, one hundred feet higher, will correspond in vertical position to the very highly bituminous slate found high in the hill near Lewis's Mill.

So far as noticed, the soil in this township is excellent. There must be limited areas over which the soil is made from decomposed shales and sandstone containing little or no lime, and this soil, where long cultivated, and having lost its original organic matter, is thin and poor, appearing all the poorer by contrast with the rich limestone lands in the neighborhood.

SMITH TOWNSHIP.

This township lies directly east of Goshen. McMahon Creek runs along its northern border, and its tributaries drain the north half of the township, while the southern portion is drained to the south by tributaries of Captina Creek. No sections were taken in this township except along the line of the railroad.

At Lewis's Mill a section was taken from the top of the hill south of the station to the bed of the stream, including the cut a little east of the bridge. It is as follows:

		Ft.	In.
1.	Summit of hill.		
2.	Not exposed	10	0
3.	Yellow shale	10	0
4.	Limestone and shales, not seen in detail	35	0
5.	Highly bituminous laminated black slate	10	0
6.	Not exposed	10	0
7.	Buff limestone (not measured) perhaps	1	0
8.	Not exposed, except sandstone at bottom	22	0
9.	Blossom of coal.		
10.	Not exposed	28	6
11.	Yellow shale	8	0
12.	Sandstone and shale	15	0
13.	Reddish clay shale	2	6
14.	Slaty coal	1	0
15.	Coal	3	6
16.	Clay shale, thickness at west end of cut	13	0
17.	Sandrock, with more or less sandy shales	23	0
18.	Blue clay shale	1	0
19.	Coal	1	10
20.	White clay parting	0	1
21.	Coal	0	8
22.	Not exposed here; elsewhere containing a stratum of limestone	6	0
23.	Sandstone	4	0
24.	Shale	1	0
25.	Buff clay	3	0
26.	Not exposed	10	0
27.	Limestone, several layers in bed of stream	4	0

(For this section, see Map XIV., No. 5.)

The two lower seams of coal in this section we believed to be the same as the Barnesville tunnel seam and the one next below it. They, with the limestone No. 27 in the above section, constitute a group which Mr. Bundy and myself traced to Belmont. The coal in the deep cut just east of Lewis's Mill could not be measured with perfect accuracy. There is over it some hard black slate, which in places is rather a slaty coal. In the second cut, east of Lewis's Mill, the lower seam of coal appears about four feet above the track. The section here is—

		Ft.	In.
1.	Sandstone, seen	1	0
2.	Shale	11	0
3.	Coal	2	0
4.	Clay	0	3
5.	Coal	0	8
6.	Clay	4	0

At the water station, a mile west of Warnock's Station, we find a seam of cement limestone. The rapid descent of the railroad from Lewis's Mill being greater than the dip of the strata, we have descended in the series to the horizon of the cement limestone, twenty-two feet above the upper Barnesville coal. In the cut at the water station this cement limestone measures four feet six inches in thickness. The section at this point is as follows:

		Ft.	In.
1.	Sandstone	26	0
2.	Coal	1	0
3.	Clay shale	25	0
4.	Dark-colored shale	3	0
5.	Sandstone, fine-grained	8	0
6.	Limestone layers and shales	6	0
7.	Shale	10	0
8.	Limestone	1	0
9.	Shale	1	0
10.	Limestone	1	0
11.	Shale	1	0
12.	Limestone	2	0
13.	Shale	1	6
14.	Clay	0	8
15.	Cement limestone	4	6
16.	Clay shale	3	0
	Railroad track. (Map XIV., No. 6.)		

On the land of William Warnock, at Warnock's Station, we found the cement limestone six feet three inches in thickness. The best exposure is in the bank of the creek, above the railroad bridge. (See Map XIV. No. 7.) Below the cement limestone are several feet of dark sandy limestone, argillaceous in places. The cement limestone found at Warnock's is a fine looking stone, and to the eye can hardly be distinguished from the Parker cement limestone at Barnesville. The analyses by Dr. Wormley show great similarity of composition. The analyses of both are as follows:

Composition of Warnock's and Parker's Cement Limestones.

	Warnock's.	Parker's.
Silicious matter	30.60	29.80
Alumina, with trace of sesquioxide of iron	13.00	13.80
Carbonate of lime	40.60	41.20
Carbonate of magnesia	15.18	15.36
	99.38	100 16

There can be scarcely a doubt that the Warnock limestone will make a good water-lime. It can be obtained in great quantities near the railroad, and coal for burning could be easily obtained. At Warnock's we heard a report that coal had been found in a well only fifteen or twenty feet below the surface. Such a coal would be in the horizon of the upper Barnesville seam, which lies from twenty to thirty feet below the cement limestone. This coal appears in a tunnel about a mile west of Glencoe Station, where it measures three feet in thickness. The section obtained at this point is as follows:

		Ft.	In.
1.	Shale	0	10
2.	Coal, blossom only seen, but reported thickness	3	0
3.	Not exposed	110	0
4.	Sandy limestone	6	0
5.	Shale, with nodular limestone	20	0
6.	Sandy limestone	3	0
7.	Shale	1	0
8.	Cement limestone	5	0
9.	Shale	1	0
10.	Limestone	2	0
11.	Shale	3	0
12.	Limestone	1	6
13.	Slaty limestone	2	6
14.	Cement limestone, first layer	2	0
15.	Slaty streak, thin.		
16.	Cement limestone, second layer	1	4
17.	" " third "	4	0
18.	" " shaly, fourth layer	3	0
19.	Sandy limestone	4	0
20.	Dark shale	5	0
21.	Coal	3	0
22.	Clay	3	0

(For this section, see Map XIV., No. 8.)

I did not learn that the coals seen in this section had been mined in this neighborhood. Farther east, in the cut at Glencoe Station, the lower seam of coal in the preceding section is found to be four feet thick, and twenty-eight feet above the bottom of the cut. The whole section at this point is as follows:

		Ft.	In
1.	Group of layers of cement limestone, seen in the last section.		
2.	Sandy limestone	4	0
3.	Shale	3	0
4.	Coal	4	0
5.	Clay and clay shale	16	0
6.	Sandy limestone	2	0
7.	Shale	3	0
8.	Cement limestone	5	0
9.	Sandy limestone, somewhat ferruginous	2	0
	Railroad track. (See Map XIV., No. 9.)		

A sample of the lowest cement limestone was obtained. The result of Prof. Wormley's anlysis is as follows:

Silicious matter	16.70
Alumina, with trace of iron	2.90
Lime, carbonate	58.00
Magnesia, carbonate	21.60
Total	99.20

This lower cement limestone is approximately in the horizon of the Parker's cement limestone of Barnesville, and is probably its equivalent.

The fall of McMahon Creek from Glencoe east is such that it exposes the Wheeling or Bellair seam of coal about a mile east of Glencoe. Here the coal first appears in the bed of the stream. The section in the bank of the creek is—

		Ft.	In.
1.	Limestone, hard and sandy	5	0
2.	Shales, with nodules of limestone	12	0
3.	Coal	0	5
4.	Shale	0	3
5.	Coal	0	11
6.	Clay	1	2
7.	Coal	2	1
8.	Slate	0	1
9.	Coal, reported	3	0
10.	Fire-clay (not measured)	3	0 ?
11.	Dark blue limestone, seen	2	0
	Bed of McMahon Creek.		

RICHLAND TOWNSHIP.

Richland township lies for the most part north of Smith township, but a corner, containing nine sections, lies directly east of Smith, and is traversed by the Central Ohio Railroad.

The Bellair coal is every where seen along the line of the railroad. At the tunnel, east of Glencoe Station, the seam shows very distinctly, where it presents divisions quite similar to those found in the seam in the creek farther west. A section was taken at this point of such strata as were visible. Beginning on the hill, we find—

		Ft.	In.
1.	Blossom of coal.		
2.	Not exposed	65	0
3.	Nodular limestone (not measured).		
4.	Not exposed	8	0
5.	Coal, reported	4	0
6.	Not exposed	53	0
7.	Limestone and shales	20	0
8.	Clay slate	6	0
9.	Coal	0	3
10.	Shale	0	8
11.	Coal, slaty	0	11
12.	Clay	1	0
13.	Coal	2	2
14.	Slate	0	1
15.	Coal	3	4

(For this section, see Map XIV., No. 10.)

Near the tunnel are the "Meehan mines" of Mr. Owen Meehan, who ships considerable coal by the railroad. The coal has the bright, resinous appearance which every where characterizes the Wheeling coal. The proximity of the coal to the road makes the location an admirable one for easy shipment.

The following results of an analysis of a sample of the coal from the mines of Messrs. Stewart, Ball, and Meehan are furnished by Professor Wormley:

Water	2.00
Ash, gray	5.40
Volatile combustible matter	55.60
Fixed carbon	57.00
Total	100.00
Sulphur in coal	3.48
" left in coke	1.53

While the sulphur is too great for a furnace coal, yet the coal is well adapted to the great majority of uses. The percentage of water is small, as compared with that of a large number of our most popular coals in southern Ohio; and this amounts, practically, to a very considerable saving.

On the land of Hon. Isaac Welsh the Bellair or Wheeling seam is found in good development, and the one eighty to ninety feet above is reported to be four feet thick. The seam above the latter is found in the neighborhood, and has been mined by Mr. Helpbringer. There is an inexhaustible supply of coal in this vicinity.

PULTNEY TOWNSHIP.

This township is one of the eastern townships of the county. The McMahon Creek divides it into two nearly equal parts. On the land of J. F. Hutchinson, section 12, a geological section was made, which revealed the more important strata over the Bellair coal:

		Ft.	In.
1.	Cement limestone, thickness not seen.		
2.	Coal, reported a little below the limestone.		
3.	Not exposed	33	0
4.	Laminated sandstone	2	0
5.	Black slate	1	0
6.	Coal, reported thickness	4	0
7.	Not exposed	29	0
8.	Limestone and shales	15	0
9.	Clay	2	6
10.	Coal	2	0
11.	Bituminous shale	3	0
12.	Blue limestone	12	0
13.	Limestones and shales	5	0
14.	Clay	1	0
15.	Nodular limestone	2	0
16.	Clay shale	5	0
17.	Coal	1	0
18.	Clay	1	0
19.	Coal, varying from 5 10 to	6	10

(Map XIV., No. 11.)

There are in the lower seam of coal two thin, slaty partings, thirty-fourand thirty-eight inches from the bottom respectively. The lower three inches of the seam are slaty, and contain fish remains and some imperfectly preserved shells. This coal is mined by Mr. Kidd, and shipped by the railroad. The coal possesses the usual characteristics of the Bellair or Wheeling coal. About twenty-eight feet above this coal is a thin seam, measuring two feet in thickness. The seam of coal about eighty feet above the lower or Bellair seam is reported to be four feet thick. It is not mined, the lower coal generally being preferred. In the spring-house attached to the former residence of Mr. Hutchinson we found a cement limestone in which a basin has been excavated for the water. The entire thickness of the layer was not seen. Prof. Wormley analyzed a sample, and reports the following result of the analysis:

Silicious matter	31.20
Alumina, with trace of iron	6.60
Carbonate of lime	37.80
Carbonate of magnesia	23.89

This limestone is worthy of further investigation. It has less alumina than Prof. Wormley finds in the Parker cement limestone, but more than is found in the reported analyses of some cement limestones in high repute. Should this limestone prove to make a durable hydraulic cement, the vast abundance of coal will furnish all the needed fuel for burning at only the cost of mining. Following the railroad eastward, we find a good exposure of the lower, or Bellair, coal t the railroad company's quarry, in section 36. A geological section at this point is as follows:

		Ft.	In.
1.	Shale, not well seen.		
2.	Coal, with one clay parting	2	0
3.	Clay	0	8
.	Coal	6	0
5.	Clay, with nodular limestone	5	0
6.	Clay shale	11	0
7.	Coarse sandstone, quarried and used for the railroad bridge at Bellair	25	0
8.	Shale	5	0
	Railroad track. (Map XIV., No. 13.)		

The stone from the quarry is used in the stone-work of the magnificent iron bridge across the Ohio River at Bellair. We find in some portions of the rock impressions of coal plants, generally large fragments of drifted wood, which became imbedded in the accumulating sand. They are found twenty or thirty feet below the Bellair seam of coal, and, of course, were deposited long before the vegetation constituting that seam of coal had grown.

About a mile west of Bellair a geological section was made, showing the upper Bellair coal, the equivalent of the upper Barnesville seam:

		Ft.	In.
1.	Limestone	2	0
2.	Shale	5	0
3.	Coal	3	6
4.	Shale	10	0
5.	Sandstone	15	0

		Ft.	In.
6.	Not seen	25	0
7.	Sandstone	2	
8.	Blossom of coal.		
9.	Clays and limestones	10	0

(Map XIV., No. 12.)

At Bellair and vicinity the lower and main seam of coal has been extensively mined for many years. It has been identified by the Pennsylvania geologists as the Pittsburgh seam. It dips below the Ohio River, in this county, to emerge again in Meigs county, nearly one hundred miles in a straight line to the south-west. The Newell's Run uplift, in Newport, Washington county, brings it to the surface, but it is here too thin to be of practical value. In the same uplift is the upper Bellair, or upper Barnesville seam, but it is also thin. There are, unfortunately, no valuable seams of coal *directly* upon the Ohio River between Belmont and Meigs counties. This fact gives no little imp r-tance to the coals of Belmont county. The Bellair or Wheeling coal is highly bituminous and cementing, of good heating power, and makes a durable fire. It requires a strong draft for its best combustion, and considerable stoking. It is used in rolling mills, for the generation of steam, and for all household and ordinary uses. The great seam underlies nearly the whole of Pultney township, and is a source of great prosperity to the region. A careful geological section was taken at Bellair, which is of great interest in showing the remarkable limestone formation above the horizon of the Bellair or Wheeling seam of coal. The section is as follows:

		Ft.	In.
1.	Fire-clay	3	0
2.	Clay, with thin layers of limestone	3	0
3.	Limestone	1	0
4.	Shale	3	0
5.	Not exposed	7	0
6.	Limestone	2	0
7.	Shale, with nodular limestone	15	0
8.	Clay and interstratified limestone	5	6
9.	Limestone	6	0
10.	Not exposed	9	0
11.	Sandy limestone	2	6
12.	Clayey limestone	1	0
13.	Cement limestone	5	0
14.	Hard limestone	1	0
15.	Cement limestone	9	0
16.	Limestone	7	0
17.	Shale	4	0

		Ft.	In.
18.	Coal, with half-inch parting, twenty inches from bottom	3	10
19.	Underclay	0	10
20.	Sandstone	16	0
21.	Shale	1	6
22.	Coal	0	3
23.	Shale	3	6
24.	Coal	1	2
25.	Clay	0	4
26.	Coal	0	10
27.	Limestone	7	0
28.	Cement limestone	6	6
29.	Limestone, with interstratified clay	9	6
30.	Clay	2	0
31.	Blue limestone	2	0
32.	Not exposed	3	0
33.	Coal	0	10
34.	Fire-clay	3	0
35.	Limestone	5	0
36.	Not exposed	20	0
37.	Coal (Bellair seam)	6	0

(Map XIV., No. 14.)

In this section only one seam of sandstone was seen, viz., the one sixteen feet thick under the upper coal. The whole hill is made up of layers of limestone, with interstratified clays and shales. This is in remarkable contrast with the formation over the equivalent of the Bellair coal at Pomeroy, where in several hundred feet of strata there was not seen a single well-defined stratum of limestone. Directly over the coal at Pomeroy are seventy feet of coarse sandrock. This shows entirely different conditions of deposition.

There are doubtless many more seams of limestone higher in the hills at Bellair, but they were not exposed. Samples of the cement limestone were furnished by Col. Poorman for analysis by Prof. Wormley. Nos. 1, 2, and 3 were taken from the lower, and 4, 5, and 6 from the upper seam:

	No. 1.	No. 2.	No. 3.	No. 4.	No. 5.	No. 6.
Silicious matter	19.50	19.60	20.80	28.30	36.60	25.60
Alumina, with iron	11.60	9.80	3.20	3.70	4.02	4.60
Carbonate of lime	42.70	48.90	51.80	38.80	37.40	47.20
" magnesia	25.50	21.18	23.91	28.38	21.18	22.30
Totals	99.30	99.38	99.71	99.18	99.20	99.70

Mr. Isaac Booth is successfully manufacturing lime from the cement stone. The lime is commended by those who have used it. There is no limit to the supply.

Bellair, with transportation by river and railroad, and an ample supply of cheap fuel, must become at no distant day an important center of manufactures. The coal mines are generally successful, and belong to the following proprietors: Jacob Hetherington and Sons, Charles Henry, Wm. Kelly, Peter Schrum, Wm. G. Barnard, and the Pittsburgh Coal Works.

MEAD TOWNSHIP.

This township is situated on the Ohio River, south of Pultney. It has an extensive river frontage, and, consequently, contains a large area of rich bottom land. The hills are full of limestone, and the soil is generally good. The township is chiefly drained by Weegee Creek, Big Run, and Pipe Creek, all small tributaries of the Ohio. The hills are high, and often steep. The Bellair seam of coal underlies the whole township, doubtless forming one continuous sheet of coal proximately six feet thick. From Pultney township the seam gradually dips, and near the mouth of Weegee Creek it is reported to be found in the bed of the river at low water.

The coal is mined at several points—at the Weegee mines, at a point nearly opposite Moundsville, and near the mouth of Pike Creek, etc. The coal may at all points be reached by slope or shaft of moderate depth. The coal every where presents the usual appearance of the typical Wheeling coal. The location directly upon the Ohio River, the advantage that can be taken of the dip of the seam for easy drainage of the mines, and the thickness and general regularity of the seam, and consequent cheapness of mining, all unite to indicate that in the future this must be a coal field of much importance.

Coal has been extensively taken from the Weegee mines, in section 32, by P. Schaefer & Co. Here the seam is reached by a slope at the base of the river hill. The coal is sold to steamboats at the landing, and also shipped in barges to markets on the river below. The Empire Coal Company, Smith & Watson, and Lockwood, Burley & Co., are all engaged in mining coal in this township.

A careful section was taken of the strata in the hill adjacent to the river, about a mile below the Weegee mines, as follows:

		Ft.	In.
1.	Laminated sandstone	6	0
2.	Limestone	3	0
3.	Shale	8	0
4.	Hard blue limestone	4	0
5.	Shale, with a little iron ore	3	0
6.	Nodular calcareous ore	0	3
7.	Shale	3	0

		Ft.	In.
8.	Bituminous shale	1	0
9.	Coal	1	6
10.	Thin underclay (not measured).		
11.	Laminated sandstone	12	0
12.	Shale	2	0
13.	Limestone	2	0
14.	Shale, with nodular limestone	9	0
15.	Hard laminated limestone	7	0
16.	Not exposed	86	0
17.	Cement limestone	8	0
18.	Not exposed	40	0
19.	Coal (Cumberland seam)	4	0
20.	Not exposed	2	0
21.	Sandstone	13	0
22.	Blossom of coal.		
23.	Sandstone	16	0
24.	Limestone	2	0
25.	Shale	0	8
26.	Cement limestone	5	0
27.	Interval down to the coal in the slope not examined in detail, but largely limestone and shales, with one thin seam of coal, about	40	0

(Map XIV., No. 15.)

Samples of the cement limestone (No. 26 in the foregoing section) were taken for analysis by Prof. Wormley, and also a sample of the limestone just above. No. 1 was taken one foot six inches from the bottom, and No. 2 from near the top of the cement stratum. No. 3 is the limestone:

	No. 1.	No. 2.	No. 3.
Silicious matter	24.00	17.40	8.60
Alumina, with trace of iron	7.00	6.20	4.90
Lime, carbonate	37.90	51.80	80.70
Magnesia, carbonate	30.47	23.94	5.69
Totals	99.37	99.34	99.89

With an adequate market, cement lime could be very profitably made in Mead township.

YORK TOWNSHIP.

This township lies on the Ohio River, south of Mead. Captina Creek runs through the middle of it. The Bellair seam of coal does not continue its dip at the same rate as seen in Pultney and Mead townships, for it is found in the bed of the Ohio River at Powhattan, at the mouth of Captina Creek. In section 20, perhaps three miles up Captina Creek, the following section was taken on the land of Albert Green:

		Ft.	In.
1.	Limestone, somewhat sandy	10	0
2.	Clay shale	4	0
3.	Nodular limestone	1	0
4.	White clay shale	5	0
5.	Coal	1	2
6.	Clay	1	0
7.	Coal	5	10

(Map XIV., No. 20.)

The coal is reached by a slope of about fifteen feet in vertical descent. It is mined at this point only for neighborhood use, and the coal is lifted by horse-power.

On the land of John Owens, section 27, the following section was taken:

		Ft.	In.
1.	Sandstone	12	0
2.	Not exposed	25	0
3.	Coal	1	6
4.	Underclay (not measured).		
5.	Not exposed	156	0
6.	Cement limestone	10	0
7.	Limestone	6	0
8.	Shale	6	0
9.	Blossom of coal (Cumberland seam).		
10.	Clay	1	0
11.	Sandstone	10	0
12.	Shale	8	0
13.	Coal (not measured).		
14.	Clay	3	0
15.	Limestone	9	0
16.	Not exposed, but fragments of a cement limestone seam seen near the top	33	0
17.	Limestone	5	0
18.	Shale	10	0
19.	Coal	2	0
20.	Clay parting	0	6
21.	Coal	5	10
22.	Interval to bed of Captina Creek, from	8 to 10	0

(Map XIV., No. 19.)

The lower coal seam is to be traced from the mouth of Captina Creek to a point in the edge of Washington township, where it passes beneath the bed of the stream. It is every where low, and is perhaps as high above the creek at Mr. Owens's bank as at any other point. The seam preserves its average thickness. From Captina Creek a vast body of this valuable seam of coal could be mined to the north and north-west.

WASHINGTON TOWNSHIP.

This township lies west of York and south of Smith, and is drained by Captina Creek and its tributaries. The valleys are somewhat narrow, but the abundant limestones make the soil of valleys and hill-sides extremely rich and fertile.

A careful section was taken at Armstrong's Mills, as follows:

		Ft.	In.
1.	Yellow shale	8	0
2.	Blossom of coal.		
3.	Clay	6	0
4.	Sandstone and shale	15	0
5.	Laminated sandstone	3	0
6.	Sandy shales	7	0
7.	Sandstone	4	6
8.	Shale	10	0
9.	Sandstone	1	0
10.	Not exposed	1	0
11.	Blossom of coal, and not exposed	3	0
12.	Shale	2	0
13.	Laminated sandstone	3	0
14.	Compact sandstone	3	0
15.	Laminated sandstone	4	0
16.	Shale	4	0
17.	Sandstone	2	0
18.	Shale	10	0
19.	Buff limestone	1	0
20.	Not exposed	12	0
21.	Limestone	1	6
22.	Sandy shale	15	0
23.	Limestone and interstratified shales	12	0
24.	Hard buff limestone	3	0
25.	Shale	8	0
26.	Shales and sandy limestones, sometimes nodular	20	0
27.	Hard sandy limestone	4	0
28.	Cement limestone	1	0
29.	Hard limestone	0	4
30.	Cement limestone	5	0
31.	Hard sandy limestone, with interstratified shales	12	0
32.	Shale	1	6
33.	Coal (Cumberland seam)	2	0
34.	Slate, " "	0	1
35.	Coal, " "	1	4
36.	Underclay	2	0
37.	Sandstone	3	0

Bed of Captina Creek. (See Map XIV., No. 18.)

Samples of coal from the lower, or Cumberland, seam were taken from the bank of Hon. Isaac Welsh, about a mile below Armstrong's Mills, and analyzed by Prof. Wormley, with the following result. No. 1 was taken from toward the bottom of the seam; No. 2 was taken from toward the top of the seam:

	No. 1.	No. 2.
Specific Gravity	1.352	1.321
Water	2.50	2.30
Ash	10.50	11.20
Volatile combustible matter	32.50	32.50
Fixed Carbon	54.50	54.00
Totals	100.00	100.00
Sulphur	2.44	2.62
Sulphur remaining in coke	1.18	Not determ'd.
Percentage of sulphur in coke (as coke)	1.81	"
Gas in cubic feet per lb. of coal	3.39	2.96
Color of ash	White.	Gray.
Coke	Compact.	Compact.

On the land of David Caldwell, on Crab-Apple Fork, section 27, the following section was taken:

		Ft.	In.
1.	Coal, with shale roof, three-feet seam, reported	5	0
2.	Not exposed	25	
3.	Sandstone and shales	11	0
4.	Shale	10	0
5.	Coal	2	0
6.	Clay	1	0
7.	Limestone	2	6
8.	Sandy limestone	1	0
9.	Limestone	2	0
10.	White sandy shale	1	6
11.	Limestone	3	0
12.	Laminated sandy shale	10	0
13.	Clay shale	5	0
14.	Laminated white sandstone	12	0
15.	Clay shale	4	0
16.	Coal	3	7
17.	Underclay	2	0
18.	Mostly shale	18	0
19.	Buff limestone	2	0
20.	Clay shale	12	0
21.	Hard limestone	1	6
22.	Clay	3	0
23.	Laminated sandstone, hard	8	0

Bed of stream. (See Map XIV., No. 16.)

The coal seam No. 1 in this section corresponds nearly in geological position with a seam forty-two feet above the tunnel seam at Barnesville. The next below, or No. 5, corresponds to the tunnel seam, and No. 16 with the seam first below the tunnel and the lower coal seam at Lewis's Mills. At Barnesville these upper seams are all thin, and of no practical value. At Mr. Caldwell's, the lowest, or No. 16, is mined to a limited extent. It is a coal of fair quality.

The Cumberland, or four-feet seam, has been mined in the north-west corner of Washington township, on Bend Fork, and appears to have a dip to the south-east, corresponding to the dip of this stream. It is nowhere more than a few feet above the water. Pieces of fossil silicified wood were occasionally seen in the bed of Bend Fork, having fallen from some stratum in the hill-sides, but their original place was not ascertained.

WAYNE TOWNSHIP.

This township lies west of Washington and south of Goshen. It is drained by Captina Creek. The soil is of fair quality.

The Cumberland, or upper Barnesville, coal seam is worked along the creek at various points. A section was taken on the land of Joseph Moore, section 17, as follows:

		Ft.	In.
1.	Blossom of coal.		
2.	Not exposed	44	0
3.	Limestone	2	0
4.	Not exposed	9	0
5.	Buff limestone	1	0
6.	Not exposed	13	0
7.	Laminated limestone	6	0
8.	Cement limestone	4	0
9.	Limestone	11	0
10.	Dark shale	2	0
11.	Coal (Cumberland seam)	2	6
12.	Clay	2	0
13.	Sandstone many feet thick, but the bottom not seen.		

(Map XIV., No. 17.)

The sandstone below the coal forms the bed of Captina Creek for two or three miles. The cement limestone (No. 8 in the above section) is the same as that found at Warnock's Station, on the Central Ohio Railroad.

CHAPTER LV.

REPORT ON THE GEOLOGY OF MONROE COUNTY.

This county lies east of Noble and south of Belmont. It has the Ohio River for its eastern boundary. The river margin is about twenty-nine miles in length. In this distance, according to report of W. Milner Roberts, United States Civil Engineer, the river falls 20.557 feet, or about twenty feet six and a half inches; making an average fall of 0.708 inches per mile. Most of the fall, however, pertains to the ripples, which, in the aggregate, fall 18.28 feet, while the descent in the pools is 2.277 feet. There are 8.56 miles of ripples and 20.44 miles of pools. The average fall in the ripples is 2 feet 1.6 inches, and that of the pools is 1.114 inches.

Nearly all of the southern half of the county, except a narrow strip along the Ohio, is drained by the Little Muskingum River and its branches. The extreme north-western portion finds its drainage by Wills Creek. Sunfish Creek drains the larger part of the northern portion. Thus there are three distinct systems of drainage, or, more properly, drainage slopes, viz., south-western, north-western, and eastern.

The soil of the county is generally good. In many sections there is considerable limestone of much fertilizing value. The character of the tillage of the soil is superior to that in many of the counties in the Second Geological District. In the survey of the county I have been much indebted to Hon. James O. Amos, of Woodsfield, now Adjutant-General of Ohio, for valuable information and assistance. He accompanied me through many townships. The county lies not only wholly within the Coal Measures, but nearer the summit of the series than any other county in the district. The highest seam of coal found in the district is on a very high hill near Baresville, Ohio township.

The determination of the relation of the coals in this county to those of Noble and Belmont is attended with unusual difficulties. The Pittsburgh, or Pomeroy, seam of coal, if continuous, is every where below the level of the valleys, and the Cumberland, or upper Bellair, seam is generally thin and unimportant. There are no coal seams, well-marked and of ready identification, and no fossiliferous limestones, like the Ames or Cambridge limestones of other counties. Indeed, there is nothing of wide range that may serve as a datum line by which the geologist may be guided. The dip of the strata, moreover, is not uniform, and, consequently, is not a reliable guide until it is determined for a given area; and identification of the same seam of coal or other stratum at two or more different points is a prerequisite to this determination of dip. Hence in a large part of Monroe county the chief geological factors are unknown terms. The supposition that the Evans coal, near Woodsfield, is the diminished equivalent of the Cumberland, or upper Barnesville seam, appears the more probable one, and I have so given it on the map of grouped sections. The other seams of coal are all, I think, accurately brought into their proper relation to this, as shown on the map.

FRANKLIN TOWNSHIP.

This township lies on the western part of the county, and borders Stock township, in Noble county. The land in the northern part of the township is high, and divides the waters of Clear Creek—a branch of the Little Muskingum River—from those of Wills Creek, which flow northward.

There is considerable limestone to be seen, and the soil is generally productive.

The Cumberland seam of coal, which extends so generally through Noble county, and which is found in the hills at Carlisle, is found in the neighborhood of Stafford. The larger developments seen were on Road Fork, and they may be located just over the line, in Elk township. Here the coal is four feet six inches thick.

The following section was taken on the land of Mr. Ed. Okey, in section 8:

		Ft.	In.
1.	Blossom of coal.		
2.	Not exposed, sandstone at top	90	0
3.	Buff magnesian limestone	10	0
4.	Shale	2	6
5.	Coal	3	8
6.	Underclay	2	0
7.	Sandstones and shales	10	0
8.	Hard limestone	3	0

This section is by oversight placed on the Noble County Map of Grouped Sections XII., No. 33.

The creek at Okey's Mill, on Clear Fork, is reported to be forty-five feet higher than Road Fork at the woolen mill, but the coal at both places is covered by the same buff limestone. Further down Road Fork the limestone is replaced by sandstone. There are changes in thickness of the coal and in the lithological character of the associated strata, and there are undulations in the strata which change locally the direction of the dip.

In section 7, in this township, the coal of the Cumberland seam is reported to be only one foot eight inches thick. It will be hereafter seen that as we go eastward this seam of coal becomes thin, and of far less value than in Noble county.

Dim traces of a higher seam were seen in section 8. This is a coal horizon, but the seam is never found to be of much importance.

SENECA TOWNSHIP.

This is the north-western township in the county. It is intersected by several branches of Wills Creek, which have, during the ages, made for themselves beautiful and fertile valleys. There is also generally limestone enough in the hills to make the soil of the hill-sides productive. The streams rise in the high lands to the east and south-east, in Summit and Malaga townships. Traces of four seams of coal were seen in passing from the valley at Calais to Miltonsburg, in Malaga township; but at the time of the examination we learned of no openings where accurate measurements could be made. Since that time I have heard that openings have been made into some of the seams. The two lower seams are pretty low in the hills, while the others are quite high.

The geological section from Calais to Miltonsburg is as follows:

		Ft.	In.
1.	Blossom of coal.		
2.	Not seen	45	0
3.	Limestone (not measured).		
4.	Not seen	92	0
5.	Blossom of coal.		
6.	Interval not seen	193	0
7.	Blossom of coal.		
8.	Underclay	2	0
9.	Buff limestone	7	0
10.	Shale	6	0
11.	Sandstone, with some shale	20	0
12.	Blossom of coal.		
13.	Shale	16	0
14.	Buff limestone	1	0
15.	Shale	4	0
16.	Buff limestone	4	0

(Map XIII., No. 1.)

The coal No. 5 in the above section was thought to be the equivalent of a thin seam seen in the deepest cut on the Central Ohio Railroad, in Goshen township, Belmont county. Coal No. 7 in the section is supposed to be the equivalent of the coal in the Sunfish valley, near Woodsfield. In the interval of one hundred and ninety-three feet between Nos. 5 and 7 in the section, which did not reveal to us its strata, every thing being buried with soil, there should be found other seams of coal, which at other points have been found of some value.

MALAGA TOWNSHIP.

This township lies west of Seneca, and borders Somerton, of Belmont county, on the north. It is, for the most part, on the high, broad ridge, which, beginning in Summit township on the south, extends north through Somerton, Warren, etc., townships, in Belmont county, and constitutes the divide between the direct tributaries of the Ohio on the east and the various tributaries of Wills Creek on the west. Much of the high land is smooth, and well adapted to fruit culture. Traces of thin seams of coal were found in going from Miltonsburg to Calais, which are mentioned in the report for Seneca township. Traces of similar seams were seen on the road from Miltonsburg to the deep valley of Sunfish Creek, in Center township, which at Ford's Mill is about three hundred feet below Miltonsburg. They were nowhere opened, and probably are too thin to be worked, except in a small way for neighborhood use, by the rude method of stripping. They are all high in the geological series, and nowhere in the Second Geological District are they found to be of much practical value. Some limestone strata were seen, which aid much in fertilizing the soil.

SUMMIT TOWNSHIP.

This township is well named, for it is upon a very high ridge, from which the water flows into Wills Creek on the north-west and west, into Sunfish Creek on the east, and into various tributaries of Little Muskingum on the south. A hill on the land of George Frock, a half mile south-west of the village of Lewisville, is one of the highest points in the county. It is one hundred and thirty feet above the upper seam of coal, and about three hundred and forty to three hundred and sixty above the lower coal found on the South Fork of Wills Creek. A distant knob, in the direction south, 25° east, is a little higher. The Lewisville hill is on the Marietta road, and, as usual in south-eastern Ohio, the road runs over the highest point! The following section was taken in passing from the Lewisville hill down to the coal seam on the South Fork of Wills Creek:

		Ft.	In.
1.	Top of knob.		
2.	Not exposed	130	0
3.	Blossom of coal.		
4.	Limestone	2	0

		Ft.	In.
5.	Shale	3	0
6.	Sandstone	2	0
7.	Shale	3	0
8.	Limestone	4	0
9.	Shale	5	0
10.	Limestone	1	0
11.	Shale, and not seen	28	0
12.	Buff limestone	0	6
13.	Shale	5	0
14.	Limestone	1	0
15.	Not seen	15	0
16.	Dark clay shale	15	0
17.	Coal (Cumberland seam)	1	0

(Map XIII., No. 2.)

On the land of Wm. Smith, section 18, the following section was taken:

		Ft.	In.
1.	Limestone	1	0
2.	Not exposed	54	0
3.	Clay shale	8	0
4.	Black slate, with coal plants	1	3
5.	Coal (Cumberland seam)	1	10

(Map XIII., No. 3.)

The coal has been mined by Mr. Smith to a small extent, and some has been taken to Woodsfield.

On the land of J. R. Fisher, on Sunfish Creek, north of Wm. Smith's, a stratum of iron ore nine inches thick is reported by Hon. J. O. Amos. It is thought to be about fifty feet above the Woodsfield (Evans) seam of coal.

WAYNE TOWNSHIP.

This township lies south of Summit and west of Center. It is drained by the Little Muskingum and its branches. The general character of the surface of the hills and valleys corresponds with that of the adjacent townships. The land is of fair quality, and some limestones are found, which serve to fertilize the soil.

In this township, as in many of the townships in this county, there is little of economic interest or value in the geological features. So far as could be learned, all the seams of coal are thin, and exposures for measurement were not found. It is, however, quite possible that at some points the coal may be thick enough to be of considerable practical value. No good geological sections were taken in the township.

BETHEL TOWNSHIP.

This is the south-eastern township of the county. It is chiefly drained by the waters of Clear Fork of Little Muskingum. The Cumberland seam of coal is found in this township, it being readily traceable from Elk township, of Noble county, on the west. On the land of Lorenzo Manly, section 2, the following geological section was obtained:

		Ft.	In.
1.	White limestone (not measured).		
2.	Not exposed	25	0
3.	Sandstone	12	0
4.	Shale	7	0
5.	Coal (Cumberland seam)	1	10
6.	Clay, " "	1	8
7.	Coal, " "	3	0
8.	Clay, sandstone, and shale	9	0
9.	Impure limestone	1	0
10.	Shale	8	0
11.	Sandstone	18	0
12.	Red shale	6	0
13.	White limestone	2	0

Bed of Indian Run. (Map XIII., No. 21.)

Mr. Frank Halliday, in the same section, has mined the same seam of coal quite extensively. The coal must be found in all the hills in its proper geological horizon.

WASHINGTON TOWNSHIP.

This township lies east of Bethel. It borders Ludlow, in Washington county, on the south. It is drained by Clear Creek and other tributaries of the Little Muskingum.

The Cumberland seam of coal is found in this township, but so far as could be ascertained it is in limited development. Very little coal has been mined in the township. The village of Graysville is supplied from Indian Fork, in Bethel township.

On the land of J. Knowlton, section 24, we find the following geological section:

		Ft.	In.
1.	Buff limestone	8	0
2.	Shale	15	0
3.	Sandstone	8	0
4.	Shale	4	0
5.	Coal	1	0
6.	Clay	2	6
7.	Coal	1	0

Bed of run. (Map XIII., No. 20.)

Traces of two higher seams of coal were seen, but the seams are nowhere opened. They are probably thin. Limestones are found in the hills, which tend to fertilize the soil.

BENTON TOWNSHIP.

This township is situated upon the southern border of the county. It is east of Washington and west of Jackson townships. The Little Muskingum River flows through it.

No very interesting geological facts were obtained here, the only coal seam mined, so far as could be learned, being one of the higher ones. The upper part of the seam is often quite slaty. On the land of Eli Eddy, section 11, the seam is mined, and found to be three feet thick. This seam is believed to be the same as that found on the lands of Wm. Raper and George Shy, section 34, Jackson township.

About thirty feet below the coal in Jackson township is found nodular iron ore. It is worth looking for in the same geological horizon in Benton, for it may be found to exist in a regular seam of much value.

In section 18 a seam of coal is reported to be four feet thick—three feet of it slaty—overlain by thirty feet of sandstone.

PERRY TOWNSHIP.

This township lies east of Washington, and is wholly upon the waters of the Little Muskingum. There is much limestone in many of the hills, and the soil is generally good.

Coal is seen at several points. At Basil Dye's, section 21, the seam is unusually thick for this region. A geological section at this place revealed the following:

		Ft.	In.
1.	Shale	6	0
2.	Hard, brittle limestone	0	10
3.	Laminated crumbling limestone	6	0
4.	Not seen	8	0
5.	Fine-grained greenish sandstone	5	0
6.	Laminated blue limestone	2	0
7.	Hard blue limestone	3	0
8.	Not exposed	80	0
9.	Shale	8	0
10.	Coal	1	6
11.	Clay shale	0	4
12.	Coal	2	7

(Map XIII., No. 8.)

This seam of coal is thought to be the Cumberland seam, and is so grouped on the map. There are so many changes of dip and undulations of the strata through all this region, that it is very difficult to make out the equivalents.

At Alexander's Mill, section 3, in this township, another section was taken, showing the coal and associated strata, as follows:

		Ft.	In.
1.	Sandstone	25	0
2.	Shale	46	0
3.	Sandstone	20	0
4.	Clay shale	50	0
5.	Coal, somewhat slaty	1	3
6.	Clay shale, with coal plants	1	0
7.	Coal	0	6
8.	Slate	0	2
9.	Coal	0	8
10.	Clay and clay shale, with nodules of siderite ore	9	0
11.	Limestone, nodular	1	0
12.	Shaly limestone	3	0
13.	Limestone	3	0
14.	Clay shale to bed of creek	3	0

(Map XIII., No. 7.)

Another seam of coal is reported as having been found eleven feet below the bed of the creek, or about thirty feet below the other seam. We had no opportunity to see it. The seam given in the section is opened and wrought in section 35, in the same township. It is also mined in Center township.

JACKSON TOWNSHIP.

This township lies upon the Ohio River. The dividing ridge between the Ohio and Little Muskingum waters extends through the western and north-western portions of the township. There is a long stretch of rich alluvial land bordering the Ohio River. This must compensate for a comparative dearth of valuable minerals. The township is not, however, destitute of coal, but the quality is not the best; and there is also promise of iron ore.

On the land of Wm. Raper, section 34, the following section was taken:

		Ft.	In.
1.	Laminated sandstone	12	0
2.	Sandy shale	8	0
3.	Coal, upper three feet slaty	4	0
4.	Underclay, sandstone, and sandy shales	30	0
5.	Red shale, with ore near the top	35	0
6.	Heavy sandrock	25	0
7.	Shale, with traces of coal	10	0
8.	Buff sandy limestone	0	10

		Ft.	In.
9.	Laminated sandrock	30	0
10.	Shale	18	0
11.	Limestone	1	0
12.	Shale	8	0
13.	Sandstone	5	0
14.	Shale, and not seen	22	0
15.	Sandstone	4	0
16.	Buff limestone	1	0
17.	Shale	5	0
18.	Limestone layers, white and buff	11	0
19.	Hard, greenish, fine-grained sandstone	3	0
20.	Interval to Ohio River	50	0

(Map XIII., No. 23.)

The last three items of the above section are not included in the map. The limestone in No. 18 of the section is sometimes burned into lime.

The same seam of coal seen on Mr. Raper's land is mined by Mr. George Shy, who lives also in section 34. The seam measures three feet, the upper part showing the usual slaty character. Iron ore is found thirty feet below the coal. It is not yet known to constitute a regular layer. Mr. Shy has dug a ton or more of it. A sample of the ore was analyzed by Prof. Wormley, and found to contain only 12.13 per cent. of metallic iron.

CENTER TOWNSHIP.

This township is central in the county, and in it is Woodsfield, the county seat. Sunfish Creek flows through it on the northern part, and branches of the Little Muskingum drain the southern portion.

The seams of coal in this township are, so far as seen, thin, although they are mined for the home supply. Some very superior iron ore is found in the red clay shales west of Woodsfield.

The following geological section is a grouping of the more important strata seen in passing from Woodsfield north, down into the valley of Sunfish Creek:

		Ft.	In.
1.	Red clay shale, with nodules of iron ore	9	0
2.	Red shale, with a little ore	26	0
3.	Limestone	1	0
4.	Red shale, with nodules of ore at bottom	27	0
5.	Not exposed	51	0
6.	Coal, reported	0	6
7.	Not seen	23	0
8.	Coal (stripped west of Woodsfield)	1	6
9.	Chiefly shales, with some nodular ore (west of Woodsfield)	70	0
10.	Blossom of coal.		

		Ft.	In.
11.	Not seen	91	0
12.	Sandstone	5	0
13.	Shale	4	0
14.	Coal (Cumberland seam)	1	8
15.	Clay, " " coal plants	2	8
16.	Coal, " "	0	2
17.	Clay, " "	0	5
18.	Coal, " "	0	10
19.	Underclay.		

(Map XIII., No. 6.)

The measurements of the lower coal were made at the bank of Stephen Evans, where the coal is mined by a drift-way. This is a good locality for finely preserved coal plants. There is by the road-side, as we descend from the high ground into the valley, a heavy sandrock, twenty feet thick (not given in the foregoing section), the place of which is twenty or twenty-five feet above the blossom of coal marked No. 8 in the section. The thin coal, No. 6, may be directly under the sandstone, although not seen at this point.

On the land of Robert Pope the same seam of coal as that mined by Mr. Evans is seen, with the following subdivisions:

		Ft.	In.
1.	Coal	1	8
2.	Clay	0	4
3.	Coal	0	2
4.	Clay	0	6
5.	Coal	0	2
6.	Clay	0	4
7.	Coal	0	9

The geological section, including this coal, is seen on Map XIII., No. 4. In the bed of Sunfish, a little above the water, we find on the land of Henry Windland a fine stratum of cement limestone. It is about seventy-five feet below the Evans seam of coal. The geological section at this point is as follows:

		Ft.	In.
1.	Coal (Evans seam)—not measured.		
2.	Not exposed	61	0
3.	Limestone	4	0
4.	Magnesian, or cement, limestone	1	0
5.	Shale	6	0
6.	Limestone	1	0
7.	Clay shale	2	0
8.	Cement, or magnesian, limestone	5	0
9.	Limestone	4	0

(Map XIII., No. 5.)

A sample of the lower cement limestone taken from near Henry Windland's Mill was analyzed by Professor Wormley, with the following result:

Silicious matter	20.90
Alumina and sesquioxide of iron	6.10
Lime, carbonate	44.00
Magnesia, carbonate	29.02
Total	100.02

This limestone has a handsome appearance, and with proper treatment should make a good cement lime.

The iron ore found in the red shales west of the town is very pure and excellent, as will be seen from the following analysis by Professor Wormley:

Specific gravity	2.900
Water	2.00
Silicious matter	13.28
Iron, sesquioxide	77.11
Alumina	4.40
Manganese	0.40
Lime, carbonate	1.79
Magnesia, carbonate	0.30
Sulphur	0.06
Total	99.34
Metallic iron	53.98
Phosphoric acid	trace.

This is scarcely a hydrated sesquioxide or limonite, the percentage of water being only 2. The iron made from this ore would be admirably adapted to the manufacture of Bessemer steel.

At Stead's Mill, section 27, the following geological section was taken:

		Ft.	In.
1.	Crumbling limestone, somewhat magnesian	2	0
2.	Interval not exposed	148	0
3.	Sandstone	10	0
4.	Shale	5	0
5.	Sandstone	1	0
6.	Coal	0	2
7.	Black bituminous slate	3	0
8.	Coal	0	2
9.	Shale	0	6
10.	Coal	1	0
11.	Clay	3	0
2.	Coal	0	6

(Map XIII., No. 9.)

In passing down Standing Stone Branch of Sunfish Creek from Woodsfield we find traces of two or three seams of coal. The upper one has supplied a little coal from stripping. This is ninety feet below the level of the street in front of the Star House. Below this are traces of a so-called pottery seam, the underclay of which is used for making ware. This pottery seam must be one hundred and thirty to one hundred and forty feet above the cement limestone. The place of the Evans coal is about seventy-five or eighty feet above the same limestone. There is on Standing Stone a heavy sandrock, forty feet thick, seen near the old pottery works. It is a firm and durable stone, but hard to work. Underneath it are clays and shales, and a trace of a coal seam.

On the land of A. Chrisner, section 14, on Standing Stone, three miles east of Woodsfield, a geological section was taken, which is seen on Map XIII., No. 12. Here both the cement limestone and the Evans coal are seen.

From Chrisner's the descent of the water of Standing Stone and Sunfish to section 25, in Adams township, a distance of four and a half miles in a straight line, is by aneroid barometer one hundred and seventeen feet. The cement limestone, which is in the bed of Standing Stone at Chrisner's, is in section 25, Adams, thirty feet above the bed of Sunfish. This gives a dip of eighty-seven feet, or about nineteen feet per mile. Below the cement limestone comes in a heavy sandrock.

ADAMS TOWNSHIP.

This township lies east of Center, and directly upon Sunfish Creek, which passes through the middle of it from west to east. The geology of the township is simple, for the cement limestone of Center township, with the seam of coal about eighty feet above it, is easily traced all the way down the creek through the township. In some places it is thirty feet above the stream, while at Cameron it dips below it. In one place a well-defined arch is made by the limestone group.

A geological section was taken on the land of Jacob Weekly, section 25, which is given in Map XIII., No. 13.

Here we have one of the very best developments of coal seen in the county. There are four feet three inches of coal, exclusive of two thin clay partings, one two and a half inches, and the other one inch thick. Over the coal is a foot of slate, and over the slate sandstone. If there were a railroad up the valley of Sunfish to Woodsfield, this would be the source of supply for the region west.

In the neighborhood of Cameron, and partly on the land of John Boughner, in section 13, a geological section was taken, which is given on Map XIII., No. 14. In this section are three seams of coal above the cement limestone—one the Jacob Weekly seam, about eighty feet above, another only seen in its blossom or stain, ninety-six feet higher, and a third, reported to be three feet thick, sixty-four feet above the second. The lower seam is mined successfully for the supply of several neighboring villages and mills. The upper seam is probably thick enough to be worked.

At Cameron the cement limestone dips below Sunfish Creek, and does not I think, reappear at any point down the stream.

On the lands of Mr. Moberly and Leonard Twinem the same shales found north of Woodsfield are seen, with similar promise of iron ore. The nodules appear to be of larger average size. The ore is excellent.

SUNBURY TOWNSHIP.

This township is situated on the northern border of the county. It lies upon the high ridge dividing the waters of Captina Creek, in Belmont county, on the north, and those of Sunfish Creek on the south. The principal drainage, however, is toward the latter stream. While there is much smooth and comparatively level land along the summit of the broad ridge, the southern slope is somewhat roughened by the tributaries to Sunfish, which in many places have scored for themselves deep and rocky channels. In the geology of the township little of economic importance and value could be found. The chief seams of coal of Belmont county are far beneath the surface. In Wayne township, Belmont county, which lies directly north of Sunbury, the upper Barnesville, or Cumberland, seam is near the bed of Captina Creek. If the Evans coal, on Sunfish, north of Woodsfield, is the same seam, it is evident that it must be far below the general surface in Sunbury. In Washington township, Belmont, in section 27, on Crab-Apple Fork, are three seams of coal, which come in above the one last mentioned. They are respectively about ninety, one hundred and thirty, and one hundred and seventy-five feet above the upper Barnesville seam, the seams being three feet seven inches, two feet, and five feet (reported) thick. These are also below the surface of the Sunbury Ridge.

Near Beallsville is a thin seam of coal, perhaps one hundred and twenty feet below the level of the village, which is sometimes stripped for local use. As we descend a valley to the south we find, about one hundred and twenty feet below this coal, under a heavy sandrock, a streak of black bituminous shale, which doubtless represents a coal horizon, although at this point no coal was found. About forty feet lower was an apparent stain of coal. It is possible that these traces may be the impoverished representatives of the two upper seams referred to on Crab-Apple Fork, in Washington. It may be that at other points in Sunbury they may be found of some value.

At another place two blossoms of coal were seen on Piney Creek, one low in the valley, and the other one hundred and twenty or one hundred and thirty feet higher. It was impossible to determine their exact stratigraphical position in the general series. The inquiries made by Hon. Mr. Amos and myself in this township were not rewarded by any definite information respecting any coal seam of value. It is, however, not improbable that somewhere these high seams—generally thin and unimportant—may be found sufficiently thick for working and adequate to all local demands.

SALEM TOWNSHIP.

This township lies east of Adams, and has the Ohio River for its eastern border. Sunfish Creek passes through the township from west to east, emptying into the Ohio at the village of Clarington. Possum Creek, which empties into the Ohio two or three miles below Clarington, drains the southern part of the township.

In descending Sunfish Creek the cement limestone, which is about eighty feet below the Woodsfield seam of coal, dips below the stream in the neighborhood of Cameron, in the western part of Adams township. From Windland's Mill, in Center township, to Cameron, this limestone has been found to dip to the eastward nearly with the fall of the creek. But in Salem township, the fall of the creek, as it approaches the Ohio River, is probably less, and thus the cement stratum would have its place somewhat below the bed of the creek at Clarington. The Woodsfield coal should be about eighty feet above. We find a seam of coal at several points in the lower part of the Sunfish valley, which is the continuation of this seam. It is seen most distinctly at the bank of Jacob Mehl, a fourth of a mile up Negro Run, a branch of Sunfish, about a mile from Clarington. Here the seam shows the following subdivisions:

		Ft.	In.
1.	Coal	1	6
2.	Clay	0	1
3.	Coal	0	6
4.	Clay	0	3
5.	Coal	0	4
6.	Underclay	2	4

At Clarington the same seam is mined by Jonathan Jones, where we find the upper bench of coal one foot six inches, separated by an inch parting from a lower bench of four inches. The lowest bench found at Mr. Mehl's bank was not noticed here. The Jones seam of coal at Clarington is about twenty-five feet above the top of the shaft sunk to reach the Wheeling seam of coal. The shaft is now filled with water, and I could learn little of the strata through which it passed. In the debris around the shaft I saw fragments of cement limestone. It was reported that this cement limestone came from about fifty feet below the top of the shaft, or about seventy-five feet below the coal. This is about the place of the cement stone, with reference to the Woodsfield seam of coal. Is the Woodsfield, or the Jacob Weekly (of Adams township), seam of coal the same as the upper Bellair and upper Barnesville seam? I have so given it in the grouping on the map, *not as a settled fact, but as the more probable determination.* It is very difficult to carry the exact place of a seam of coal through long ridges and highlands, such as hem in the Sunfish valley on the north and west. The dip is unknown both in rate and direction, and the seams of coal are often subject to very great changes in thickness and quality.

If the Clarington coal seam, twenty-five feet above the shaft, is the upper Barnesville seam, then the shaft, eighty feet deep, is deep enough to reach the Wheeling seam; at least, the seam could not be far below, for the greatest interval I have found between the two seams is one hundred and five feet. The shaft should certainly have been sunk a few feet lower before abandonment, or a trial boring should have been made. If the seam above the shaft is not the upper Barnesville, or upper Bellair, seam, it must be the one found in Belmont county some ninety feet higher—the first seam below the tunnel at Barnesville—and in that case the shaft, or boring, must be sunk ninety feet deeper to reach the Wheeling seam. But the shaft is deep enough to have passed through the upper Barnesville seam, but nothing was seen of this, so far as I could hear. The probability is, I think, in favor of regarding the coal above the shaft as the upper Barnesville seam, which is the Cumberland seam of Guernsey, Noble, and Washington counties. If a few feet had been bored below the bottom of the shaft without finding the Wheeling seam, we might have serious doubts in regard to finding it at all. At Somerton, in Belmont county, its horizon was passed through in boring, and no coal was found. In several counties between Meigs and Belmont it is subject to great changes, and it often disappears altogether. There are certain areas where it is continuous and uniform, where a shaft might be sunk to it, with a strong antecedent probability of finding the seam in good development; but as a rule it is not safe to sink a shaft to find this or any other seam of coal in Ohio, without first making a trial boring.

Besides the seam supposed to be the upper Barnesville, or Cumberland seam, mined by Mr. Jones, near Clarington, and by Mr. Mehl, on Negro Run, there are in Salem two well-defined seams higher in the hills—one about one hundred feet above Mehl's seam, and the other about seventy feet higher. Both of these have been opened, but are little worked.

In passing up Negro Run we find on the land of Abraham Long, section 2, both of these seams. The geological section is as follows:

		Ft.	In.
1.	Coal	2	0
2.	Shales, with a little sandstone	70	0
3.	Coal	2	10
4.	Slate parting	0	2
5.	Coal	0	8
6.	Not seen, probably clay	0	3
7.	Hard blue slate	0	6
8.	Blue, sandy, bituminous limestone	0	8
9.	Blue slate	2	0
10.	Limestone, weathering buff	2	0

(Map XIII., No. 19.)

SWITZERLAND TOWNSHIP.

This is the north-eastern township of the county. The land is generally high, and, from the ridge running east and west through the center of the township, streams flow to the north into Captina Creek, to the east into the Ohio, and to the south into Sunfish. The soil is largely formed of disintegrated shales and sandstones, and is naturally less rich than the more limestone soils, but the German and Swiss farmers have done wonders in its cultivation, and there is no better farming in the State. Almost every farm has its small vineyard, and other fruits are successfully cultivated. There is an air of neatness and thrift quite in contrast with the slovenly character of much of our native American farming in Southern Ohio.

On the land of Jacob Davis, in section 3 of range 4, is seen in the bed of a stream a seam of coal, reported to be four feet thick, which is the same seam as the upper one on the land of Abraham Long, in section 2, Salem township. The coal is somewhat slaty. It is given in Map XIII., No. 22. Above this seam of coal no other coal was seen in climbing three hundred and sixty-eight feet to the top of a high knob on the farm of Charles Dota, about two miles to the north or north-east of Mr. Davis's, in section 3. On the summit of the knob are several feet of crumbling limestone. Below the limestone are red and yellow shales, below which is a heavy sandrock, nearly fifty feet thick. (See Map XIII., No. 18.) The highest part of the ridge cannot be less than five hundred and fifty fe t above the Ohio River, and it may be six hundred feet.

On the land of Ezekiel Mills is a layer of limestone. It is probably not less than one hundred and fifty feet below the limestone on Mr. Dota's hill. Nothing more of geological interest could be found among these high hills.

GREEN TOWNSHIP.

This is an irregularly shaped township, lying west of Ohio township. It is drained chiefly by the Little Muskingum River and its branches, excepting the eastern part, in which are the heads of Possum Creek. A section was taken on the land of Harvey Huffman, disclosing three seams of coal. The section is as follows:

		Ft.	In.
1.	Blossom of coal.		
2.	Not exposed	72	0
3	Sandrock	23	0
4.	Shale	3	0
5.	Blossom of coal.		
6.	Not exposed	65	0
7.	Slaty coal, with shale roof	0	6
8.	Slate parting	0	1
9.	Coal	0	9
10.	Parting	0	1
11.	Coal	0	10
12.	Parting, thin.		
13.	Coal	0	8

The middle seam of the above section, or No. 5, is worked near Newcastle, where it is two feet thick. It is said to be of excellent quality. No other seams were seen in this township.

OHIO TOWNSHIP.

This township is situated upon the Ohio River. From the curves of the river it has a long stretch of river border, and, consequently, a large area of rich alluvial valley land. The hills back from the river are very high. The north-western portion of the township is drained by Possum Creek, which flows in a general north-eastern direction, and empties into the Ohio in Salem township. The population is similar to that of Switzerland township, and the cultivation of the soil receives very careful attention. Near Sardis two seams of coal are found—the lower one about ninety feet above the Ohio River, and the other about one hundred and ninety feet higher. (See Map XIII., No. 10.) The lower was not measured. It is probably the equivalent of the Woodsfield seam. The upper seam presents the following subdivisions:

		Ft.	In.
1.	Shale	3	0
2.	Coal	0	6
3.	Clay	0	3
4.	Coal	1	8

The quality of the coal of the lower bench is good. This seam is reported to be worked at another point, and found to be four feet thick. This measurement probably includes the clay parting. A seam of hard blue limestone, two feet thick, is seen about one hundred and forty feet below the upper coal. A very long section was taken at Baresville, extending to the top of a very high hill, about two miles from the village, which disclosed four seams of coal. The lowest one, probably the Woodsfield seam, is about forty-five feet above low water in the Ohio River. This is two feet thick. The next is one hundred and ninety-three feet higher, with nine inches of coal in the upper bench, separated from the lower bench of two feet by four inches of clay parting. About one hundred and forty-seven feet higher is the blossom of another seam of coal. Nearly three hundred feet higher, and on the summit of the hill, is another blossom of coal. This hill, by the barometer, is six hundred and seventy-nine feet high from the low-water level of the Ohio River. About one hundred and thirty-five feet below the top of the hill are six feet of limestone, the lower two of which are cement limestone. Eighteen feet lower are two feet of sandy limestone. This section is seen on Map XIII., No. 11. It is for the most part a weary alternation of sandstones and shales.

CHAPTER LVI.

REPORT ON THE GEOLOGY OF PICKAWAY COUNTY.

This county lies wholly within the Scioto valley, and is bounded by Franklin county on the north, Fairfield and Hocking counties on the east, Ross county on the south, and Fayette and Madison on the west. The principal affluents of the Scioto within this county are on the east—Scipio Creek and Little Walnut Creek; and on the west, Darby Creek and Deer Creek. The last mentioned empties into the Scioto in Ross county. Deer and Derby creeks are streams of considerable size, which rise in the north-west, beyond the limits of the county, and flow through it to meet the Scioto.

SURFACE GEOLOGY.

The general surface of this county is comparatively level, and constitutes a part of the broad area of the smooth and unbroken country which stretches away to the north and west through a large number of counties. The valley of the Scioto, which in southern Ross, and in Pike and Scioto counties, is gradually diminished in width as it approaches the Ohio River, becomes in Pickaway county wide enough to include nearly all the county. No high, rough hills border the river; but in the distance, especially on the east, we find a somewwat elevated horizon, as the lowlands gradually pass by beautiful undulations into the highlands, which divide the waters of the Scioto from those of the Hocking. It is among these gentle hills that we find the finest scenery of the county.

The whole county is covered with Drift, and every where can we find, in gravel or bowlders, evidences of an agency which has brought foreign materials and scattered them over the surface. The bowlders are composed of granites, diorites, quartzites, etc., which have come from regions north of the lakes. Occasionally a limestone bowlder is seen, and much of the Drift gravel is composed of the same material. The whole surface of the county presents the appearance of having been once the bed of a shallow sea, for the gravel and sand show ripple marks and other modifications, such as water only could produce. The bowlders were, as I think, dropped from floating ice. They are seen almost every where, but perhaps more along the eastern edge of the county, especially in Salt Creek township, and may be traced in diminished numbers for a considerable distance down the Salt Creek valley. This Salt Creek presents to the geologist some very interesting features. It rises in Salt Creek township, within the proper basin of the Scioto valley, but leaves the basin and curves to the eastward for many miles among the high hills of Hocking and Vinton counties, to come back into the narrowed valley of the Scioto in the south-east corner of Ross county. To make this distance it has been obliged to work out a deep channel for itself in the Waverly sandrock. In some places it flows in a narrow gorge, with scarcely room enough upon the banks beneath the cliffs for highways. Some of the wildest and most picturesque scenery in the State is to be found on the waters of Salt Creek.

Beneath the surface in the lower valleys of the county we find blue and yellow Drift clays. In the blue clays are often found fragments of wood. I am indebted to G. W. Hurst, M.D., of Williamsport, for a fine specimen of coniferous wood taken from a well forty-four feet deep. The wood is in fine preservation. I am also under obligations to Dr. Hurst, who takes no little interest in these matters, for a sample of fine yellow clay, which he thinks of promise as a material for paint. It is entirely free from grit, and was deposited as a sediment in very quiet waters.

The soil of Pickaway county is of great fertility, and this is probably the richest county, agriculturally considered, in the Second Geological District. The alluvial lands along the Scioto River, Darby and Deer creeks are remarkably rich, while the terraced plains, with their limestone gravels, are scarcely less so. On the uplands the soil is also good. So far as I have seen, there is less waste land than in any county in the district. Indian corn is, perhaps, the staple crop, and in the summer we may ride for miles with scarcely a break in the continuity of the cornfields. With such soil, with clear and beautiful streams, and with such a fine climate, the farmers of Pickaway have a "goodly heritage," and may consider themselves well compensated for the want of the more important minerals.

GEOLOGICAL FORMATIONS.

The leading features of the geology of the county are simple, and easily understood. The Waverly sandstone, Huron shales, and Corniferous limestone are all found within the county. The Waverly formation, which underlies nearly the whole of Fairfield county, has its line of western outcrop along the eastern border of Pickaway. Probably nearly all of Salt Creek township is within the range of the Waverly; and wherever along the eastern borders of Washington, Walnut, and

Madison townships, the eastern highlands project themselves westward in spurs, the Waverly will be found. The Waverly sandstone is seen in good development on the waters of Salt Creek, in Salt Creek township, in Hocking county. Should the proposed railroad to the coal fields in Vinton and Jackson counties pass down Salt Creek, through the Salt Creek townships of Pickaway and Hocking—a feasible route—valuable quarries of this stone might be opened. There would be little superficial drift to be removed. Directly west of the line of the Waverly is the great Ohio Black Slate of the former geologists, the Huron Shale of Dr. Newberry, which dips beneath the Waverly to the east. This slate underlies the larger part of the county, but is generally so buried by the Drift and other surface materials as to be seldom seen. It appears, however, in the beds of Darby and Deer creeks. At Williamsport, in Deer Creek township, there is a good exhibition of it. Dr. Hurst, of Williamsport, has sent me a sample of the slate, prepared for use as a writing slate. If by some baking process it be rendered harder and tougher, and, consequently, more like the metamorphic slates of Vermont and Wales, this great deposit of slate might become of economic importance. There are many places in Ohio where it might be quarried at very slight cost. In the slate at Williamsport are sometimes found thin flakes of asphalt, or hardened bitumen, but not in sufficient quantity to be valuable. The same substance is found in the black slate elsewhere. At Willlamsport we find small quantities of iron pyrites, or bi-sulphide of iron, imbedded in the slate. It is of no value, except for the manufacture of copperas, or sulphate of iron; and for this purpose, it does not exist in sufficient quantity.

The Black Slate formation where measured in the Ohio River hills is a little over three hundred feet thick. It extends from the Ohio River to Lake Erie, and is one of the most distinct and noticeable features of our Ohio geology. The black color of this slate is derived from the large amount of bitumen it contains. Prof. Wormley, Chemist of the Geological Survey, reports the volatile matter (bitumen chiefly) as 8.40 to 10.20 per cent. This is nearly one-fourth as much as we find in some bituminous coals. We have, therefore, in the three hundred and twenty feet of black slate, bituminous matter enough to furnish with the requisite bitumen a seam of coal from sixty to eighty feet thick. The conditions under which this formation was deposited involved comparatively quiet water, charged with a constant supply of fine sediment, with which there was at all times commingled organic matter, which alone could have furnished the bitumen. The even distribution of the bitumen throughout the entire mass of the sediments would imply that the water abound-ed with the minuter forms of vegetable or animal life. Thus far, search for these forms has been unrewarded. After a failure by myself, I placed samples of the slate in the hands of Prof. Wormley, whose skill in microscopic researches is well known, and whose instruments are of the most perfect kind. Thus far his search for distinct organisms has been unsuccessful. It is reasonable to suppose that the organisms contained no silica or lime, and that in their decomposition and bituminization all organic structure was destroyed.

The black slate is an evident source of rock oil, or petroleum. It affords oil readily by artificial distillation, but we find abundant evidence that it is distilled naturally. At numerous points we find springs of oil at the top of the slate. Generally they are in the lowest layers of the overlying Waverly sandstone, as if the ascending oil (for oil, being lighter than water, is upward in its tendency) had been intercepted by the sandstone, and had flowed out between its more open layers. Such oil springs abound in the western part of Scioto and eastern part of Adams counties. In the black slate are often found septaria, or large calcareous concretions, which are generally hollow, and contain crystallized calcite, and often shining globules of asphaltum. Near Delaware, and further north, they contain the remains of fishes of the most remarkable size and form. Oil is easily distilled from this black slate, but the yield is not large, and such distillation will be unprofitable while the earth yields petroleum so bountifully. The slate, when burnt and pulverized, is said to answer an excellent purpose for coating for roofs, when mixed with coal tar. Wells bored in the black slate often strike fissures charged with combustible gas, and the gas may be economically used for lighting and warming dwellings and factories. It is so utilized at Painesville, and at other places on the Lake where wells have been bored into the black slate.

Corniferous Limestone.—This important formation is found in the western part of the county. It is the limestone so largely used at Columbus, where it is found on the west side of the Scioto River. The State House, the walls of the Penitentiary, etc., etc., were constructed of this stone. It contains interesting remains of fishes, shells, etc., already described in a previous volume of the Geological Report. In Pickaway county this limestone appears in the bed of Deer Creek, a few miles west of Williamsport. From this point it should be found northward to Columbus, unless buried by Drift and valley deposits. Where the Cincinnati and Muskingum Valley Railroad passes over this formation, on the western edge of the county, the rock is probably covered by superficial materials; at least I have heard of no quarries of this stone along its line. It appears in the north-western corner of Ross county. The Ohio Canal, in passing down the Scioto valley, follows the belt of the black slate, and is too far removed from the limestone on the west and the Waverly sandstone on the east to be available as a means of transportation.

The underlying rock strata in the county are too deeply buried to exert any fertilizing effect upon the surface soils. The soil derives its peculiar fertility from the calcareous nature of the Drift materials, and from the rich alluvial deposits which border the streams. Such soil is alone a noble endowment for the county. Coals and ores must in any locality be exhausted in time, but the soil of Pickaway, with proper tillage, will be a perpetual source of prosperity and wealth.

GEOLOGY OF FAIRFIELD COUNTY.

This county is bounded on the north by Licking county, on the east by Perry and Hocking, south by Hocking, and west by Pickaway.

It is noted for the general fertility of its soil rather than for any important minerals.

SURFACE FEATURES.

The county is situated so as to include on the north a portion of the level country characteristic of the central part of the State, and on the south a portion of the hill region of south-eastern Ohio. The northern part of the county is smooth and beautiful, while farther south, along the Hocking and some of its tributaries, we find rugged hills and dizzy cliffs. Many of the valleys among these hills are broad and very attractive, not only for their fertility, but as gems of landscape beauty.

The northern townships, Walnut, Liberty, and Violet, are drained by Little Walnut Creek, which empties into the Scioto in Pickawy county. Such portions of Bloom, Amanda, and Clear Creek townships as lie upon the western slope of the divide between the Hocking and Scioto rivers, are also drained by streams flowing into the Scioto. The Hocking River is at Lancaster an inconsiderable stream, formed by the drainage of Greenfield township, to which are added, near the city, the waters of Fetters, Baldwin, and Pleasant runs, which rise in Pleasant township. Richland and Rush Creek townships are drained by Rush Creek. At Bremen the latter is joined by the East Branch of Rush Creek, which flows westward through the central part of Perry county. Rush Creek empties into the Hocking River at Sugar Grove, in the southern part of Berne township. Clear Creek, which rises in Amanda township, flows through the north-east corner of Clear Creek township, and through nearly the center of Madison, and empties into the Hocking River in Hocking county.

Drift.—The whole county may be included within the area of the Drift. In the lower grounds we find in sinking wells the blue Drift clays, and every where are to be seen the gravel and bowlders of the Drift period. The quantity of Drift materials originally brought into the county must have been immense, for from the heads of the Hocking must have been obtained the supply of sand and gravel needed to form the vast gravel terraces which skirt the river to its mouth. Bowlders are found every where in the lowlands and on the highlands. They are of all sizes, from that of the famous one on Baldwin's Run, a little east of Lancaster, which is approximately eighteen feet by sixteen feet in its two diameters, down to those only a few inches through. They are granites, diorites, quartzites, and other hard rocks, capable of enduring the rough usage to which they have been subjected since first they were broken from their original beds far north of the lakes. In some cases the bowlders are limestone, and so abundant that they are broken up and burned for quicklime. This has been done to a considerable extent in Fairfield county.

In the immediate valley of the Hocking we find the modified Drift in the form of sand and gravel terraces, which were once great sand flats and bars, formed by the stream when it stood from eighty to one hundred feet higher than now. Much of the city of Lancaster is built upon such a terrace. Underneath the sand and gravel, and elsewhere in the lower grounds, we often find the blue Drift clay containing scattered bowlders. In this clay we obtain trunks of trees, roots, twigs, etc., generally of coniferous type. They represent the vegetation which grew in the valleys or along the hill-sides at the beginning of the Drift era. Many specimens of such buried wood have been found in sinking wells in Lancaster. The foregoing are the leading facts of Drift phenomena in Fairfield. The general subject of the Drift and of Drift agencies is more fully considered in Chapter L., in this volume of the Report.

The geology of Fairfield county is very simple. The county lies wholly within the range of the Waverly formation, with a trifling exception of a very limited area in the extreme eastern edge of the county. This exception is found on the high hill in the neighborhood of East Rushville. Here, south of the village, we find a thin seam of coal, and other rocks characterizing the Coal Measures. It is possible that in the eastern edge of Rush Creek township there may be some hill-tops which belong to the same formation. There are, however, no available coal seams in the county.

The Waverly formation is seen at so many points that is impossible to designate them. The upper portion of it, or that which lies directly beneath the Coal Measures, is well seen in the ravine between East Rushville and West Rushville. Here the stone is comparatively fine-grained, but is for the most part too soft for use as a building stone. In the bank of the creek, below the mill-dam, we find ten or twelve feet of bluish sandy shales, which have afforded some new and interesting molluscan fossils. The usual Waverly fossils are found in the strata above. The Waverly sandstone seen in the cliffs along the Hocking is generally coarse-grained, often passing into a true conglomerate, and it shows the same character in the hills and highlands west of the river. It is more commonly of a rich yellow color, but is sometimes a darkish brown. In many places the stone is firm in texture, and capable of resisting great pressure without crushing. It has been quarried and used, with excellent effect, in the beautiful court-house at Lancaster, and in some important buildings in Columbus. In the Geological Report for 1869 the quarries near Sugar Grove were referred to and commended. Since that time an increased quantity of the stone has been quarried. In the neighborhood of Lancaster are several excellent quarries, but from none of them is stone obtained for shipment by canal or railroad. The demand for building stone of this quality will constantly increase, and the time is not far distant when many extensive quarries will be opened among the hills and cliffs which border the Hocking River in this county. The same character of coarse-grained Waverly stone is found in Licking county, at Hanover, and on the Licking River; but these points are a little more distant from Columbus. At Lithopolis is an exposure of the lower part of the Waverly formation, and the stone is—what we should expect it to be—fine-grained, and showing all the characteristics of the typical Waverly stone as first quarried at Waverly, in Pike county. The Lithopolis stone is of a light drab-color, is of fine, even texture, and easily wrought.

The natural wealth of the county lies in the Waverly stone and in the remarkable fertility of the soil. The latter is adapted to the growth of grains and grasses, and upon the hills the leading fruits of the climate grow in luxuriant abundance. Large quantities of grapes are produced upon the farm of the State Reform School. There are other large vineyards among the hills, and considerable wine is made. The general character of the cultivation of the soil is excellent, and the farmers are generally prosperous and independent.

REGISTERS.

Register of Map XI. of Grouped Sections of Washington County.

1. Geological section, land of Henry Wagner, Coal Run, Wesley township.
2. " " Henry Barnes, section 6, " "
3. " " Stephen Hobson, " 36, " "
4. " " Pitt Goddard, fraction 7, Fairfield "
5. " " John Storts, section 17, Decatur "
6. Coal in section 24, Wesley township; ore in section 18, Palmer "
7. Geological section on Dana farm, below Beverly, Waterford "
8. " hill below Coal Run village, near Ewart and Mills's coal bank, Adams township.
9. Geological section on land of Wm. G. Woodford, near Watertown, Watertown township.
10. Geological section on land of Wm. Bell, Barlow township.
11. " " Harvey Ellenwood, section 16, on Little Hocking, Dunham township.
12. Geological section, half a mile above the mouth of Little Hocking, Belpre township.
13. Geological section on land of Henry Ross, one and a half miles above the mouth of Big Run, Adams township.
14. Geological section on land of Edwin Guthrie, section 28, Belpre township.
15. " " G. Brown, two miles above mouth of Cat's Creek Adams township.
16. Geological section on land of Nicholas Basil, three miles above mouth of Cat's Creek, Adams township.
17. Geological section on land of John Spears, half a mile above mouth of Bear Creek, Muskingum township.
18. Geological section on land of Hugh Jackson, Aurelius township.
19. " narrows on Ohio River, Warren "
20. " on land of Vincent Payne, Salem "
21. " near Salem village, Salem township.
22. Combined section, upper part of Bear Creek, Salem township.
23. Geological section on land of W. Hamilton, section 23, near Germantown, Liberty township.
24. Geological section on land of B. F. Dyar, section 7, Muskingum township.
25. " " Henry Barnhardt, section 8, Liberty township.
26. " showing the higher shales and sandstones.
27. " branch of Pawpaw Creek, north-west corner of Liberty township.

28. Geological section near Perkins's oil well, No. 1, Lawrence township.
29. " near mouth of Conley's Run, Newport "
30. " on land of Albert Ewing, section 34, Ludlow township.
31. " " Seth Adams, section 33, Wingett's Run, Ludlow township.
32. Geological section on land of John Goodrich, section 3, two miles from the Ohio River, Independence township.
33. Geological section on land of Joseph Chris, section 13, on Davis Run, Independence township.
34. Geological section at Bloomfield, section 21, Ludlow township.
35. " on land of C W. Talbot, section 8, Grandview township.
36. " " Eli Eddy, seetion 11, Jolly township.

REGISTER OF MAP XII. OF GROUPED SECTIONS OF NOBLE COUNTY AND SOUTH HALF OF GUERNSEY.

1. Geological section on land of Horatio Grummond, Adams township, Guernsey county.
2. Geological section near Bysville, Jackson township, Guernsey county.
3. " two miles west of Mt. Ephraim, Seneca township, Noble county.
4. Geological section of Cambridge limestone, Tunnel Hill, Cambridge, Guernsey county.
5. Geological section at Cambridge, Guernsey county.
6. " near " "
7. " near Cumberland, Spencer township, Guernsey county.
8. " near Claysville, Westland " "
9. " near Scott's coal mines, Center township, Guernsey county.
10. " near Campbell's Station, Wills " "
11. " on the land of John Anderson, section 8, Richland township, Guernsey county.
12. Geological section near Salesville, Millwood township, Guernsey county.
13. " near Millwood village, "
14. " Senecaville, Richland township, "
15. " near Cassell's Station, section 23, Adams township, Guernsey county.
16. Geological section on land of Robert Murray, section 13, Jackson township, Guernsey county.
17. Geological section near Hartford, Valley township, Guernsey county.
18. " west of Caldwell, Sharon township, Noble county.
19. " in section 33, Seneca " "
20. " south-east of Point Pleasant, Valley township, Guernsey county.
21. Geological section in section 13, Center township, Noble county.
22. " near Williamsburg, Beaver township, Noble county.
23. " near the "Notch," Buffalo " "
23A. " boring at Ava Station, Buffalo " "

24. Geological section at Kennonsburg, Wayne township, Noble county.
25. " two miles north of Williamsburg, Beaver township, Noble county.
26. Geological section at Hiramsburg Station, Noble township, Noble county.
27. " on land of Mr. Hastings, section 15, Beaver township, Noble county.
28. Geological section on southern slope of hill between Seneca Creek and Wills Creek, Noble county.
29. Geological section near Archer's store, section 6, Enoch township, Noble county.
30. " near "Soak'em," Olive township, Noble county.
31. " near Carlisle, Stock " "
32. " on land of A. Enochs, section 36, Stock township, Noble county.
33. Geological section on land of E. Oaky, section 8, Franklin township, Monroe county.
34. Geological section one mile below woolen factory, Road Fork, Elk township, Noble county.
35. Geological section near Harrietsville, Elk township, Noble county.
36. " in section 25, Elk " "
37. " near Macksburg, Jefferson " "

Register of Map XIII. of Grouped Sections of Monroe County.

1. Miltonsburg to Calais.
2. Lewisville, Summit township.
3. Wm. Smith, section 18, Summit township.
4. Robert Pope, Center township.
5. John Windland, Center township.
6. Woodsfield, general section.
7. Alexander's Mills, section 3, Perry township.
8. Basil Dye, section 21, Perry township.
9. Stead's Mill, section 27, Center township.
10. Section near Sardis.
11. Baresville, Ohio township.
12. A. Chrisner, section 14, Center township.
13. J. Weekly, section 25, Adams township.
14. John Boughner, near Cameron, section 13, Adams township.
15. J. Jones's coal bank, Clarington.
16. Outline section at Clarington.
17. Shaft at Clarington.
18. Charles Dota, Switzerland township.
19. A. Long, section 2, Salem township.
20. J. Knowlton, section 24, Washington township.
21. Lorenzo Manly, section 2, Bethel township.
22. Jacob Davis, section 3, range 4, Switzerland township.
23. Wm. Raper, section 34, Jackson township.

Register of Map XIV. of Grouped Sections of South Half of Belmont County.

1. Outline section near Barnesville.
2. Section on railroad from Barnesville west.
3. Deep cut, section 28, Goshen township.
4. Somerton, Somerton township.
5. Lewis's Mills, Smith "
6. Water station, " "
7. Cement limestone, Warnock's Station, Smith township.
8. Railroad tunnel, one mile west of Glencoe Station, Smith township.
9. " cut, Glencoe Station, Smith township.
10. " tunnel, Richland township.
11. J. F. Hutchinson, section 12, Pultney township.
12. West of Bellair, Pultney township.
13. Railroad quarry, half a mile west of Bellair, Pultney township.
14. Section at Bellair.
15. Near Wegee mines, Mead township.
16. David Caldwell, section 27, Washington township.
17. Joseph Moore, section 17, Wayne "
18. Armstrong's Mill, Washington "
19. John Owens, section 27, York "
20. Albert Green, section 20, York "

SALT IN THE SECOND GEOLOGICAL DISTRICT.

Salt is made in the following counties in the Second Geological District: Meigs, Athens, Perry, Morgan, Muskingum, Noble, and Guernsey. In former days salt was made in Jackson county, and a little in Scioto, and, possibly, a very small quantity in one or two other counties. Brine of greater or less strength has been found in wells bored for oil in almost all the counties in the district. The geological formation which affords the supply of brine used at the various salt-works is the Carboniferous, and chiefly the lower member of it, viz., the Waverly. In many places in railroad cuts, and similar exposures, we find the salt appearing as an efflorescence on the face of the rock. Where the Waverly constitutes high ridges, with ample opportunity for the drainage of the waters which have for ages percolated through the sandrock, it has been found that the saline elements have been removed, and the water within the rock is now fresh.

A well bored at the State Reform School, on the high lands south-west of Lancaster, into the Waverly conglomerate, affords fresh water. But where the Waverly has dipped below the surface, and passed under the productive Coal Measures, we find almost universally more or less brine in the wells which penetrate it. The salt-works on the Ohio River, in Meigs county; on the Hocking River, on Monday Creek, in Perry county; on the Muskingum River, in Muskingum and Morgan counties; and the Scott works, in Guernsey county, all draw their chief supply of brine from the Waverly. The small works at Olive, Noble county, obtain brine from a sandrock in the Coal Measures. It is probable that in several wells at other points named brine from the upper, or Coal-Measure sandrocks, is mingled with Waverly brine, the upper brine not being tubed off; but as a rule the chief supply comes from the Waverly sandstone. The depth at which the Waverly is reached varies with the location of the well.

The wells at the salt-works in Athens and Perry counties, being nearer the outcrop of the Waverly, are less deep than at Pomeroy, as are also the wells in Muskingum less deep as a rule than those in Morgan. The wells at Pomeroy are proximately one thousand feet deep. Those at Salina, in Athens county, are scarcely six hundred. The M'Cuneville wells on Monday Creek, in Perry county, are nearly nine hundred feet deep below the surface, which is one hundred and fifty feet below the horizon of the Nelsonville, or Straitsville, seam of coal. These find their brine in the lower portion of the Waverly sandstone. The Salina and Chauncey wells obtain their brine in the Upper Waverly. The difficulty in south-eastern Ohio is not in finding brine of sufficient strength and in sufficient quantity—although sometimes a well may be a failure—the leading considerations are cheap fuel and cheap transportation. As mines are opened and extensively wrought, the refuse coal not marketable for ordinary uses will be more and more employed in making salt, and in this way the cost of the fuel will be reduced to a minimum. Such is the competition, that few salt-works can now afford to pay much for coal. Cheap transportation by river or railroad is so important that no salt-works can prosper not located upon one or the other. To some extent salt is transported in bulk, and the expense of barrels saved.

Samples of manfactured salt were obtained from a large number of the salt furnaces in the district, which were analyzed by Prof. Wormley. From a few furnaces the samples did not not reach us. Quite a number of specimens of brine were obtained, but before Prof. Wormley, in the multiplicity of his labors, could examine them, they were so modified by evaporation and by chemical changes produced by air passing through the porous jugs and imperfectly sealed corks, that no satisfactory analyses could be made. Should the work of the Survey be resumed, every precaution will be taken to secure for the laboratory the brines in their original state.

I append Prof. Wormley's analyses of the salts in a tabulated form. Numbers 29, 30, and 31 are of samples of salt from Saginaw, Michigan, Onandaga Salt Company, New York, and Kanawha, West Virginia. It will be seen from the tables that several samples from the Muskingum valley contain over ninety-seven per cent. of chloride of sodium, and at the same time the percentage of the undesirable chlorides is small. The tables deserve careful study.

TABLE OF ANALYSES OF SALTS.—By Prof. T. G. Wormley.

	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.
Water	2.900	3.100	2.500	2.800	3.400	4.000	3.250	2.150	3.300	1.900	2.100	2.600	2.800	1.150	1.700	1.700
Insoluble matter	0.018	0.016	0.008	0.006	0.006	0.004	0.010	0.014	0.010	0.010	0.014	0.016	0.020	0.008	0.020	0.054
Sulphuric acid	trace	trace	....	....	......	....	....	....	trace	....	....	....	....	....	....	....
Calcium, chloride	1.431	1.487	1.232	1.076	0.843	0.954	0.976	1.343	1.354	1.387	0.843	1.787	1.630	0.788	0.480	0.480
Magnesium, "	0.608	0.633	0.513	0.436	0.359	0.419	0.402	0.608	0.590	0.684	0.436	0.966	0.757	0.394	0.249	0.231
Potassium, "	0.152	0.183	0.152	0.137	0.152	0.137	0.095	0.106	0.183	0.212	0.151	0.182	0.242	0.333	0.511	0.273
Sodium, "	94.891	94.581	95.595	95.545	95.240	94.486	95.267	95.779	94.563	95.807	96.456	94.449	94.551	97.327	97.040	97.262

1. Eureka Furnace, Ohio River.
2. Newcastle " "
3. Clifton, "
4. Syracuse, "
5. Coal Ridge, "
6. Minersville, "
7. Valley City, "
8. Hartford City, "
9. Hocking Valley Coal and Salt Company, Chauncey, Athens county.
10. Havener and Benjamin, Malta, Morgan county.
11. Wm. Sherwood, three miles above Malta, Morgan county.
12. John Havener, " " " "
13. James Moore, four " " "
14. Big Bloom Furnace, eight " " "
15. Samuel Miller, half a mile below " "
16. C. Wilson, three miles " " "

TABLE OF ANALYSES OF SALTS—Continued.

	17.	18.	19.	20.	21.	22.	23.	24.	25.	26.	27.	28.	29.	30.	31.
Water	2.500	2.000	1.800	1.100	2.100	1.100	1.000	1.300	2.000	1.700	2.800	3.150	1.300	1.100	2.000
Insoluble matter	0.014	0.040	0.017	0.030	0.016	0.009	0.032	0.016	0.010	0.008	0.014	0.116	0.062	0.278	0.012
Sulphuric acid	....	....	....	....	....	....	....	....	....	....	trace	....	*0.833	*1.797	trace
Lime, sulphate	....	....	....	0.035	....	....	0.004	....	....	....	....	....	....	....	....
Calcium, chloride	1.110	1.087	0.888	0.433	1.221	0.610	1.976	0.788	0.654	0.999	1.454	0.732	0.796	0.207	0.677
Magnesium, chloride	0.573	0.565	0.445	0.350	0.607	0.103	0.958	0.385	0.309	0.514	0.650	0.436	0.291	0.094	0.240
Potassium, "	0.156	0.090	0.151	0.574	0.273	0.303	0.151	0.106	0.076	0.151	0.122	0.122	0.122	0.095	0.137
Sodium, "	95.647	96.218	96.699	97.478	95.783	97.875	95.879	96.905	96.951	96.628	94.960	95.444	96.596	96.429	96.934

17. A. Morrison, nine miles above McConnelsville.
18. J. R. Patterson, eight miles above "
19. B. J. Converse, five " "
20. W. R. Kelly, three " "
21. W. R. Kelly, half a mile above "
22. Barnes and Sons, six miles below "
23. Stansbery; one and a half miles below McConnelsville.
24. M. Cooper, five miles below Zanesville.
25. O. Ballou, six miles below Zanesville.
26. Jno. Stevens, nine miles below Zanesville.
27. South Olive, Noble county.
28. E. M. Scott, Cambridge, Guernsey county.
29. Saginaw, Michigan.
20. Onandaga Salt Co., New York.
31. Kanawha, West Virginia.

* Sulphate of lime.

THE space allotted to Second District in this volume is necessarily so limited that a full and special discussion of petroleum, as existing in the district, could not be inserted, as I had proposed. Much detailed information, however, will be found in the reports on several counties.

I append some tables of analyses by Prof. Wormley which have never been published in tabulated form. Many of them were made for private parties, at their own cost, and are published by permission. They will be valuable for reference.

TABLE OF ANALYSES OF IRON ORES IN SECOND GEOLOGICAL DISTRICT.—By Prof. T. G. Wormley.

	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.
Specific gravity	....	....	....	....	....	....	....	....	....	....	....	....	2.624
Water	10.70	7.90	17.70	12.00	5.80	7.20	8.43	10.00	10.00	10.70	12.85	4.60	13.20
Silicious matter	36.45	....	6.30	14.96	15.32	13.20	35.88	13.04	17.92	13.76	20.04	10.76	14.96
Iron, carbonate	....	12.87	....	....	....	....	....	....	....	....	....	....	....
" sesquioxide	50.50	36.70	68.88	66.44	66.66	75.35	54.19	72.63	69.96	73.80	58.27	80.51	67.35
Alumina	0.18	1.60	1.20	3.20	2.20	....	0.01	0.20	0.60	0.10	trace	1.20	....
Manganese	....	6.20	....	0.50	1.80	2.00	....	....	....	0.50	5.80	....	0.90
Magnesia, phosphate	0.33	....	....	2.05	....	....	0.18	....	0.96	....	....	....	....
Lime, "	0.62	0.89	1.28	0.51	0.89	0.54	0.05	0.68	0.41	0.41	1.30	....	0.63
" carbonate	....	20.96	2.96	....	4.84	0.91	1.64	....	0.73	0.38	0.14	1.30	0.81
Magnesia, carbonate	0.52	3.63	2.49	....	1.39	0.83	....	3.54	....	0.07	1.21	1.30	....
"	....	....	....	....	....	....	....	....	....	....	....	....	1.32
Sulphur	0.106	0.10	....	0.08	0.13	....	0.08	0.04	0.02	trace	0.10	....	trace
Totals	99.36	99.21	100.81	99.74	99.03	100.03	100.63	100.13	100.60	99.72	99.71	99.67	99.57
Metallic iron	35.35	31.90	48.22	46.51	46.66	52.76	37.93	50.84	48.97	51.66	41.78	56.36	47.15
Phosphoric acid	0.28	0.41	0.83	0.24	0.41	0.25	0.12	0.31	0.63	0.19	0.60	trace	0.29

1. Ore, Bessemer, Athens county.
2. " over Bayley's Run coal, Trimble township, Athens county.
3. " above Maxville L. S., Reading township, Perry county.
4. " "Sour Apple," Harper's, New Lexington, Perry county.
5. " " Wesley Moore, Perry county.
6. " Jacob Martzoff, Monday Creek, Perry county.
7. " in Perry county, 2½ miles east of Rushville.
8. " Garrison's, Perry county, 2½ miles east of Rushville.
9. Crossenville, Perry county
10. Between Bremen and Maxville, Perry county.
11. Col. Teeters, Ava Station, Noble county.
12. Enoch's ore, Noble, county.
13. J. Bolin, 54′ above L. S., Zanesville.
14. J. Kline, above lower L. S., Zanesville.
15. J. Rodman, 27′ below L. S., Zanesville.
16. Newton township, Muskingum county.

ANALYSES OF IRON ORES, Etc.—Continued

	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.
Specific gravity	....	....	....	....	....	2.900	....	....	....	2.916	2.924	....	....	....
Water	....	....	18.95	10.90	8.00	2.00	....	....	....	7.20	5.20	....	1.50	....
Silicious matter	....	....	12.92	14 90	20.94	13.28	....	....	....	16.40	21.68	....	17.14	....
Iron, carbonate	....	....	....	....	....	....	....	....	....	....	....	....	....	....
" sesquioxide	....	....	60.90	68.94	66.13	77.11	....	....	....	44.86	60.44	13.89	78 95	17.32
Alumina	....	....	2.00	0.70	1.80	4.40	....	....	....	3.60	....	....	....	....
Manganese	....	....	trace	1.75	trace	0.40	....	....	....	2.00	8.00	5.90	0.40	....
Magnesia, phosphate	....	....	1.14	....	....	....	....	....	....	....	....	....	....	....
Lime, "	....	....	2.63	0.76	1.24	....	....	....	....	1.50	0.54	....	....	....
" carbonate	....	....	....	0.07	0.08	1.79	....	....	....	22.18	2.08	....	1.95	....
Magnesia, "	....	....	0.34	1.09	1.20	0.30	....	....	....	1.43	2.04	....	....	....
Sulphur	....	....	0.16	....	0.05	0.06	....	....	....	trace	trace	....	....	....
			99.04	99.11	99.44	99.34	....	....	....	99.17	99.98	....	99.96	....
Metallic iron	12.56	5.27	42.63	48.26	46.29	53.98	12.13	18.03	18.00	31.40	42.31	9.72	55.27	12.13
Phosphoric acid	....	....	1.82	0.35	0.57	trace	....	....	....	0.70	0.25	....	trace	....

1. Marietta street, Zanesville.
2. North-east corner of Wayne township, Muskingum county.
3. Red ore, Olive Furnace, Lawrence county.
4. N. Axline, east of Rushville, Fairfield county.
5. Soft red ore, " "
6. Near Woodsfield, Monroe county.
7. Edwin Guthrie, Little Hocking, Washington county,
8. " " "
9. Edwin Guthrie, Little Hocking, Washington county.
10. Edwin Guthrie, Little Hocking, Washington county, fourth stratum from top.
11. Edwin Guthrie, Little Hocking, Washington county, fifth stratum from top.
12. S. S. Smith, Palmer township, Washington county.
13. Fred. Kueck, Elba Station, Washington county.
14. Geo. Shy, Jackson township, Monroe county.

ANALYSES OF IRON ORES, Etc.—Continued.

	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.
Specific gravity	......	......	3.250	3.465	2.571	......	......	2.052	......	......
Water	6.15	3.99	6.40	3.59	......	7.20	5.00	*11.55	12.50	10.80
Silicious matter	18.44	4.80	23.28	10.08	10.00	23.44	26.75	38.72	21.96	40.87
Iron, carbonate	31.16	68.15	45.54	56.39	55.44	54.51	13.31	33.72	......	......
" sesquioxide	26 68	11.64	14 58	14.07	13.32	3.43	11.30	8.34	59.49	41.24
Alumina	2.20	0.20	0.40	1.00	3.00	0.40	0.80	......	0.80	1.20
Manganese	5.30	......	0.50	2.70	trace	trace	trace	2.30	1.40	trace
Lime, phosphate	0.21	0.68	0.67	0.67	7.64	0.61	0.52	......	trace	0.26
" carbonate	5.25	6.05	5.16	5.16	7.39	3.86	37.30	2.30	1.60	2.15
Magnesia, carbonate	4.54	3.32	2.80	4.86	3.02	6.20	4.57	2.49	2.72	2.87
Sulphur	0.06	0.31	0.50	0.54	0.17	0.17	0.23	0.16	trace	trace
Total	99.99	99.24	99.83	99.06	99.98	99.82	99.79	99.58	100.47	99.39
Metallic iron	33.72	41.05	32.19	37.07	36.44	32.52	14.34	22.12	41.06	29.85
Phosphoric acid	0.10	0.31	0.31	0.31	3.50	0.28	0.32	trace	......	0.07

1. Under Bayley's Run coal, Ewing, Trimble township, Athens county.
2. Newton township, Muskingum county.
3. Ives Run, Zanesville, "
4. James Colvin, Hopewell township, Muskingum county.
5. Slago's Run, near Zanesville, "
6. Blue ore, Putnam Hill limestone, Saltillo, Perry county.
7. Mr. Gorby's farm, Hiramsburg Station, Noble township, Noble county.
8. Blackband, near Cassel's Station, Guernsey county.
9. Dug-way, section 7, Trimble, Athens county.
10. Vein No. 3, Moody's land, Trimble, Athens county.

* Includes volatile combustible matter.

TE OF ANALYSES OF CEMENT LIMESTONES IN SECOND GEOLOGICAL DISTRICT.—By Prof. T. G. Wormley.

	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.
Silicious matter........	19.50	19.60	28.80	28.30	36.60	25.60	16.70	17.28	29.80	30.60	24.00	17.40	31.20	19.10	15.20	20.90
Alumina and iron	11.60	9.80	3.20	3.70	4.02	4.60	2.90	1.40	13.80	13.00	7.00	6.20	6.60	8.65	4.40	6.10
Water, undetermined	....	....	....	....	....	....	....	....	....	....	....	....	....	5.15	....	....
Lime, carbonate	42.70	48.90	51.80	38.80	37.40	47.20	58.00	62.50	41.20	40.60	37.90	51.80	37.80	47.70	49.80	44.00
Magnesia, carbonate ..	25.50	21.18	23.91	28.38	21.18	22.30	21.60	17.40	15.36	15.18	30.47	23.94	23.89	19.40	30.65	29.02
	99.30	99.38	99.71	99.18	99.20	99.70	99.20	98.58	100.16	99.38	99.37	99.34	99.49	100.00	100.00	100.02

1. C. L. Poorman, Bellair, Belmont county, lower seam.
2. " " " "
3. " " " "
4. " " " upper seam.
5. " " " "
6. " " " "
7. Cement limestone, Glencoe, Belmont county.
8. Cement limestone, 22′ above upper Barnesville coal, at Barnesville, Belmont county.
9. Parker's cement, Belmont county.
10. Warnock's Station, Belmont county, Central Ohio Railroad.
11. Wegee, Belmont county, cement, one foot six inches from bottom.
12. Wegee cement, near top .
13. Jos. F. Hutchinson, Pultney township, Belmont county.
14. Pigeon Branch, Whipple's Run, Washington county.
15. J. H. Roberts, buff limestone, Muskingum county.
16. Henry Windland, Center township, Monroe county.

ANALYSES OF COALS OF SECOND GEOLOGICAL DISTRICT.—BY PROF. T. G. WORMLEY.

	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14
Specific gravity	....	....	....	....	....	....	1.300	1.338	1.375	1.295	1.314	1.301	1.264	1.381
Water	4.00	4.90	4.20	4.30	4.10	4.70	4.00	4.30	3.00	3.00	2.40	5.00	4.80	4.50
Ash	2.30	2.90	3.30	3.00	6.80	10.00	5.00	6.20	13.00	5.40	8.50	7.40	3.40	3.40
Volatile combustible matter	36.00	33.10	35.40	33.10	31.30	29.30	32.00	34.80	29.60	35.00	35.60	32.30	35.20	37.50
Fixed carbon	57.70	59.10	57.10	59.60	57.80	56.00	59.00	54.70	54.40	56.60	53.50	55.30	56.60	54.60
Total	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	2.44	2.52	2.71	1.20	1.15	0.60	1.78	2.149	2.84	5.49	4.99	1.85	1.26	2.96
" left in coke	0.85	0.93	0.93	0.46	0.52	0.054	0.82	1.19	1.37	2.23	3.29	0.42	0.69	1.89
" in per cent. of coke	1.41	1.50	1.53	0.73	0.80	....	1.28	....	2.02	3.58	5.30	....	....	....
Cubic feet of gas per lb. of coal	3.42	3.35	3.30	3.35	3.12	3.19	3.18	....	2.98	3.42	3.01	3.12	3.42	3.12
Ash	gray	gray	gray	gray	dull white	dull white	gray	....	gray	gray	gray	red	reddish	r
Coke	comp.	comp. metallic	comp. metallic	comp. metallic	comp metallic	....	comp.	....	comp.	comp.	comp.	comp.	comp.	comp.

1. A. B. Johnson, Bayley's Run, Trimble township, Athens county; bottom.
2. A. B. Johnson, Bayley's Run, Trimble township, Athens county; middle.
3. A. B. Johnson, Bayley's Run, Trimble township, Athens county; top.
4. Bayley's Run seam at Ewing, Trimble township, Athens county; lower.
5. Bayley's Run seam at Ewing, Trimble township, Athens county; top.
6 Boring on Green's Run, Trimble township, Athens county.
7. Floodwood upper coal, York township, Athens county.
8. 3′ seam, 30′ above Nelsonville seam, York tp., "
9. Philip Totnan, Big Run, Athens county.
10. Marietta Run, Berne township, lower, Athens county.
11. " " top, "
12. Bayley's Run coal, Trimble township, bottom, Athens county.
13. Bayley's Run coal, Trimble township, middle, Athens county.
14. Bayleys's Run coal, Trimble township, top, Athens county.

REPORT ON THIRD DISTRICT.

BY EDWARD ORTON.

DR. J. S. NEWBERRY, *Chief Geologist:*

DEAR SIR:—I hereby submit reports on the following counties: Butler, Warren, Preble, Greene, Madison, Franklin, Pike, Ross, Fayette, Clinton, Shelby, Miami Champaign, Logan, Brown, and Darke. These lists comprise all of the counties originally assigned to me in the division of the State into geological districts that have not been already reported upon, together with those that have been subsequently added to my district.

The reports on the eight counties that compose the first division, I have written; the remainder are to be credited to the several local assistants whose names are pre fixed.

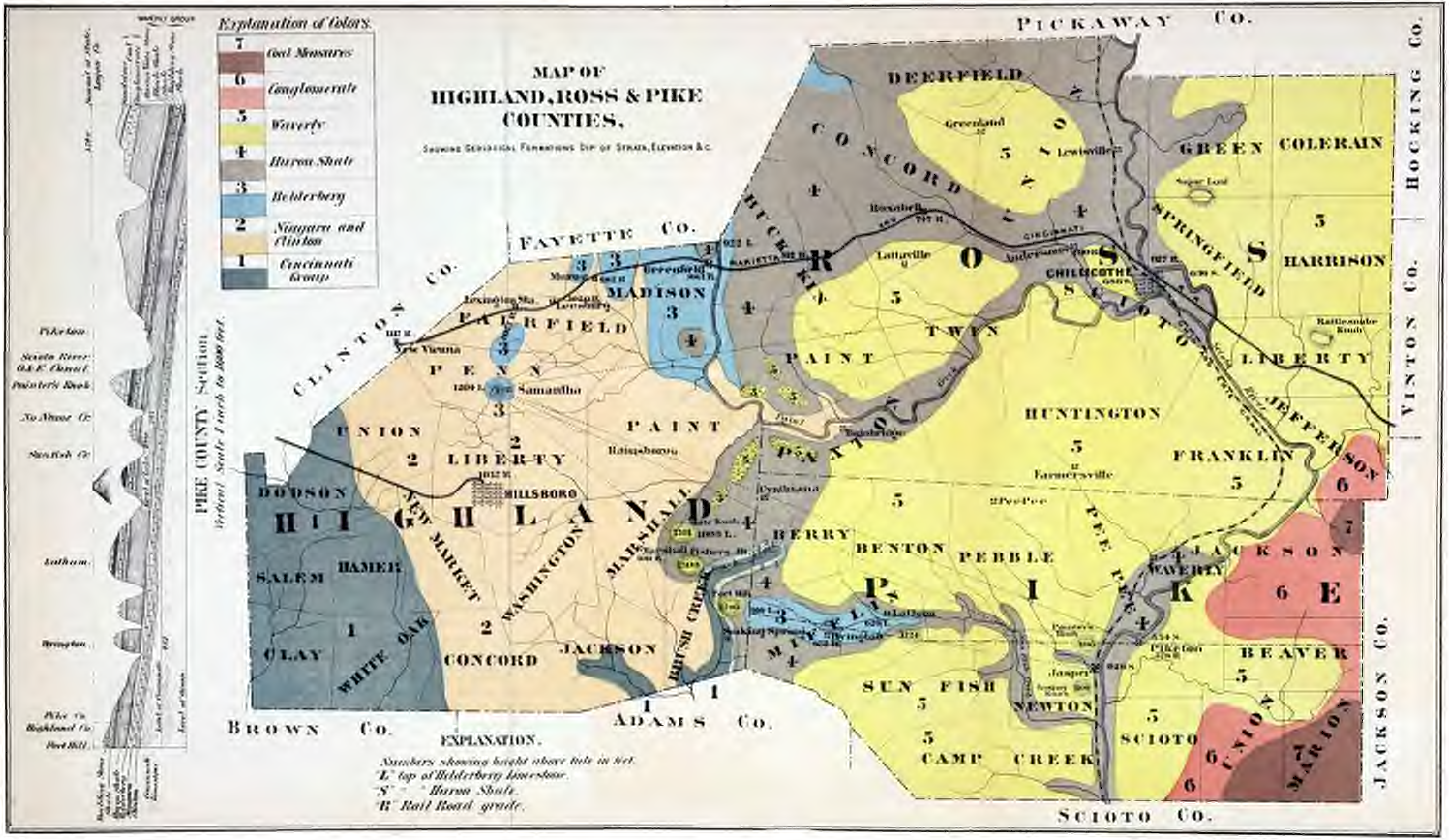
I take this opportunity of acknowledging the competent services of Mr. Franklin C. Hill, Mr. J. Y. Bergen, Jr., and Prof. C. M. Galloway, who were employed for several months each on counties which I have examined. The geology of the western half of Ross county was principally worked out by Mr. Bergen, and the definition of the valleys, modern and ancient, of the Great and Little Miamis, is due to the united labors of Messrs. Bergen and Galloway.

I have been laid under weighty obligations for local guidance and hospitable entertainment to a great number of people in south-western Ohio during the progress of the Survey, but in almost every county that I have personally examined there are some gentlemen that have given me such important aid in my work that I should do wrong if I failed to make a public acknowledgment of their services. In this list I will name Messrs. J. Kelly O'Neal, Israel Harris, W. H. Bean, Drs. Aaron Wright and W. L. Schenck, of Warren county; Hon. W. D. Gilmore, Capt. W. L. Shaw, Thos. Pottinger, Esq., and the late Dr. Dunham, of Preble county; R. G. Dun, Esq., and Drs. John Beach and W. A. Beach, of Madison county; and Messrs. Maurice Reiche, J. T. Moore, Joseph Foster, H. W. Overman, and James McBride, of Pike county.

With great respect, very truly yours,

EDWARD ORTON,
Assistant Geologist.

COLUMBUS, OHIO, Dec. 3, 1874.


MAP OF
HIGHLAND, ROSS & PIKE
COUNTIES,
SHOWING GEOLOGICAL FORMATIONS DIP OF STRATA, ELEVATION &C.
Explanation of Colors.
7 Coal Measures
6 Conglomerate
5 Waverly
4 Huron Shale
3 Helderberg
2 Niagara and Clinton
1 Cincinnati Group
PIKE COUNTY Section
PICKAWAY CO.
HOCKING CO.
VINTON CO.
JACKSON CO.
SCIOTO CO.
ADAMS CO.
BROWN CO.
CLINTON CO.
FAYETTE CO.
HIGHLAND
ROSS
PIKE
DEERFIELD
CONCORD
UNION
GREEN
COLERAIN
SPRINGFIELD
HARRISON
BUCKSKIN
TWIN
PAINT
HUNTINGTON
LIBERTY
JEFFERSON
FRANKLIN
SCIOTO
MADISON
FAIRFIELD
PENN
PAINT
LIBERTY
DODSON
SALEM
HAMER
CLAY
WHITE OAK
NEW MARKET
WASHINGTON
CONCORD
JACKSON
MARSHALL
BRUSH CREEK
BERRY
BENTON
PEBBLE
PEE PEE
JACKSON
WAVERLY
BEAVER
SUN FISH
NEWTON
SCIOTO
CAMP CREEK
UNION
MARION
CHILLICOTHE
HILLSBORO
Greenland
Lewisville
Samantha
Rainsborough
Farmersville
Bainbridge
Piketon
Jasper
EXPLANATION.
Numbers showing height above tide in feet.
"L" top of Helderberg limestone.
"S" " " Huron Shale.
"R" Rail Road grade.

CHAPTER LVII.

REPORT ON THE GEOLOGY OF PIKE COUNTY.

I. SITUATION AND TOPOGRAPHY.

Pike county is bounded on the north by Ross, on the east by Jackson, on the south by Scioto and Adams, and on the west by Highland and Adams counties. The Scioto River traverses it from north to south, entering it at the north-eastern corner, bearing from that point south-west to the center of the county, and thence due south to the county line. This broad and deep valley constitutes by far the most important feature of the topography of the county. The east and west divisions which it makes of the county are somewhat unequal in area, the latter being the larger. Each of these divisions is again divided into a north and south portion. Sunfish Creek, which rises in the extreme western portion of the county, flows through the central region of this part of the county, until within five miles of the Scioto, very nearly east. It is deflected at this point at a right angle, and after flowing five miles to the southward bends as abruptly to the east again. But the slighter valley of Noname Creek continues from the first point named, the east and west furrow begun by the Sunfish valley, across the entire western half of the county. The valley of the Sunfish is deep and narrow. On the eastern side of the river, and exactly opposite the mouth of Noname, the valley of Beaver Creek reaches the river after having traversed the whole eastern portion of the county, through which it has flowed in a westerly direction. These two valleys of Sunfish and Beaver creeks, it will thus be perceived, make as natural a highway from west to east, across the entire breadth of the county, as the Scioto valley does through the county from north to south. In the extreme north-western and south-eastern corners of the county, near Cynthiana and California respectively, there are conspicuous examples of surface erosion that do not belong to either of the systems thus far named, but which are connected with the drainage systems of adjoining counties. Neither case, in fact, is explicable by existing agencies of erosion. The California valley, which is very broad and deep, is occupied by an insignificant stream that flows with a sluggish current upon the surface of the deep Drift beds by which the valley is filled. The Drift in the vicinity of Cynthiana often exceeds fifty feet in depth, and the origin of the great excavation which has here been effected must be sought in the Glacial epoch, or in pre-glacial times.

Two of the tributaries of Sunfish Creek, viz., Chenoweth's Fork and Morgan's Fork, are of considerable size, and have wrought out quite important valleys for themselves.

The tributaries of Beaver Creek are of much less importance.

Besides these, there are but few streams in the county that have effected modification enough in the surface to deserve especial mention. The most important of those that remain are Camp Creek, Peepee Creek, and Crooked Creek, all of which are upon the western side of the Scioto.

The tributaries of the Scioto on the eastern side of the valley, with the single exception of Beaver Creek, already named, are of much less extent. None of them reach back from the river more than five or six miles. At that distance, at least, they reach the high lands, from which they descend very rapidly to the river. They are fed by no generous springs, and find their principal office in the removal of the superfluous rain-fall.

The surface of the county has never been covered and modified by the deposits of the Drift as the areas to the northward have been. It presents, therefore, all the peculiar features that a country exposed to the wear and waste of atmospheric agencies for tens of thousands of years must show. It is easy to see what was the original condition of this area. It consisted of a plateau, gently sloping to the east or south-east. The western boundary of the plateau stands more than one thousand three hundred feet above the sea. The elevation at the middle line of the county was at least one hundred feet less. Only limited portions of the old plateau remain. The extent and conformation of these old remnants vary very much in different sections of the county, depending on the geological formations in which they severally occur. On the extreme western side of the county, where four hundred feet of easily eroded shales overlying Upper Silurian limestones form the surface, the remnants are of small extent, and occur for the most part as conical hills, the shales having been swept away from broad valleys to the limestone floor. These conical hills of denudation, when seen from the limestone terraces of Highland county, fifteen or twenty miles to the westward, present more the appearance of mountains than any other elevations in the State, and are locally known under this designation.

Passing eastward and southward, we find the solid courses of the Waverly series constituting the original surface, and, as a consequence, larger portions of the original plateau have been preserved. In Sunfish, Newton, and Camp Creek townships, these islands of the middle and upper Waverly frequently take in several thousands of acres. But the amount of denudation that has been suffered even here is strikingly shown in the few summits that rise so conspicuously along the western boundary of the Scioto valley in the central districts of the county. Painter's Knob, near Jasper, can be taken as a representative of this class of summits. It has an elevation of 633.3 feet, by the engineer's level, above low water of the Scioto, 764.5 feet above low water of the Ohio at Cincinnati, and 1196 5 feet above tide water. Its elevation above the general level of the country around it is nearly four hundred feet. In other words, the middle and upper Waverly have been carried away, by aqueous agencies, from wide belts of country to a thickness of at least four hundred feet

On the east side of the Scioto the geological composition of the plateau again changes. The Waverly beds have now been carried by the easterly dip that prevails in all of this portion of the State below the Carboniferous conglomerate, heavy deposits of which constitute the highest surface of Jackson, Beaver, and Marion townships. In the first-named township especially, this formation impresses peculiar features on the country which it occupies. Its purely silicious composition renders it proof against all chemical agencies of the atmosphere. The borders of the high lands that it forms are, therefore, almost every where precipitous walls of the pebble rock, the height of which depends upon the thickness of the formation, generally ranging between seventy-five feet and one hundred feet. The valleys are narrow, and the ridges between those that are contiguous project with their well-defined boundaries like the fingers from the hand.

The highest land of the county, as has already been intimated, is found on its western border. The hills along the Scioto are absolutely higher above the base from which they rise, but the base itself is depressed more than one hundred feet below the lowest land on the western boundary. The elevation of a few points in the county are appended. Those marked with a star are taken from the survey of the abandoned railroad line from Hillsborough eastward to Jackson. The remainder have been determined by the level during the progress of the Geological Survey in the county. In the railroad survey, low water at Cincinnati is counted four hundred and forty feet above tide water, which is eight feet in excess of the figures given by Humphrey and Abbott. The elevations can accordingly be reduced by this amount. The first station named lies just outside of the county limits, but there are several summits within the boundaries that would vary but very little from these figures:

	Feet.
Fort Hill, above tide water	1285.5
Byington* (railroad grade) above tide water	672.0
Latham,* "	631.0
Hill south-east of Latham, "	1224.0
Shepherd's Mountain, between Cynthiana, and Latham (by barometer), above tide water	1170.0
Scioto bottoms at Jasper, above tide water	566.0
Low water of Scioto at Jasper, "	533.2
Jasper Knob, "	1193.6
Painter's Knob, "	1196.5
Piketon* (railroad grade at depot), above tide water	578.0
Riley's Mountain, Jackson township, above low water of Scioto (about)	575.0
" " " above tide water (about)	1150.0
Low water of Scioto on north line of county, above tide water (about)	575.0
Low water of Scioto on south line of county, above tide water (about)	500.0

A range of about eight hundred feet is thus shown to exist between the lowest and the highest land of the county. The greatest vertical range in any one neighborhood, however, as has been already intimated, is found in the hills bordering the Scioto valley. The summits near Jasper—Painter's Knob and Jasper Knob—which lie within two or three miles of the Scioto, rise to a height of six hundred and thirty-three and six hundred and thirty-one feet respectively above low-water mark.

II. GEOLOGICAL STRUCTURE.

The geological range of the county exceeds the vertical range above named by at least fifty per cent. In other words, the aggregate thickness of the different strata shown in the county is not less than twelve hundred feet, the difference between these figures and the vertical range above named being accounted for by the dip that prevails.

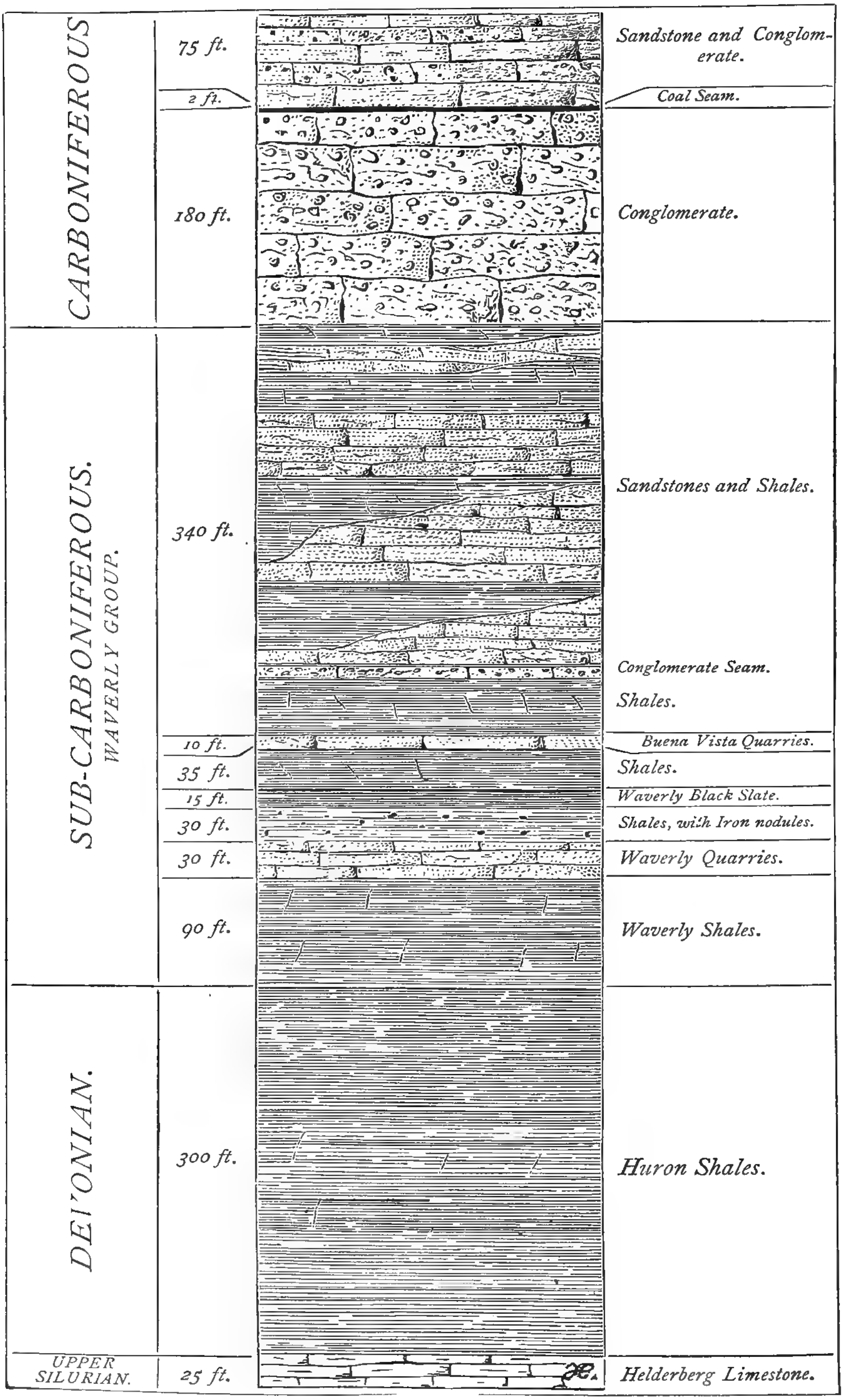
The appended diagram represents the general composition of the geological series of Pike county. It will be observed that the scale is extensive, not only in absolute thickness but in the variety of formations comprehended within it. It is scarcely inferior in either respect to that of any county in the State. (Figure 1.)

A brief description of the different members of the series will now be given.

1. The lowest rock, geologically speaking, in Pike county, is found upon its western border. At a few points in the deeper valleys of this portion of the county, and principally in the valleys of the Sunfish and

FIG. 1.

General Section of the Rocks of Pike and Ross Counties.



its larger tributaries, a few feet of limestone rock are uncovered. The thickness of this formation as it is exposed here nowhere exceeds twenty-five feet. There is no ambiguity as to the place of this limestone in the geological series. Its stratigraphical position, its lithological character, and its fossils identify it unmistakably as the latest recognized but most extensive of the limestones of the State. It has been described in the Geology of Ohio as the *Waterlime Group* of the Lower Helderberg series. It brings the name above given with it from its outcrops in eastern New York, where it constitutes a very valuable deposit of cement rock; but the name is a misleading one in nine hundred and ninety-nine out of one thousand exposures in the West. While cement is found in it in a few places in Ohio, the great mass of it is a dolomitic or magnesian limestone, scarcely to be distinguished in chemical composition from the heavy beds of Niagara limestone that underlie it. In all of south-western Ohio it can be perfectly distinguished by a local name, derived from its most extensive and valuable exposures, which occur at Greenfield, Highland county. It will be treated under this designation—the Greenfield stone—in this report.

The Greenfield stone is the highest Silurian formation in this portion of Ohio. It has peculiarities of bedding and color that serve to distinguish it from all other limestones with which it is associated. It lies generally in very thin courses, of the kind commonly called "shelly." Its light-brown color is not easily to be confounded with any variety of the Niagara, which is the limestone with which it is most closely associated. Its evenness of bedding is another of its distinguishing characters. But few fossils occur in it, but these few are thoroughly characteristic, being strictly confined to this one formation. They consist of casts of a bivalve crustacean, *Leperditia alta*, and of several species of brachiopod shells, among which the genera *Nucleospira*, *Pentamerus*, and *Meristella* have been identified.

But an indifferent quality of building stone is furnished by this formation in Pike county. The deficiency in this respect, however, is less noticed from the fact that all parts of the county are bountifully supplied with the sandstones of the Sub-Carboniferous and Carboniferous formations, among which the finest building stones of the State are included.

The Greenfield stone of Pike county is burned into lime of the finest quality. It has the general composition and character of the Springfield lime, but even surpasses this standard product in whiteness and economy of working. There is no point in Ohio in which the best quality of lime can be manufactured as cheaply as in the Sunfish valley. The hills that bound the valley are covered with wood, from which a cheap supply of fuel can be obtained. The limestone lies in ledges fifteen or twenty feet in thickness, whole acres of which are almost bare of soil. When transportation shall be furnished by an east and west line of railroad along the Sunfish valley, it is certain that a large business must grow up in this manufacture.

The limestone in these valleys is traversed by well-marked joints, which are occasionally enlarged into deep fissures, as can be seen in the bed of Sunfish Creek, in the neighborhood of Byington.

The line of junction between the limestone and the overlying slates can be distinctly followed through almost its whole extent in the county, being unobstructed by Drift beds, and, to a great degree, by the products of disintegration from the adjacent rocks. There are numerous localities where unsurpassed opportunities are furnished for the study of this line of demarkation between Silurian and Devonian time.

The limestone finally disappears at the mill site opposite Latham, dipping steeply beneath the slates. It is not to be seen again this side of the folds of the Alleghanies, its nearest point of emergence being on the Niagara River, a few miles below Buffalo, New York.

2. The next formation in ascending order is the well-known member of the Ohio series designated by the geologists of the former Survey as the "*Ohio Black Slate*," and known in the present Survey as the *Huron Shale.* In the central portions of the State, and thence to the northward, it is underlain by the *Corniferous limestone*, but in the area now under consideration it always covers, as has been already stated, the Greenfield stone. Its place in the geological scale is made out with a little difficulty on account of its paucity in fossils, but it seems to belong, on stratigraphical grounds, to the Middle Devonian.

The Huron shales make a very important element in the western half of Pike county. Its whole thickness is shown in the hills of the western border. Its uppermost courses make the bed of the Scioto River, and are nowhere seen to the eastward of the margin of the valley.

In an excellent section just west of the county line, furnished by *Slate Knob*, a thickness of two hundred and forty-eight feet was found by the level; while in Fort Hill, two or three miles to the eastward, they were found to be two hundred and fifty-six feet thick. The greatest measured section gave three hundred and thirty-two feet. There is no doubt that the formation increases in thickness to the eastward, and it is probable that the average is not less than three hundred feet.

All of the peculiarities of the formation are shown with great distinctness in the western regions of the county. Its lower portions are quite heavily charged with sulphuret of iron, and, indeed, a notable quantity of this substance is found throughout the whole series. Spheroidal concretions—often quite symmetrical in form, and varying in size from an inch or two in diameter to five or six feet—abound in the middle portions of the series. At the centers of these concretions, as they occur to the northward in the State, very interesting remains of fossil fishes have been found; but the only fossils noticed in concretions here are of vegetable origin, and these are very rare.

The shales are charged with a large amount of soluble matter, and as their texture sometimes allows a very free percolation of water, the springs that issue from them are to a considerable extent mineral springs. Sulphureted hydrogen, compounds of iron, silica, lime, magnesia, and soda are found in many of them. When the water holding these materials is evaporated, as it must be when oozing from the beds of shale in weak springs, these mineral contents are deposited in beds of travertine, sometimes of considerable extent. These travertines, so far as examined, are all ochreous—sometimes, indeed, being so rich in iron as to constitute strong and excellent ores. The composition of two specimens is shown by the following analysis made by Prof. T. G. Wormley, Chemist of the Survey. No. 1 is from Grassy Fork, No. 2, from Idaho:

	No. 1.	No. 2.
Silicious matter	33.20	8.85
Sesquioxide of iron	50.80	73.08
Lime	1.10	1.30
Magnesia, carbonate	0.23	0.53
Phosphoric acid	0.06	0.10
Water, combined	14.45	16.00
	99.84	99.86
Metallic iron	35.56	51.16

There is every reason to believe that the amount of lime was originally much larger in the travertine. Atmospheric agencies would necessarily remove this element from all exposed portions of the deposit. The supply is too limited to make these beds of account in iron-making. As sources of ochre they promise better, but it is doubtful whether economical working of such capricious supplies can be effected even for this limited use.

The points at which the ochreous tufas have been found to occur in largest quantity are on the Grassy Fork of Sunfish Creek, two miles above its mouth, and on a small tributary of Sunfish Creek that enters it quite near to Idaho.

In the last named neighborhood a few fragmants of metallic antimony were found a few years since, and the discovery caused considerable local excitement. It is safe to say that the metal was dropped at the place where it was found, either by accident or design, and that it was in nowise a product of the rocks of Pike county.

Occasional seams of clay are to be seen in the series, but they do not seem to be of great horizontal extent, as they constitute but weak water-bearers for the localities where they are found. The shales weather quite rapidly, when exposed to atmospheric agencies, into clays similar to the bedded clay already mentioned.

No fossils besides the obscure ones already noticed in connection with the concretions have been found in the Huron shales within the limits of Pike county.

The soils derived from the shales are thin and comparatively unproductive. The water-supply will be treated in a subsequent part of this report, in connection with the same line of facts as derived from the other formations of the county.

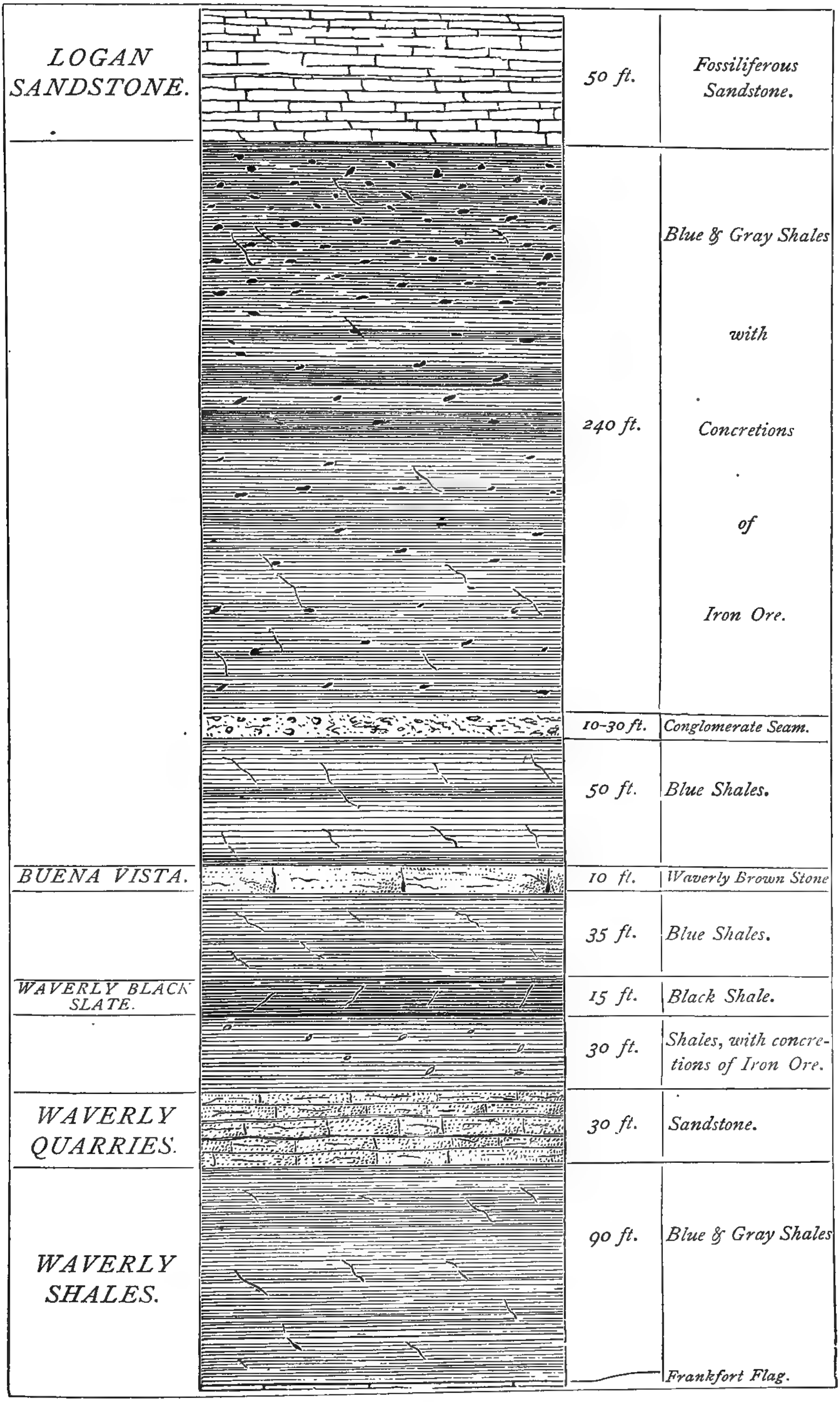
The bituminous matter, to which the color of the shales is due, varies in proportion between eight and fifteen per cent. There is enough of it, however, to render the shales liable to take fire under favorable conditions. Seldom a summer goes by without some case of this sort occurring. These fires last for days, weeks, or even months; and in Camp Creek township, half a mile above the mouth of the stream from which the township is named, a slate hill was on fire for more than three years.

The products of the combustion of the shales are red clays, which served in early times as pigments for the aborigines. The red banks, from which Paint Creek derived its name, probably owe their origin to such agencies, though it must be added that the oxidation of the sulphuret of iron with which the shales are heavily charged often imparts to the outcrop this same red color.

3. We come now to the great system of Sub-Carboniferous shales and sandstones, which has its typical exposures in Pike county. It derives its name, indeed, from Waverly, the county seat. It appears that the town itself was so named by a land surveyor of the Scioto valley, about the time that the remarkable series of novels known as the Waverley Novels were in course of publication. It is unfortunate that, in its application to the village, the spelling of the name should have been changed, an *e* having been omitted from the final syllable. As it is, the name marks one of the few points of connection between geology and literature. This designation was first attached to the series under consideration by the geologists of the former Survey, the stone quarries of this group of rocks being even at that time very well known through the State. The use of Waverly stone for the construction of the Ohio Penitentiary at Columbus, and for many other buildings in this city, and its distri-

Fig. 2.

GENERAL SECTION OF THE WAVERLY SYSTEM IN PIKE AND ROSS COUNTIES.



bution along the line of the Scioto valley canal and the Ohio River, had already brought it into prominent notice.

The Waverly series is by far the most important division of the geological scale in the county. Its horizontal extent, its vertical thickness, its economical products, its relations to the soils, the water-supply, and the topography of the districts which it occupies, all combine to make it, beyond question, the leading formation in this part of Ohio.

It reaches in the summits of the hills to and even beyond the western boundary of the county, and only in the extreme north-eastern and south-western corners is it covered with the higher formation of the Sub-Carboniferous conglomerate and the thin edge of the Coal Measures. Throughout the central districts of the county, on both sides of the Scioto, it is by far the most conspicuous formation, constituting often all of the visible surface and always all of the highest land.

Its vertical thickness cannot be measured in any one section. Painter's Knob and Jasper Knob—two summits the height of which has been already given—furnish the heaviest single sections, and as each of them takes in more than one hundred feet of Huron shales, they give the most extended general section of the rocks of the county. Not less than five hundred feet of the Waverly series is to be found here. In the north-eastern corner of the county, in Jackson township, the series is all embraced within less vertical thickness than this, for although the bottom of the series does not appear there, a well-marked horizon which belongs at one hundred and forty to one hundred and fifty feet above the base can be followed, and measurements can be carried from this to the base of the overlying conglomerate, which shows in great force in all of the highlands in this region. The total thickness of the formation here does not exceed four hundred and fifty feet. There is nothing in Pike county, then, to indicate a greater thickness of the Waverly series than about five hundred feet.

In composition the series consists principally of shales and sandstones. The order in which the beds are arranged is very much the same in all parts of the county. A general section is appended (see Fig. 2), and a brief description of the main beds will here find place.

1. The lowermost eighty to one hundred feet of the series consists of blue and drab shales, interrupted with occasional thin courses of solid stone. The boundary between these Waverly shales and the underlying Huron shales is tolerably well marked by the change of color in the beds. The Huron shales are nearly uniform in color and in texture. The change of color, indeed, from black to blue, or drab, with some change in composition also, is the principal reason for making the division between

the beds at this point. There are no fossils found in either. At Piketon, where the junction between the two groups of rocks is shown with all possible distinctness, it appears, from the occurrence of thin beds of black shale in the lowermost twenty feet of the Waverly beds, that the formation of a shale entirely like the Huron in character was resumed more than once in the early days of the deposition of the Waverly group; but these returns of previous conditions in the seas were of short duration, and were soon lost altogether.

A few thin courses of solid stone of remarkable evenness and of very fine grain occur almost every where at ten to twenty feet above the base. They can be seen to excellent advantage in the river bank, on the land of Mr. John Gregg, two miles above Piketon. Analysis shows that these hard and ringing layers have a large enough amount of lime and magnesia in their composition to put them in the list of impure limestones. This is the only known occurrence of calcareous layers in the whole Waverly series until, at least, its very summit is reached in the regions to the eastward of Pike county. The composition of two specimens is shown in the appended analyses made by Prof. Wormley, Chemist of the Survey. The sample marked No. 1 was obtained from Wolf Run, one mile east of Buchanan. No. 2 comes from the neighborhood of Mineral Springs, on the north line of Adams county:

	No. 1.	No. 2.
Silicious matter	71.40	58.80
Alumina and iron	2.40	5.80
Carbonate of lime	24.40	27.00
Carbonate of magnesia	1.05	8.62
	99.25	100.22

The Waverly shales were evidently formed under very different conditions from those to which the origin of the overlying group must be referred. The latter never show ripple-marks, sun-cracks, or other indications of having been formed in shallow water, while the Waverly shales are conspicuously marked in this way. The surfaces of successive layers, for many feet in thickness, are often covered with ripple-marks, all of them holding the general direction of north 53° west, or south 53° east.*

Exposures of these beds are of common occurrence through all of the western half of the county. On Wolf Run, a small branch of Peepee

* The Survey is indebted to H. W. Overman, Esq., County Surveyor, for a very careful series of measurements. Of twenty-four observations, fourteen were found south 53° east, as given above. Four points showed south 65° east; one south 46° east; one south 57° east. The points that showed south 65° east overlie the other exposures, and probably indicate a real change of direction in the wave action.

FIG. 3.

SECTION OF WAVERLY SHALES AT PIKETON.

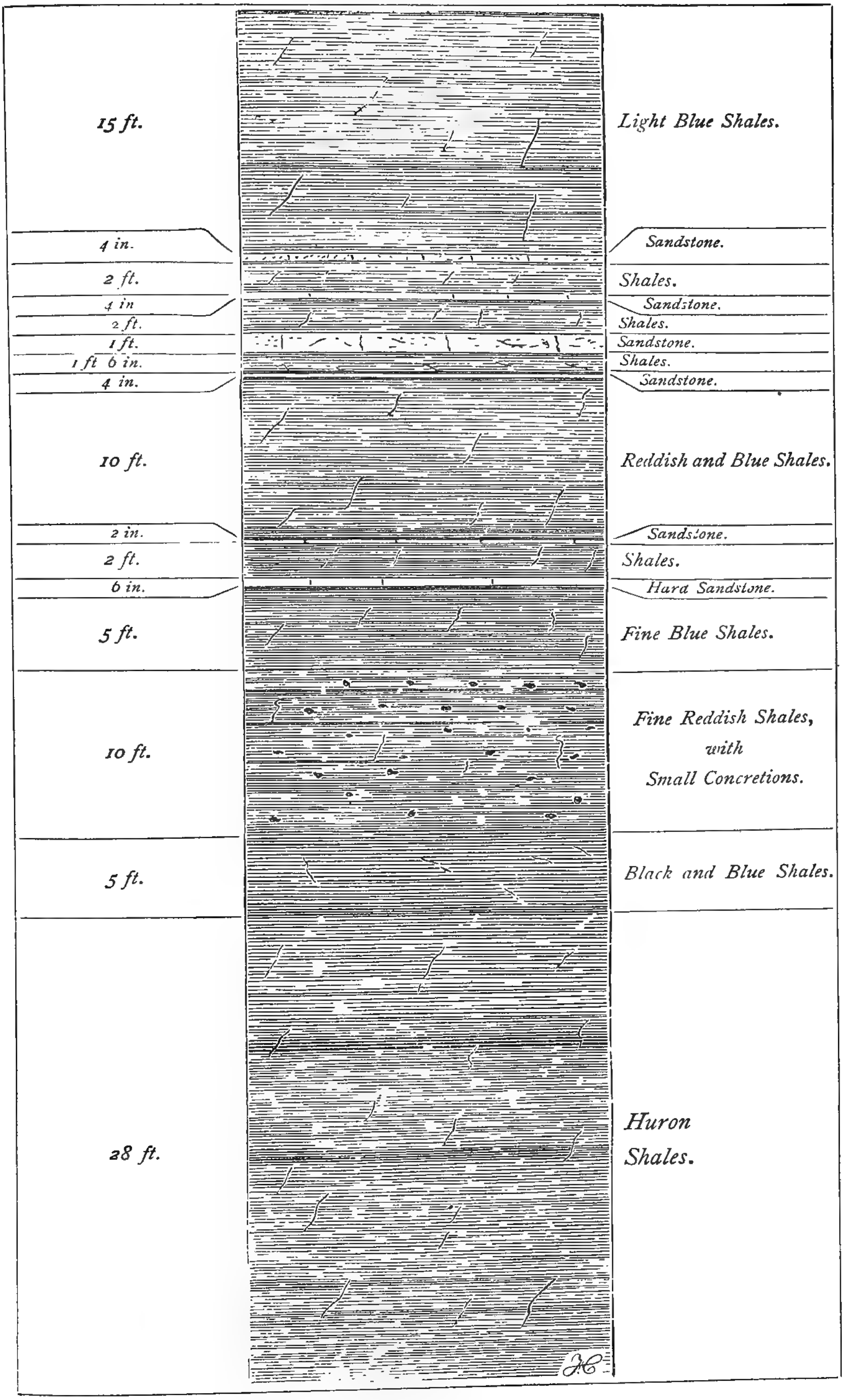
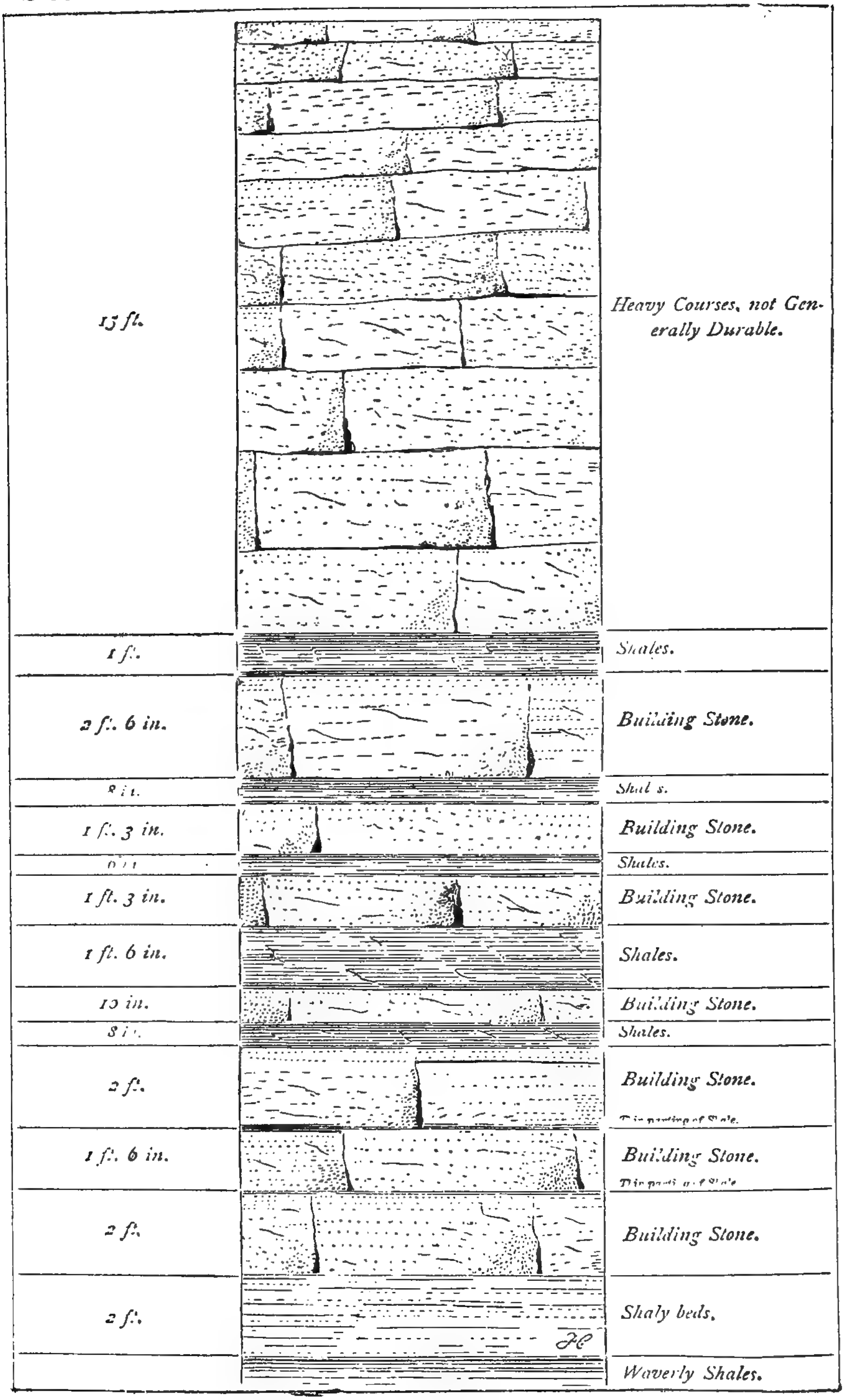


FIG. 4.
SECTION OF WAVERLY QUARRY COURSES AT JASPER.



Creek, one mile east of the village of Buchanan, a very interesting exhibition of the ripple-marks is furnished. There is an equally good exposure along the Waverly and Chillicothe pike, near the north line of the county. The section of the lower beds at Piketon is represented in the following diagram. (See Fig. 3.)

The thickness of the shales has already been given as varying between eighty and one hundred feet. At Jasper they measure 95 feet; at Prather's quarries, two miles north, and on the same side of the river, 89 feet; at Waverly, 90 feet; at Chillicothe, 83.67 feet.

2. The Waverly shales are overlain by heavy ledges of the finest building stone in Ohio. This division may appropriately be called the *Waverly Quarry System.* Wherever this series is shown in southern Ohio, ledges of building stone are found at this general horizon. It is this very ledge, indeed, that gave its name to the whole formation. All of the stone quarried at Waverly and its vicinity, at an early date, came from this horizon. The greatest thickness found in this division is thirty-two and a half feet. This measurement was obtained in a closed section one mile south of the village of Jasper. Its composition is shown in the appended figure. (See Fig. 4.) From Jasper to Waverly, where the typical quarries of the system occur, the thickness never reaches these figures, because of the fact that the system as it is here shown is in no case entirely complete. Its uppermost beds have been removed by denudation. At Jasper the quarry beds measure twenty-five feet, and at Waverly they do not fall below twenty feet. The quarry courses thin out, however, rapidly to the north and east. At Marcus's Run, on the east side of the river, three miles above Waverly, there is a fine exhibition of a closed section of the quarry courses in which they measure less than ten feet. On the western side of the county, also, not only is the thickness reduced, but the character of the courses is changed. They consist to a much greater degree of thin and "shelly" layers than in the central districts above described. At Jasper and Waverly the lowermost course of the system is generally one of the most valuable, but on the east side of the river, at the locality just mentioned, the lower course is worthless, and the only available bed lies just at the summit of the system. Many courses that in the quarry appear desirable, prove unreliable when exposed to the weather. Serious loss results if there is a lack of knowledge or of conscience on the part of the quarryman in the selection of the proper courses. Experience alone can determine the character of the several beds, and it is not safe to apply conclusions drawn from one element of the series at a particular point to the same element at another point. The most valuable courses in the quarry pass sometimes quite

abruptly into a very rough and ungainly stone, called "Turtle-back," or "Nigger-head," by the quarrymen. Their surfaces in such instances are generally covered with marks, indicating origin in shallow water. They are destitute of lines of bedding, and present rather the appearance of concretionary structure than of deposited layers. Such courses are altogether valueless as building stone, and are used only for the protection of river banks and for other similar purposes. The large amount of waste material to be moved in reaching the most reliable and desirable courses constitutes the main element in the expense of quarrying. In the Jasper quarries, for example, not more than ten feet of the thirty feet that belong to the system can be put into the market as first-class building stone.

Of the many shades of color displayed by the Waverly quarry courses, perhaps a light drab can be taken as the standard; at least it is the color which is most highly esteemed for architectural purposes. It is not, however, an original color of the stone, but has been formed by the action of the atmosphere on the external portion of the exposed layers. The native color of the beds from which this most approved variety is derived is a delicate blue—a little deeper than the shade known among painters as French gray. By the oxidation of some of its materials, or, possibly, by the removal in solution of a small portion of oxide of iron, the change is effected. The very slight difference in composition between the weathered, or bleached portion, and the blue stone, is shown in the following analysis made by Prof. Wormley. The samples taken for analysis were from the quarries of Maurice Reiche, Esq , of Waverly, who has made a very careful study of the building stones of the Scioto valley, and to whom the Survey is indebted for much valuable information:

	No. 1. (White stone.)	No. 2. (Blue stone.)
Silicic acid	91.30	91.00
Protoxide of iron	0.86	1.17
Sesquioxide of iron	0.06	0.30
Alumina	5.79	5.20
Lime	trace	trace
Magnesia	0.32	0.28
Water, combined	1.30	1.80
	99.63	99.75

The change from the blue color to the lighter tint has taken place in all exposed portions of the rock, but seldom extends inward more than ten or twelve feet. As these weathered portions have been first removed, not only on account of the desirability in color, but also by reason of their greater accessibility, it has come to pass in all of the larger quarries that the supply of the first variety is much more limited than formerly. The blue stone when laid in masonry undergoes a change of color in its exposed portions similar in kind to that which the outer portions of the native beds have already passed through.

There is also in the Waverly system a large amount of stone of a yellowish cast, which deepens by exposure; but this, though equally durable, is less sought for the better class of buildings.

On the western side of the county especially, though not strictly confined to this region, these same courses are beautifully variegated with bands of red, yellow, and brown. This variety is shown in its best state near Cynthiana, and whenever railroad transportation shall be furnished to this region, it may be counted certain that the admirable qualities of this stone will be in demand for ornamental architecture. This variegated sandstone happens to have a constitution that fits it for use as grindstones, for which it is in considerable local demand.

There is also in the same locality, viz., near Cynthiana, a very white and fine-grained representative of the quarry courses, which, among other uses, has been in limited demand for gravestones. The whiteness of the stone has more than once suggested it as a glass-making rock, but the subjoined analysis shows that the property in question is due to the absence of oxides of iron, and that in reality the sandstone is not of the highest degree of purity.

The specimen in question was taken from the quarries of John Traber, Esq., on the western edge of Shepherd's Mountain:

Silicic acid	91.35
Iron, sesquioxide	trace
Alumina	6.00
Lime, carbonate	0.75
Magnesia, carbonate	0.34
Water, combined	1.00
	99.44

The principal defects which the Waverly stone exhibits in its application as a building stone are the following:

a. Some varieties of it are too tender for the uses to which they are put. For the exposed courses of buildings, for steps, or flaggings, such varieties are ill adapted.

b. Many representatives of the Waverly stone are unable to endure the action of the atmosphere. When exposed to the weather a process of exfoliation begins, which, though it advances very slowly, results in the destruction of the stone.

c. Nodules of oxide or sulphuret of iron quite frequently occur, which are decomposed by exposure to the air, and which by their decay not only weaken the stone, but disfigure it by rusty stains that spread widely from these points.

The deposits that belong to this horizon constitute by far the most valuable of the geological products of the county. They are exposed in almost every square mile of the western half of the county. The Sunfish valley is walled with it throughout its whole length, as are also all of its tributaries, small and great, and a bold escarpment of the quarry courses, broken only by the streams that seek the river, constitutes a considerable portion of the western margin of the Scioto valley.

3. Immediately above the Waverly quarries comes in a very interesting formation, to which attention has been repeatedly called in the previous reports of the Survey. The formation in question has been designated by the Chief Geologist the "*Cleveland Shale*," and by Professor Andrews the "*Waverly Black Slate.*" It consists of a black shale more highly charged with bituminous matter than the great black slate below it, the proportion sometimes rising as high as twenty-four per cent. Unlike the slate below it, viz., the Huron, it is often highly fossiliferous. Two species of brachiopods are especially abundant in it, viz., *Discina capax* and *Lingula sub-spatulata.* The remains of fishes are also of frequent occurrence. Its thickness, as measured in the Scioto valley, varies from seventeen and a half feet to twenty-seven feet. The former measurement was taken from an exposure on the land of John Gregg, Esq., opposite the village of Waverly; the latter was obtained from the best section of it to be found in all the Scioto valley, viz., on the banks of Stony Creek, just north of the line of Pike county.

The highly bituminous character of the stratum makes it frequently give rise to oil springs, the fair promise of which has led to many unprofitable borings in various portions of the county. The most notable display of petroleum in this region is to be found at the "Tar Spring," in Sunfish township, on Chenowith's Fork, about five miles above its mouth. The locality may be more accurately defined as belonging to Chestnut's Mountain. The horizon of the spring is in the Buena Vista stone, a fine ledge of building rock that directly overlies the slate. The volume of water is weak, and the petroleum, which rises with the water in part, and in part oozes out of seams in the rock, is so abundant that the surface of the water in the spring is constantly covered with a dark, tar-like product, the result of the inspissation of the oil. A considerable amount of money was expended here—several thousand dollars—as is stated, in the days of the oil excitement; but, as will be recognized from the facts stated above, there was not good geological ground for expecting success.

A well sunk to the same horizon in the village of Buchanan, or Peepee, for the purpose of supplying the engine of a saw-mill with water, yielded, when first opened, a barrel of oil, but the supply did not prove permanent.

The formation extends almost to the western edge of the county, its extreme outcrop being found at the summits of Shepherd's Mountain, Perry township, and of Renoe's Mountain, Mifflin township; while in Jackson township its easternmost exposures are within three or four miles of the eastern line of the county. It is found at the level of the river, on Joseph Foster's farm, opposite Sharonville, where it contains abundant and very interesting remains of fossil fishes. The Waverly black slate furnishes an admirable guide to the geology of the county, contrasting sharply, as it does, in lithological characteristics, with the beds above and below, and admitting of easy and certain recognition. It makes a plane of division in the Waverly series that has been turned to account in the determination of the total thickness of the series. On the western side of the river numerous sections furnish every facility for measuring the interval between the Huron shales and the Waverly black slate, and at the point last named, viz., the farm of Joseph Foster, Esq., opposite Sharonville, it lies at the level of the river, and within three or four miles the westernmost coal seam is reached. The whole interval is exposed to view in numberless sections, some of them in perpendicular walls of seventy-five to one hundred feet.

The extreme elevation of the base of the Waverly slate above the summit of the great black slate is, as will be seen by a combination of measurements already given, one hundred and twenty-two feet; but for the greater number of instances this maximum must be reduced by five or ten feet. The coal seam of Jackson township has an absolute elevation of three hundred and eighty-five to four hundred feet above the black slate of the Waverly. The element of dip, however, supervenes, and a full discussion of the thickness of the Waverly series in Pike county will be reserved until the constitution of the series has been more extensively described.

The geological interest of this stratum lies largely in the clear proof that it furnishes of a sudden and considerable subsidence of the sea bottom after the Waverly quarry courses had been deposited. These latter beds were formed in shallow water, as is attested by the numerous indications to which attention has been already called; but the finely divided and uniform materials that compose the slate contain an abundance of fossil shells and fishes, and are not only wholly free from any markings that would indicate origin in shallow water, but could only have been accumulated at considerable distance from the shores. That the change was suddenly accomplished is evident from the very abrupt boundary that obtains between the quarry courses and the black slate. The upper boundary of the slate is equally well marked. The conditions under which this deposit was formed were evidently very nearly like those to which the Huron shales owe their origin, and were in marked contrast with both those that immediately precede and immediately follow them.

Contrary to what might be expected, this slate proves to be quite refractory when exposed to heat, if the heat be applied carefully at first. It has in this way acquired a local reputation as a *firestone*, and is used for chimney jambs and other similar purposes.

4. The next division in ascending order has for its chief characteristic the well-known and very valuable quarries of the Waverly system that lie along the Ohio River below Portsmouth. This subdivision has a definite base, viz., the upper surface of the Waverly black slate; but there is no characteristic stratum that constitutes a convenient superior limit. As the most valuable of the building rock, however, that is furnished by this part of the series in southern Ohio occurs within fifty feet of the slate, these fifty feet next above the slate may be somewhat arbitrarily taken as a subdivision. It may be designated as the Buena Vista section—the name being derived from a locality on the Ohio River that furnishes a large amount of stone of unequaled quality. This division is very well represented in Pike county, and some of the most valuable building stone of the Scioto valley belongs to it. The Buena Vista quarries, as is stated by Prof. Andrews in the Preliminary Report of the Ohio Geological Survey for 1869, immediately overlie the Waverly black slate. There is a series of beds sometimes exactly corresponding to this in geological position, and sometimes separated from the slate by a few intervening feet of shale or clay, but which agree so closely with each other in physical characteristics as to make their identity probable. The courses of stone that are exposed at the Tar Spring have already been referred to. Occupying, as they do, the position of the Buena Vista stone, and consisting, like it, of massive layers, the identification of them with the above named quarries will hardly be questioned. The color of these beds, however, in all exposed portions, is brownish yellow. In a very promising quarry opened near the summit of a hill south-east of the village of Latham, a heavy ledge—belonging certainly very near to this horizon—agrees quite well, both in color and texture, with the Buena Vista stone. The great extent of the true Waverly quarries in all this portion

of the county, however, and their accessibility, take away all reason for seeking out any other supply, so that these courses have not been worked to any considerable extent on the west side of the Scioto. The case is different on the east side of the river. The strong easterly dip to which the rocks are subjected carries the Waverly quarries below the surface before the valley is fairly left, and the higher beds are then sought for. The color which has been spoken of as characterizing the rock at the Tar Spring marks it through all its northern exposures in the county. Instead of being counted a disadvantage, the variety which it adds to the builder's resources constitutes a positive argument in its favor. To the north and north-east of Waverly, for twelve or fifteen miles, this Buena Vista stone is very abundant. The best quarry of it yet opened within the limits of Pike county is on the farm of John Gregg, Esq., opposite the village of Waverly, where it occurs in a single massive course, seven feet and two inches in thickness, and perfectly homogeneous in color and character—at least for the limited extent which has thus far been worked. The stone taken from the quarry has been mainly handled by Morris Richey, of Waverly, who has brought it into market under the name of the Waverly brown stone. It has been used for the construction of several large buildings in Columbus during the last five years, where it is coming to be looked upon as one of the most desirable of the native building stones of Ohio. It is to be observed, however, that the brown color for which it is so justly admired is not a natural, but a derivative color, formed from the conversion of a notable quantity of protoxide of iron into sesquioxide. As in the true Waverly quarries, where a similar conversion of the outside portions has been effected, the change does not extend more than twelve or fifteen feet beyond the surface. The original color of the rock is blue, of a considerably darker tint than the native color of the lower courses of building rock, viz., the true Waverly quarries. Its composition is shown in the following analysis made by Prof. Wormley for the Survey. The sample submitted was taken from Gregg's quarries, and only the brown or weathered portion of the layer was analyzed:

WAVERLY BROWN STONE.

Silicic acid	73.90
Protoxide of iron	.....
Sesquioxide o iron	13.44
Alumina	8.56
Lime	trace
Magnesia	0.46
Water, combined	3.30
	99.66

It must, however, be observed, that this ledge, in the central and northern portions of the county, is not in immediate contact with the Waverly black slate, but is separated from it by a varying number of feet of soft shales and clays. The distance between the upper surface of the slates and the quarry beds is sometimes as great as twenty-five feet, but is generally less than twenty feet. This heavy ledge fails altogether in the exposed sections of Pebble and Benton townships, its place in the scale being there occupied by shales, seams of fire-clay, layers of concretions incrusted with a thin scale of iron, together with many thin and worthless beds of impure sandstone. The above enumeration will also apply with sufficient exactness to the one hundred feet overlying the Buena Vista ledges in the region east of the Scioto. The general composition of these clays and blossoms of ore is shown in the appended analyses. Number 1 is a clay from Gregg's farm, between the black slate and the brown stone; number 2 is a fair representative of the clays that compose a notable part of the series for one hundred feet at least above the black slate in Pebble township; and number 3 gives the constitution of the scale of ore that incrusts the concretions to which reference has already been made:

	No. 1.	No. 2.
Silicic acid	61.00	61.10
Alumina	22.25	22.79
Sesquioxide of iron	5.55	4.81
Lime	0.70	0.70
Magnesia	1.40	1.40
Potash and soda	3.90	2.75
Water, combined	4.80	5.80
	99.60	99.35

	No. 3.
Silicious matter	32.12
Sesquioxide of iron	53.97
Alumina	1.80
Manganese	1.00
Phosphate of lime	2.11
Magnesia and sulphur	trace
Water, combined	8.30
	99.30
Metallic iron	37.767
Phosphoric acid	1.279

The large amount of potash and soda in analyses 1 and 2, and the equally unusual percentage of phosphate of lime in No. 3, are points of sufficient interest to be noticed here. These are the substances upon which, more than upon any others, the fertility of soils depends, and the proportions here given are sufficient to make the soils derived from these shales and clays of the very highest degree of excellence. They explain the great fertility of these upland soils of the county when found in a state of nature, as is attested by the luxuriant growth of all the better sorts of timber that are to be looked for in this region. Under skillful tillage, also, they yield excellent results; but the modes of treatment in common use are so ill-adapted to their constitution that much of the land, when cleared, is counted unproductive and rated low.

At various points in the county, but still more conspicuously just beyond its northern boundary, a stratum of conglomerate occurs between twenty-five feet and fifty feet above the Buena Vista stone. It has not been distinctly seen in place within the limits of Pike county, but it is quite certain to be recognized by the pebbly waste of its outcrop. The most southerly point at which it has been met is on the farm of Thomas Walden, in the southern portion of Pebble township. This point, then, marks the extreme extension of that heavy bed of conglomerate which makes so conspicuous an element in the geology of the counties northward, as shown by Prof. Andrews in the report of 1869. As is the case in all of these Sub-Carboniferous and Coal-Measure conglomerates in Ohio, nearly every pebble is quartz. The weight of one of the largest from this horizon was found to be six ounces, even after a considerable fragment had been broken off.

No opportunities have been found, especially on the west side of the Scioto, for studying the remainder of the series with the same care that has been given to the lowermost two hundred and fifty feet. There are at least three hundred feet of higher beds contained in the knobs, that have already been described as making so striking a feature of the county, on the west bank of the river, in the central portions of the county. But these elevations are for the most part wooded; no water-courses flow from them; no quarries have been opened in them; and the opportunities for seeing their real structures are of the poorest. There are much better exposures of the upper Waverly on the east side of the river; but, as will be presently shown, the series is so different there that the facts obtained from the latter section would not hold true in the one now under consideration.

A few statements can, however, be made in regard to these three hundred feet that will prove of service to those who are interested in comparing the varying elements of the Waverly group in different sections of the State.

(1.) With the exception of the Waverly shales and the Waverly black slate, the beds already described are almost, or altogether, destitute of fossils. The only organic remains found in the Waverly shales are sea-weeds, and these are principally found in the uppermost layers. The contents of the black slate are more varied and interesting, as has been already shown; but all the rest of the series thus far reviewed is destitute of plant or animal life. In the beds that remain to be characterized, however, both vegetable and animal fossils occur in considerable abundance. The peculiar cock-tail fucoid (*Spirophyton cauda-galli*) begins about three hundred feet above the base of the series, and is thenceforward abundantly met with. There is one well-marked fossiliferous stratum, in which mollusks and crinoids abound, about four hundred feet above the base. This is well shown in various exposures on Chestnut's Mountain, Sunfish township. It is also found in all of the ground high enough to hold it to the northward, and also upon the east side of the river. No quarries have been opened at this horizon, and no good opportunities have been found for collecting fossils.

(2.) While shales and sandstones alternate through all the series, there seems to be in Pike county less of the former element, in proportion, above three hundred feet than below. In particular, the highest beds on the west side of the Scioto, as in the caps of the knobs, are quite firm in composition. They probably constitute the "Logan Sandstone" of Prof. Andrews. There are known to be scattered through this upper portion occasional valuable quarry courses, but they have not been worked enough to show their extent or availability. In all of the higher beds, so far as noted, the color of the solid courses is darker than that of the true Waverly quarries. A fawn-colored tint marks all of the highest beds.

On the east side of the river, in the central portions of the county, a very similar line of facts obtains; but in the north-eastern corner, and along the eastern border of the county generally, the Waverly system is much reduced in thickness. In Jackson township it is not more than four hundre and fifty feet in thickness. The place of the upper beds is supplied by heavy deposits of Coal-Measure conglomerate.

5. This conglomerate is a new element in the geological scale of the county. As Prof. Andrews has shown in his report upon the counties to the eastward, the deposit is one of quite limited extent. It stretches in a north-easterly and south-westerly direction from the west side of Jackson county into Scioto county. It occupies all of the highest ground of the four following townships in Pike county, viz., Jackson, Beaver, Marion, and Union. In the first named township its outcrops in the hills that border the Scioto valley overhang the river. It has a thickness in

the "Chimney Rocks," near the mouth of Hickson's Run, of one hundred and eighty-nine feet, as given by barometer. It consists almost exclusively of silicious materials, quartz pebbles, and sand. The stem of a calamite or a sigillaria—well-known coal plants—is occasionally met with. There are streaks of iron in the sand that cements the pebbles, which resist weathering agencies better than even the remainder of the series, and they are frequently left in relief upon the surface of exposed beds.

The outcrop of the conglomerate in Jackson township is almost always a vertical wall from fifty to one hundred feet in height. A line of weak springs marks its base. Occasional seams of shale are found interstratified with the formation, so that the soil formed from it, though thin and poor, as is shown by the stunted pines and oaks which it bears, is, after all, less sterile than it would have been if composed of the silicious conglomerate alone. The greater distance of the conglomerate from the river in the other townships named, and the consequent more gradual descent of the drainage streams, forbids the formation in this area of the precipitous cliffs of Jackson township; nor has the thickness of the stratum been elsewhere found as great as in the section at the Chimney Rocks above reported.

6. The last element to be named in the scale of the county is a coal seam. It does not, however, occur at the very summit of the series, but is found in certain limited areas interposed between the beds of conglomerate and coarse sandstone just described. It forms a part of the unmistakable western boundary of the Jackson county coal field. There seems little reason to doubt that the Pike county seam is the extension of the well-known "shaft coal" of Jackson Court House, which is found in a like situation with reference to the conglomerate. At all events, a seam resting on the conglomerate, and covered by conglomerate, or coarse sandstone, can be followed westward from this last named point to the district now under consideration. Callahan's bank, three miles west of Jackson Court House, where a three-feet seam, which is identical in quality with the shaft seam, occurs; Whaley's bank, two miles to the west and north from the above named outcrop, where the same three-feet seam has been worked; and Downard's bank, on the western line of Jackson county, where a blacksmithing coal, three feet thick, is now open, connect the coal of section 19, Jackson township, Pike county, so directly with the shaft coal, that there is not much risk in identifying the various exposures as parts of one and the same seam. That the Pike county seam is the western boundary of the coal field is shown in the fact that the same ledge that holds the coal is exposed for two miles to the westward, from top to bottom, and no trace of the seam is found.

In Jackson township coal has been taken out at several points for family or neighborhood use, and the seam has been marked at many points where it has not yet been opened. One of the best known openings is at Johnson's bank, in section 31. The seam here has a thickness of twenty-five inches. It rests on conglomerate, from which it is separated by a thin sheet of fire-clay, and is overlain by a heavy ledge of the same material. The seam is also shown in precisely similar relations on the land of Isaac Wickline, in section 22.

The coal taken out from Johnson's bank has a fair local reputation, and has been used by blacksmiths in the neighborhood with satisfaction. It strongly resembles, in physical characteristics, the Jackson shaft coal, and the following analysis by Prof. Wormley shows it to agree quite closely with that excellent seam in chemical composition. Analyses are also introduced here of several of the coals, above referred to, that connect the Pike county seam with the Jackson Court House mines. Downard's bank has an excellent local reputation. Whaley's bank is not now open. Callahan's bank yields a coal not inferior in any respect—at least as far as purity is concerned—to the best coal of Jackson county. The analysis of the shaft coal is added, to give opportunity for comparison:

	Johnson's.	Downard's.	Callahan's.	Shaft coal.
Specific gravity	1.313	1.323	1.295	1.267
Moisture	6.40	7.70	8.00	7.50
Ash	4.70	6.50	3.10	4.10
Volatile combustible matter	33.60	29.30	26.30	30.90
Fixed carbon	55.30	56.50	62.30	57.50
	100.00	100.00	100.00	100.00
Sulphur	0.57	1.09	0.57	0.74
Sulphur left in coke	0.38	0.52	0.21	0.22
Sulphur forming per cent. of coke	0.63	0.82	0.32	0.34
Gas per lb. in cubic feet	3.64	3.82	3.80	2.51
Ash	Yellow	Yellow	Yellow	......
Coke	Pulverulent	Pulverulent	Pulverulent	......

No coal has yet been found in Beaver township. The great amount of rock removed in the formation of the broad trough of Beaver valley might account in part for its absence; but there are reasons for believing that the conglomerate extended to the eastward in a promontory through Beaver township, Pike county, and Liberty township, Jackson county, separating two westward extensions of the coal fields—the first of which has already been noticed, and the second of which comes to view in the two townships south of the last named, viz., in Marion and Union townships.

The lower coal seam has been worked for several years in the neighborhood of California, in section 33, Marion township. The coal is somewhat slaty in parts of the seam, but answers very well for household use. It measures twenty-one inches to twenty-four inches at the only opening now worked. It rests on a heavy ledge of very coarse conglomerate, and is situated in all respects like the outcrops of Jackson township.

The same seam has been worked three miles to the north-west of this point, on the farm of John Feesor, in section 19, Union township. This is the westernmost outcrop of coal thus far recorded in the State. It is, in fact, west of the line which the Scioto River reaches in its excursion to the eastward in the northern part of the county. If a similar deflection of the river had chanced to take place at this point, coal would have been found on the west side of this great boundary—the Scioto River.

Analyses of the coal furnished by the last named townships are here added. The first is the California coal, from A. Hendricks's bank; the second is from Feesor's bank, Union township:

Specific gravity	1.327	1.378
Moisture	8.70	7.10
Ash	4.20	6.80
Volatile combustible matter	28.30	29.50
Fixed carbon	58.80	56.60
	100.00	100.00
Sulphur	0.74	0.46
" left in coke	0.27	0.27
" forming per cent. of coke	0.42	0.42
Gas per lb. to cubic feet	3.64	3.24
Ash	Yellow	Yellow
Coke	Pulverulent	Pulverulent

A brief summary of the facts in regard to coal in Pike county will be here given.

The lower seam has been found and worked in three townships of the county. The seam has a general thickness of two feet. The quality of the coal is certainly fair. It is nearly free from sulphur, but has a larger percentage of ash than is found in coals of the first quality. This fact is not, however, shown in the analyses above given. It is by no means certain that the seam extends uninterruptedly between even the nearest outcrops. The lower coal seam is known to be every where capricious, suddenly thinning out and disappearing; but observations and examinations made, some of which have been given above, would warrant a reasonable expectation of finding it on parts of sections 2, 3, 10, 11, 18, 19, 22, 23 of Jackson township, and on sections 20, 21, 28, 29, 32, and 33 of Marion township, and on sections 19, 20, and 31 of Union township, in addition to openings already made. The area in which it occurs, and may occur, is considerable, and the fuel buried here can not fail to be valued and turned to account as the country grows older. The same seam, in heavier volume, is also to be looked for on the western side of Jackson township, Jackson county.

The topography and geological scale of the county have now been briefly treated, and the principal points of interest in regard to origin, history, and economical applications, have been noticed in passing. The following topics remain to be discussed, with equal brevity--the Drift formations of the county, the soils, and the water-supply.

The true glacial Drift is not prominently shown in Pike county. It is éven a question whether any part of the surface is to be referred to it. Besides the great trough of the Scioto River, which constitutes a feature by itself in the topography of the county, there are three principal regions in which heavy deposits occur that are referable to some division of the Drift. These regions have already been referred to in the discussion of the topography of the county. One of them, the Cynthiana valley, holds the north-west corner; another, the California valley, holds the south-eastern corner; while the third, the broad furrow of Beaver valley, traverses the eastern central district. These valleys are all filled with heavy beds of blue clay, the depth being known to exceed fifty feet, in portions, at least, of each. In the counties north of Pike two varieties of blue, Drift clays are found—the first, or lowermost, being the tough, unstratified clay, containing polished and striated bowlders of northern origin, which is commonly known as hard-pan. It can be quite confidently referred for its origin to the melting of the great glacier, which covered the northern portion of the continent at the height of the Glacial Period.

A second variety is a *stratified* blue clay, which contains frequent traces of vegetable and animal life. Its origin is referred to the time of continental submergence that followed the melting of the glacial sheet. The few opportunities found in which the blue clays of Pike county seem to show that they belong to the latter division, vegetable remains being quite frequently met with in digging wells in the first two of the localities named. These stratified beds are very likely underlain by the true bowlder clay.

The uplands of the county are altogether destitute of Drift deposits.

It is certain that the great ice-sheet never brought its burdens of foreign materials to these areas. There are in Pike county no deposits of bank gravel—the great resource of the districts north for road-making—if a single exception is made for the neighborhood of Cynthiana. The river beds and banks furnish an abundant supply of gravel to the regions adjacent; but the absence of bank gravel shows that we have passed beyond the most characteristic effects of the Drift.

The Scioto valley—like all similar valleys in this portion of the State—is filled with deposits of modified Drift throughout its whole extent. This valley Drift in Pike county is recognized under four divisions, viz., the first, second, third, and fourth bottoms. The first bottoms, the lowest of the series, comprise the lands that are overflowed at every flood; the second bottoms are covered only with extreme high water. The boundary of the third bottoms is quite distinctly shown in a terrace fifteen or twenty feet in height, and its surface is elevated by the same measure above the highest floods. The fourth and last division has an elevation of about sixty feet above low water, and is generally bounded by a distinct terrace. It is not to be understood that all of these divisions are to be recognized every where. Sometimes the first bottoms extend to the edge of the bedded rocks which bound the valley; and more frequently the four divisions are all represented in a bank fifty or sixty feet above the river channel. Between Jasper and Piketon the whole series is very handsomely shown.

The third and fourth divisions agree in general composition. They both consist of gravel—a large part of which is limestone—of sand, loam, and clay, variously intermingled. The broad, fertile, and well-drained tracts of the fourth bottoms furnish very attractive and advantageous locations for residence, and have been selected for the two principal towns of the valley, viz., Waverly and Piketon.

The first and second bottoms furnish the most productive lands of the county. There is, in fact, no better corn land in the State than this division within the limits of Pike county. Their fertility is maintained unimpaired by annual deposits from back-water—the overflow of the river being now quite commonly regulated by levees. The depth of the annual deposit upon the lowest bottoms varies from one inch to one foot. When the larger measure is reached, a winter must intervene before the mud works kindly under tillage.

As the drainage of the State was gradually arrested in the later stages of the Drift period by the northward subsidence of the continent, it seems probable that the valley was largely filled to the height of the last terrace. When a re-elevation began, the clearing out of the old channel would necessarily follow, with the establishment of the terraces that make so conspicuous a feature in the valleys to-day.

III. SOILS.

The subject of the soils of the county follows next in order, and has, indeed, already been touched upon in the reference to the deposits that fill the Scioto valley.

The Scioto valley is far more productive than any other equal area within the county. The variety of soils found within it has been indicated in the description of the different elevations which the valley deposits now hold. The two lower members of the series give excellent examples of alluvial soil. They constitute in Pike county, and below, one of the great corn fields of Ohio. They are planted every summer, and it is by no means uncommon to find eight or ten square miles of Indian corn in one unbroken tract. The ordinary yield ranges between fifty and seventy-five bushels to the acre.

The soil of the terraces is not thus renewed by natural agencies, and though still very productive, shows in a marked degree the incipient exhaustion that all of the land of this part of the State, except the alluvial bottoms, exhibits under the system of tillage now in use. These areas have been growing less tractable of late years by the exhaustion of their organic matter. The plowing in of clover restores this element, and works admirably in ameliorating the lands that have grown stubborn.

The remaining valleys of the county have not shared in the geological fortunes of the Scioto valley, and, consequently, lack its fertility. None of them contains limestone gravel to any extent.

The intervals of the Sunfish are quite narrow, and the soil is decidedly inferior to that of the river valley.

The clays of the Beaver, California, and Cynthiana valleys form for the most part cold soils, better adapted to grass than to cereals.

The upland soils of the county are, without exception, native soils, formed where we find them by agencies such as we now see at work. Being made from different materials, as the different belts of the geological scale successively form the surface, they exhibit great differences in composition and character. Three general divisions will be recognized by every one acquainted with the county as dividing among them the upland areas. They are the slate soils, the Waverly soils, and the conglomerate soils.

On the western border of the county, especially in Perry and Mifflin townships, we find the Huron shales largely displayed. The soil formed from their weathered outcrops is quite characteristic, being emphatically a thin soil, slight in volume generally, and so lacking in favorable conditions that no ordinary field crops can be raised upon it with profit. Forest trees, however, within quite a limited range of species, manage to grow upon it. In fact, they establish themselves upon raw banks of shale before any such changes have been wrought in it as would make it proper to term it a soil The chestnut (*Castanea vesca*) and the Spanish oak (*Quercus palustris*) are every where characteristic trees, and the chestnut oak (*Quercus castanea*) is also common, though less abundant than the first named trees. Fruit trees are also found to thrive well and produce well upon slate soils; but grasses and cereals either fail altogether in them, or have but a dying life.

The products of the weathering of the shales are accumulated in the valleys as quite stubborn clays, which contain the elements of fertility, it is true, but which require more careful treatment than they generally obtain to render them at all desirable for tillage. The lands of this division are, on the whole, decidedly the least productive within the county. If left to produce the only vegetation for which they show a natural adaptation, viz., forest growth and orchards, they can be made to serve a very useful purpose; but when hill-sides of shale are stripped of their forest growth and subjected to tillage, they soon become as nearly desert as any lands in the State ever become.

The Waverly soils come next in order. They are in every way more important than the preceding division. They occupy a much larger portion of the surface of the county, covering, in addition to all other exposures, all of the table-lands of the western side of the county; instead, as in the case of the shales, being confined to the slopes of the hills—and they are, besides, much more productive, the farming land which they furnish yielding excellent rewards to skillful husbandry. They vary among themselves according to the character of the particular strata from which they have been formed; but these varieties are kept within quite narrow limits. But few of the sandstone beds are destitute of clay, and all of the shales contain more or less sand. The percentage of silica is so large in some of the soils that they come under the category of light soils; but in much the larger number of instances the clay predominates, and a strong, tenacious soil is the result. Most of them are naturally light-colored. They rarely show the reddish tints of the native soils to the westward. They contain in abundance all of the chemical elements necessary for vegetable growth, but under cultivation they generally stand in urgent need of the amelioration that a good supply of organic matter in the soil furnishes. Their native fertility is shown by the luxuriant forest growth with which they are covered. There is no finer timber produced in the State than the hills of Pike county supply. The variety is large, embracing poplar, hickory, ash, walnut, and oak. The flanks of the hills are covered equally with the summits.

A notable difference will, however, be observed by even a casual observer between the northern and the southern slopes of the hills. This difference is shown not only in the amount but also in the kinds of timber produced. It depends on physical conditions altogether, the two most prominent being the following: Our heaviest rains coming from the south, wear away the forming soil from the sides of the hills against which they beat; and, in the second place, the action of the sun is far more powerful on southern slopes than on northern, reducing the moisture of the soil very often below the limit which vegetation generally requires. The kinds of timber, as intimated above, are found to vary very much in the different exposures. On the south side the same trees are found growing that have already been named as characteristic of the slate soils. On the summit of Windle's Knob, one of the high points of the county, five miles west of Waverly, and on its northern slope, the following varieties of trees were counted within the area of forty square rods:

Red Oak	Quercus rubra.
Pigeon Oak	Quercus acuminata.
Chestnut Oak	Quercus castanea.
Chestnut	Castanea vesca.
Black Walnut	Juglans nigra.
Hickory	Carya alba.
Blue Ash	Fraxinus quadrangulata.
Black Locust	Robinia pseudacacia.
Redbud	Cercis Canadensis.
Dogwood	Cornus florida.
Basswood, or Lin	Tilia Americana.
Persimmon	Diospyros Virginiana.

Like all the other lands of this part of Ohio, these Waverly soils are generally subjected to a rude and exhausting system of tillage; but wherever an exception is made to this rule the lands yield a generous return. One or two farms in Pebble township, near the little village of Buchanan, give a hint of the possibilities that are latent in these uplands under wise husbandry. There is no defect in them, let it be repeated, in natural composition or constitution. Under proper treatment, they make the business of agriculture a living business for the tiller of the soil, while at the same time they become more and more adapted to the work required of them.

The conglomerate soils of the eastern uplands of the county need no extended remark. There are barren areas within them, derived from the pebble beds, without any admixture of shales; but, for the most part, they are covered with the forest growth that belongs to thin soils. The steep slopes of the hills on the northern sides are always productive. It costs much more to till them than to till the great valleys, but the slopes are scarcely less productive than the richest of the valleys.

The first named of the native soils of the county was spoken of as specially adapted to the growth of timber and to the production of fruit. While the remaining divisions are not limited, as are the shales, to such lines of production, it may be said that all of the highlands of the county are happily adapted to these same interests. For successful fruit-growing, the hills of Pike county can not be excelled in southern Ohio. By their elevation they gain exemption from late frosts in spring—one of the chief obstacles to fruit-growing in the State. A peach crop is very seldom forfeited on the high grounds.

For a cause presently to be mentioned, these uplands can not be very successfully devoted to stock-raising; nor can cereals be produced from them in remunerative degree, if the same system that prevails in the valleys is followed here; but an intelligent adaptation of means to ends in dealing with them will make them more kindly and more fruitful soils than the most favored regions of the New England States, or the eastern border of the country generally; and however poor these lands are now counted in comparison with the beautiful plains below them, we may be sure that they contain untold possibilities of agricultural wealth, which are certain, at some future day, to be utilized.

IV. WATER-SUPPLY.

One topic remains to be discussed, viz., the important one of water-supply. This will be considered in connection with the geological divisions already given.

1. There are many springs at the lowest geological horizon of the county, viz., at the surface of the limestones along the western edge of the county. Though issuing from the limestones, they are in almost all cases derived from the porous beds of the overlying Huron shales. If the springs are weak, and especially if the water moves from them slowly, they are very likely to be impregnated with dissolved mineral matters, of which sulphur and iron are chief. Such springs invariably acquire a local reputation as medicinal, and though, as a rule, pure water is to be preferred for human use to supplies that are burdened with mineral matters dissolved from the rocks, the nature of the impurities here

contained renders it improbable that the use of these waters can do much harm.

There are several springs of unusual volume in this district. The most notable is one well known through the whole Sunfish valley as the "Big Spring," or "Campbell's Spring." It is without doubt the largest spring in south-western Ohio. It is universally believed in the neighborhood, and, apparently, on good grounds, that a mountain stream called "Drybone," which disappears abruptly from its bed two miles to the westward, emerges again as Campbell's Spring, its waters having been cooled, clarified, and re-enforced by their subterranean journey. It is claimed that the water has been tracked through the mountain that intervenes by bran or chaff, which was thrown into the stream, and which was found again in the spring. There is reason to believe that the spring has more than one principal source.

An attempt was made a year or two since to utilize this strong and steady stream of water by making it turn a mill-wheel. To secure the necessary "head," a heavy wall was laid in cement around the spring; but the water rose only four or five feet before it burst out from the side of the mountain a few rods to the northward of its old point of emergence, thus rendering the enterprise fruitless.

2. No valuable springs occur in the black slate series. Indeed, there is no geological formation in the State that furnishes water of as poor quality and in as inadequate supply as this. "Seeps" rather than springs occur at infrequent intervals in its outcrops, but the water is mineralized to such an extent as to be unfit for use by man or beast. Wells are, in like manner, impossible or unprofitable in this formation, the quantity or quality of the supply, or both, being objectionable.

3. The frequent courses of shale that occur in the Waverly series prevent water from entering or passing through it to any great extent; and this great division of the rocks of the county must, therefore, as a whole, be set down as poor in water-supply. Where some of the sandstone strata—as, for example, the Waverly quarry courses—are exposed for any considerable area, springs of pure water mark the outcrop of the first underlying seam of shale; but there is no considerable line of springs to be referred to this horizon, nor, indeed, to any other horizon in all of the series. What few springs occur are generally of fair quality, but of light volume, and, for the most part, fail during the heat of summer.

The Waverly table-lands, of which extended mention has been made, are especially defective in natural water-supply. The weathered products of their rocky floor generally form a compact and fine-grained clay subsoil, at least as impervious to water as the shaly beds from which in large measure this subsoil is derived; consequently the rain is refused entrance, and springs, wells, and living streams are alike impossible. There are weeks, or even months, during almost every summer in which all surface water disappears from these extensive areas, and stock of all descriptions must be driven daily from one to four miles for water. For domestic use cisterns are every where constructed, and the clay is so tenacious that it holds water quite well without cement, a dry wall being generally laid to guard the excavation. What are called wells in these areas are generally pits in this impervious clay, and the entire supply is derived from surface water. The wells then differ from the cisterns principally in this respect, viz., the latter are supplied from the roofs, while the former receive their supply from the foul and neglected surface adjacent to house or barn. Water from such sources must always be looked upon with grave suspicion. There is no question but that it is very often the medium for spreading disease and death. It is obvious that all the roofs of these regions should be taxed for water-supply.

4. The conglomerate of the eastern side of the county furnishes at its base occasional springs upon which some dependence is placed. The seams of shale, however, distributed even through the conglomerate, interfere with its service as an efficient water-bearer.

5. The Drift deposits of the county furnish the usual line of facts in this connection. The Scioto bottoms are full of water throughout their whole extent, but it is generally necessary to go to the level of the river before reaching it. For the third and fourth bottoms, which have been already mentioned as the most desirable locations for residence, the distance is so great as to render this source practically inaccessible.

It will be seen, therefore, that almost all of the county is, to a greater or less degree, defective in natural water-supply. Springs, wells, and water-courses are quite inadequate to meet the demands in large areas of the county. The people of such districts can not move too soon in securing the artificial reservoirs that must take the place of the natural supplies. Economy, comfort, and health alike demand more careful provision for this indispensable element, in properly constructed and properly guarded cisterns.

CHAPTER LVIII.

REPORT ON THE GEOLOGY OF ROSS COUNTY.

The general geology of Ross county agrees very closely with that of Pike county, already given. The two counties have a common geological scale, and their principal topographical features, which are very similar, they owe to a common geological history. They differ, however, in one important particular, viz., the characteristic deposits of the glacial Drift cover the northern townships of Ross county, but are wanting at least in the uplands of the regions to the southward.

A detailed description of the geological series of the county would, therefore, involve a needless repetition of the statements of the preceding chapter. In the present report, therefore, only those facts which are peculiar to the area now under consideration will find place.

The various topics to be treated will be taken up in the same order as in the preceding section.

I. SITUATION AND TOPOGRAPHY.

Ross county is bounded on the north by Pickaway, on the east by Hocking, Vinton, and Jackson, on the south by Pike, and on the west by Highland and Fayette.

As in Pike county, the chief feature in the topography is the broad and deep trough of the Scioto valley, which traverses the county from north to south, dividing it into two unequal areas, the western side exceeding the eastern in the ratio of 2:1. The river cuts the north line of the county at very nearly the middle point, and flows thence almost directly south to Chillicothe. It is here strongly deflected to the eastward; and in the extreme south-eastern corner of the county the main valley is not more than four miles distant from the Jackson county line.

The western side of the county is deeply divided and subdivided by the valley of Paint Creek and that of its principal tributary, the North Fork. Paint valley is, next to the Scioto, the most important of the surface features of the county.

East of the Scioto, and in the south-eastern corner of the county, Salt

Creek flows in an old and deeply excavated valley. These constitute the leading cases of erosion and material modification of the surface. Still other examples are furnished by Deer Creek and Kinne-Kinnick, on the northern side, and by Indian and Walnut creeks on the south.

The high table-lands that make so prominent a feature in the topography of Pike county are wanting here, except in the southern tier of townships, and in several of these there are but few examples.

Paint Creek is flowing, for a short portion of its course, in a new valley, the origin of which can easily be understood in the light of recent geological history. There are numerous cases of this kind in south-western Ohio, an interesting one of which is given in the report on the geology of Clarke county, in the first volume. The facts connected with the present instance, however, are more remarkable than any yet recorded in this geological district. As the origin of this new valley is unmistakably connected with the history of the Drift period in the county, a full account of the case will be deferred until that part of the report is reached in which the formations of the Drift shall be taken up.

II. GEOLOGICAL SERIES.

1. There are several facts which render the limestones of Ross county much more interesting and important than those of Pike county. In the first place, the county stretches several miles further to the westward, and thus takes in a larger area of these rocks. In the second place, and chiefly, they have been laid bare in the deep valley of Paint Creek and its tributaries through all of the western border of the county, so that not only is a large area exposed, but the valley has been cut entirely through the Helderberg series deep into the Niagara group. The section thus exposes two Silurian limestones instead of one, as in the district beyond. In addition to these points, it may be remarked that the deep gorge of Paint Creek furnishes some of the most picturesque scenery of southern Ohio.

On the west line of Buckskin township, for two miles above and two miles below the Marietta and Cincinnati Railroad, the valley of Paint Creek is hewn out of the heaviest section of limestones of the Helderberg division known in this part of the State. There are not less than forty feet shown in vertical section in the Rucker quarries, opposite Greenfield. It is probable that this forty feet exhausts the Helderberg series in its downward reach, or, in other words, that the courses immediately beneath belong to the Niagara group. The character and value of the stone and the extent of the quarries have been described at length.

in the chapter on Highland county in the Report of 1870, and no further mention of these facts is demanded here. It may be said, in passing, that these quarries furnish in their remarkably even-bedded courses some of the most desirable stones of the State. The fact that all the fragments and waste of the quarries can be burned into lime of fair quality, renders the working of them as economical as possible.

But few varieties of fossils are seen in the quarry rock. The bivalve crustacean, *Leperditia alta*, which is characteristic of the formation, covers thickly the surfaces of many successive layers. A favosite coral is not uncommon, and several species of brachiopod shells are occasionally met with.

Two miles below the Greenfield quarries the rock becomes more fossiliferous, and well-preserved casts of several species of shells have been found. They are referred to the genera *Atrypa, Nucleospira, Meristella,* etc. The species are probably undescribed.

The Helderberg limestone is through all of these exposures—a magnesian limestone, containing forty to forty-four per cent. of carbonate of magnesia, and fifty to fifty-four per cent. of carbonate of lime. As the name of the lower member of the group denotes—to which this division, now under consideration, undoubtedly belongs, viz., the waterlime—a cement rock often finds place in the series. The formation is true to its name in Ross county. On the Rittenhouse farm, in Concord township, the upper beds of the series have long been burned into a hydraulic lime of a high degree of excellence. Experience of its qualities for thirty years makes it certain that it is a strong and durable cement. Its composition is given in the report on Highland county, above named. The supply is large, and the cement can be manufactured at advantage in all respects. It requires to be worked, however, in a different manner from the cements in common use, and this fact has hindered the development of the business here. The valuable properties of the stone will doubtless be utilized in time to come.

The lowest courses exposed in the bed of Paint Creek, at the locality named above, viz., two miles below the railroad crossing at Greenfield, belong, as has been said, to a different horizon, viz., to the Niagara group. They are very readily distinguished, both by lithological characters and by the fossils which they contain. The upper beds of this series in southern Ohio are almost every where characterized by the very conspicuous casts of one or more of the following fossils, viz., *Pentamerus oblongus, Trimerella Ohioensis, Megalomus Canadensis.* The casts sometimes make up the very substance of the rock. Other forms are intermingled occasionally in great abundance. The more noticeable sorts are favosite corals, univalve shells, and chambered shells. The beds on Paint Creek, for a dozen miles below the last named point, are occupied very largely by casts of *Megalomus*. This remarkable fossil occupies nearly, or quite, ninety feet of limestone, near the mouth of the Rocky Fork of Paint.

As the Helderberg limestone is followed to the southward and eastward it is observed to thin out very rapidly. An excellent section—one of the best in this whole region—is found on the banks of Buckskin Creek, two miles north of Bainbridge, on the Greenfield road. The Megalomus beds of the Niagara, the Helderberg (waterlime), and the Huron shale are all shown in a section of fifteen feet. In other words, the Megalomus beds reach up almost to the shales—a thin wedge of Helderberg alone separating the two formations.

It will be remembered that a few miles to the south-westward the Helderberg disappears in places entirely, the Huron shales lying upon the Niagara strata. The uppermost member of this formation at this point is a peculiar sandstone, which has been described as the Hillsborough sandstone. There are a few exposures of this sandstone in Paxton township, in the vicinity of the caves of Rocky Fork.

We find in the great exposure of limestone at the Falls of Paint, in the beds that underlie the *Megalomus* division, another of these fossils above named in equal abundance. The casts of *Pentamerus oblongus* here make up the very substance of the rock.

As Paint Creek turns in the extreme south-western corner of the county abruptly to the north-east, the heavy easterly dip of the limestones soon buries them below the surface. Their last appearance is opposite the village of Bainbridge.

An admirable general section of the rocks of the western side of Ross county is furnished by Benner's Hill, in the same neighborhood. The summit is five hundred feet above the valley, and the following scale—the formations being represented in their true order—is shown in the steep ascent:

	Feet.
Upper beds of Waverly group (Buena Vista division,.etc.)	42
Waverly black slate	15
Waverly quarry courses	31
Waverly shales	50
Huron shales	332
Helderberg limestone (waterlime)	15
Niagara limestone (Megalomus division)	15

Both of the limestones here shown are capable of furnishing an unlimited supply of lime of the highest quality. It is not, indeed, surpassed in whiteness, mildness, and durability by any lime of the State.

The Niagara rock is ill-adapted to building purposes, coming out of the quarry in massive and ungainly blocks; but the close proximity, in this region, of the fine courses of the Waverly quarries renders it unnecessary to turn it to such uses.

2. The Huron shales are, perhaps, the most characteristic formation of the western half of Ross county. They occupy a large area, and impress peculiar features upon the soil, the vegetation, and the scenery. They afford at Benner's Hill, above mentioned, the heaviest section yielded by the formation in Ohio, viz., three hundred and thirty-two feet. The composition of the series, as shown in this and closely adjoining sections, has two points that deserve mention. The first is the occurrence of twenty-six feet of white and blue clays at the base of the series; and the second, which is much the more interesting observation, is the occurrence of a calcareous layer, well charged with fossils, at the height of forty to fifty feet above the base of the system. The clays are shown on the west side of Benner's Hill. The limestone seam is best seen at Ferneau's Mill, one mile east of Bainbridge. Mr. J. H. Poe, of Chillicothe, first called attention to its existence, and to him the Survey is indebted for a very interesting fossil—the body of an hitherto undescribed crinoid—obtained from this locality. The calcareous seam varies between three inches and six inches in thickness. Its composition is shown in the appended analysis, made by Prof. Wormley:

Silicic acid	53.20
Iron and alumina	2.10
Carbonate of lime	37.20
Carbonate of magnesia	6.88
	99.38

Its interest lies in the fact that no other such seam has been reported in the whole extent of this formation. Taken as a whole, the Huron shales are almost entirely destitute of traces of either vegetable or animal life. Two brachiopod shells, a *Discina* and a *Lingula*, have been found at various points in the system, and the great concretions which the formation holds have yielded the remains of some remarkable species of fishes; but throughout most of its extent it is utterly barren of palæontological interest. One of the difficulties in settling the Ohio geological scale, or, at least, of correlating certain of its upper members with the members of the eastern geological series, has lain in the fact that fossils, the true labels of the rocks, are here wanting. The outcrop of the slates on the western side of Ross county promises valuable contributions to our knowledge of the life of the seas and shores during the long period in which these black shales were accumulating upon the floor of the ancient ocean. The few square feet exposed in the bank opposite Ferneau's Mill have already yielded a new crinoid belonging the genus *Melocrinus* and described by Prof. Whitfield in Vol. II. of the Ohio Palæontology; a tentaculite, identified by Prof. Whitfield as *Tentaculites fissurella*, and which is found at the east in the Marcellus slate; and several obscure and undetermined corals. Vegetable remains are also sometimes met with in the same locality. A calamite, several feet in length, was found at the center of a large concretion, and a prostrate tree, the bark of which had been converted into coal, was traced by Mr. Bergen, assistant in the survey of the county, for thirty feet over an exposed layer of shale.

This field is commended to the attention of local geologists as well worthy of careful exploration. Such an exploration is almost sure to be rewarded by the discovery of new species of fossils.

The exposures of the slates along the course of Paint Creek are unsurpassed. The whole series, except fifty or sixty feet of the lowermost beds, is shown in two nearly vertical sections—the first one occurring at the well-known locality, Copperas Mountain, and the second at the equally well-known but less accessible locality, the Alum Cliffs. Copperas Mountain is situated three miles east of Bainbridge. The Alum Cliffs are five miles due west of Chillicothe.

Paint Creek washes with the full force of its current the foot of the slate hill known as Copperas Mountain, and thus secures a constant exposure of the formation in a nearly vertical wall one hundred and fifty feet in height. The hill rises to a height of five hundred and fifty feet, so that the whole thickness of the slates is contained in it, and much besides; but the uppermost one hundred and twenty-five feet of the formation are not shown as distinctly as the lower portions.

At the Alum Cliffs section, which is the new valley of Paint Creek, to which reference has already been made, the uppermost beds are shown in a wall very nearly vertical to an extent at least of one hundred feet. The Huron shales are here covered by the Waverly shales and the Waverly quarries, and the section is for the most part closed by the Waverly black slates. The upper beds of the division are shown with great distinctness within the limits of the city of Chillicothe, and upon all sides of it.

The concretions by which the Huron shales are every where characterized occur mainly in the lowermost one hundred feet. Many of them possess remarkable symmetry. The smaller ones frequently consist of sulphuret of iron. The larger ones have either organic or crystalline nuclei, and in far the larger number of instances the latter.

3. The Waverly shales of Ross county require no extended mention. They do not generally attain to the thickness which this division shows in Pike county, and on the western side of the county are considerably reduced. In the city of Chillicothe they measure 83.67 feet in thickness.

They indicate the same general history which the series elsewhere shows, their surface being covered with sea-weeds, sun-cracks, and ripple-marks. Where exposed on Stony Creek, in Franklin township, they afford the finest series of ripple-marks known in the Third Geological District. Similar exposures are shown in the same township, on the line of Indian Creek and its tributaries.

In the report on Pike county a calcareous layer of remarkable compactness and evenness was noted as occurring near the base of the Waverly shales, and its composition, as shown by chemical analysis, was given. This same layer extends through all of the outcrop of this division in Ross county. In the vicinity of Frankfort considerable account is made of it as a building and flagging stone. Mr. Bergen, who made the examination of this part of the county, proposes that it be recognized as the Frankfort flag.

4. The Waverly quarry system continues to furnish in its northward extension a large supply of excellent building stone. The character of the rock quarries agrees very closely in color, texture, and composition with the stone derived from the typical exposures; but a very much larger proportion of the series in Ross county is valueless than in the district below. The stone is quite frequently found in a peculiarly rough and ungainly condition, known among the quarrymen as "turtle-back," or "nigger-head." In this state it has no possible uses, except as protection for river banks. In all of the central regions of the county the division is very much lighter than at Waverly and Jasper, being frequently found to measure five to ten feet only against thirty feet in the Pike county quarries. In Paxton and Buckskin townships there is a larger amount of stone again, but it is not found in as thick and valuable courses as to the southward.

5. Ascending in the scale, we next come to that interesting stratum, the Waverly black shale. No finer exposures of this are possible than are furnished in hundreds of sections through all of the central regions of the county, upon both sides of the Scioto River. The greatest thickness yet observed in this formation is found in Franklin township, near the mouth of Stony Creek, where it measures not less than twenty-seven feet. It is charged at this point with its characteristic fossils, *Lingula melia* and *Discina Newberryi*, and the remains of fishes, often in an excel-

lent state of preservation, can hardly be called rare. The teeth and plates are the parts generally shown. In a small run that crosses the old Marietta road, three miles above Chillicothe, interesting slabs were found.

This slate contains sulphuret of iron in considerable quantity, and the water that descends through it is, consequently, charged with the products of the decomposition of this substance. Sulphur springs often mark its outcrops. A spring of this kind, quite well known in the north-eastern quarter of the county, finds its way through the slate on the north side of Sugar-Loaf Mountain, near the south line of Green township. The slates have a thickness of twenty feet at this point, and are overlain by a heavy and interesting section of the upper Waverly.

6. This last named division, the upper Waverly, including every thing in the series above the Waverly black slate and below the Carboniferous series, remains to be briefly characterized. It constitutes a valuable element in the county geological scale, absolutely and relatively more valuable than the same member in Pike county. The extreme thickness of this division does not exceed four hundred and twenty-five feet in any single section. A greater thickness of these beds may, perhaps, be found in the north-eastern corner of the county, where the series is certainly quite different from that observed in the south-eastern section. In Liberty and in Jefferson townships the upper beds of the Waverly are reduced in thickness, and the place is supplied by a heavy deposit of Carboniferous conglomerate, as in the adjacent districts of Pike and Jackson counties. Single sections of considerable extent and interest are found in Mount Logan, opposite Chillicothe; in Sugar-Loaf Mountain, three miles above; in Rattlesnake Knob, Liberty township; and also in the highest points of Huntington and Franklin townships.

But few points in the composition of the series demand consideration here. Its economical value, to which reference has already been made, lies principally in the fine development of the Buena Vista courses in the south-eastern portion of the county, and especially in Franklin and Jefferson townships. A great amount of most desirable and accessible building stone is exposed in the first named township, on the western bank of the Scioto River. The quarries of J. E. Higby are more largely worked, and therefore more widely known, than any other. They are located upon the line of the canal, which furnishes convenient and cheap transportation. As in the Gregg quarry at Waverly, the stone is all furnished by a single course, eight feet in thickness. The course can easily be split into two courses of equal thickness. All of the quarrying has thus far been done along the margins of the hills, where the stripping is quite light, and a very large quantity of rock remains within easy reach.

This bed is very soon lost as it is followed to the other side of the river, the strong easterly dip carrying it below the surface in three or four miles from the exposures here named. It agrees in color with the Waverly brown stone, as well as in geological position. The brown color of both is due to a change in the oxide of iron which the stone contains, and it is always limited to a few feet upon the exposed edges of the quarries.

This course has thus been shown to extend for at least twenty miles along the Scioto valley, on both sides of the river. A very large amount of building stone, scarcely surpassed in the State in desirable qualities, is contained in it, which is sure to find its way into the general market.

A single quarry has lately been opened on the Clemons farm, a mile above the Higby quarries, and at an horizon higher by ninety feet than the latter. The quarry shows two courses of the highest degree of excellence, separated by a shaly parting of one or two inches. The lower course is twenty inches thick and the upper one thirty-six inches. It is not probable that these courses extend as widely as the Gregg or Buena Vista stone, but few points having been observed at which it was shown.

An interesting section of this portion of the geological series of the county is shown in the district now under consideration, on the south bank of Stony Creek, very near its mouth. The uppermost twenty-five feet of the Waverly shales appear here. Above them the Waverly quarry courses, sometimes reduced to two in number, and not exceeding six feet in thickness, are shown in a nearly vertical wall. The Waverly stone is of the worthless variety already described. It is overlain by twenty-seven feet of the Waverly black slate, the heaviest section of this stratum yet reported in southern Ohio, fifty feet above which come in the Buena Vista beds, or the Gregg and Higby quarry stone. Ascending still another fifty feet, and a Waverly conglomerate is found. This is one of the very few points on the west side of the Scioto in which this formation appears. Its outcrop here is within sight of the great wall of Carboniferous conglomerate on the east side of the river, but it belongs to an horizon several hundreds of feet lower than that held by the latter. It is made up entirely of quartz pebbles, some of them having a diameter of four inches. This stratum is shown at several other points in the same neighborhood, at least by its waste, but it must be set down as exceptional rather than as a normal element of the county scale. It is interesting largely from the fact that it seems to constitute the westernmost extension of the great conglomerate that Prof. Andrews has described in the region to the north-east of this.

The remainder of the series consists, for three hundred feet, of beds of shale, holding great quantities of flattish concretions, which contain a clayey center, covered with a thin blossom of iron ore. These concretions vary in size from an inch to a foot in their largest diameter, and are every where throughout this region characteristic of the Upper Waverly. Thin courses of a light brown sandstone often find place, but there is scarcely the possibility of a quarry in this whole interval.

But few fossils are found in all of the series thus far traversed. The singular form, *Spirophyton*, is met with quite frequently through several hundred feet, but it is only at a height of three hundred and fifty feet to three hundred and seventy-five feet above the Waverly black slate that a stratum comes in that may be called highly fossiliferous.

It is shown in very many sections in the county, but the best exposure of it yet noted occurs on the south side of Sugar Loaf Mountain, about one hundred feet below the summit. An opening has been made here for a quarry. Attention was first called to this point by Mr. J. H. Poe, of Chillicothe. The usual line of Waverly fossils is to be seen here—remains of crinoids, bryozoans, and bivalve shells.

The uppermost seventy-five feet of Mt. Logan, and also of Rattlesnake Knob, show the same stratum, as do also all the high lands in the north-eastern corner of the county, especially in Colerain township. It will also be remembered that the high ground of Pike county shows, in many places, this same fossiliferous formation.

Comparatively little valuable quarry stone is found above the Buena Vista beds, but there is hardly any part of the county that does not possess a fair neighborhood supply within easy reach.

The geological scale of the county has now been briefly reviewed, as far at least as its bedded rocks are concerned, and the chief points of interest in it have been touched upon. Its Drift formations must be discussed with equal brevity.

II. DRIFT DEPOSITS.

The Drift deposits of Ross county are much more interesting and important than are those of Pike county, or of any of the districts to the southward. A principal point of interest is found in the fact that the boundary which separates the regions, every part of which has been covered by the Drift formation, from those in which the high lands, at least, were never occupied by the glacial sheet, passes through the northern and central townships of the county. In other words, a part of the county agrees in its later geological history with the northern part of the State and of the continent, while the larger portion takes its place with the regions to the southward over which the northern ice never advanced. This boundary is perfectly distinct in several townships, while in others it is less sharply defined.

Beginning on the eastern side of the county, it passes through the northern half of Colerain township in a south-westerly direction, not far south of the line of the Adelphi and Chillicothe pike. It leaves almost all of Green township to the northward. West of the river it coincides, in a general way, with the Chillicothe and Greenfield pike, passing, however, two or three miles below it on the west side of Buckskin township. There are, within the area to the northward, and especially along its more southerly extension, occasional summits that stood above the glaciers, but the clay and bowlders that mark the Drift overlie all of the ordinary high land of the country, as is well shown along the road above named in the vicinity of Lattaville.

This boundary is shown with great distinctness in Colerain township. A very instructive view can be obtained by following the eastern road leading from Mooresville to Adelphi. Ascending a branch of Walnut Creek, the native rocks are shown in more or less extensive sections on every hand, and the soils are seen by all of their characteristics to have been formed, where they now lie, by the weathering and disintegration of these rocks. The banks of the stream approach each other more and more closely, until at last the road is shut within a narrow valley, above which rise, on either side, steep hills of sandstone and shale. The gorge proves to be a pass, and after a rapid ascent, an open country is reached which differs, in a very marked degree, from that left behind. A broad valley, filled with gravel and clay, and dotted with bowlders, is found at a high level; the native rocks are so well covered that no clue to their composition is furnished, and rounded outlines prevail in all of the scenery, instead of the angular contour observed before. The gravel and clay contain a considerable quantity of limestone pebbles and bowlders, and thus the land comes to be known as limestone land. Its natural vegetation and its agricultural capacities are as sharply distingushed from those of the lands on the other sides of the hills as is the scenery. A great improvement is at once visible in the farm buildings, the quality of which is, in a general way, determined by the degree of fertility of the soil. On looking back, after passing a mile or two to the northward, the explanation comes clearly to view. The Drift-storm was stopped by this range of hills, against the northern slopes of which these heavy beds of clay and gravel are piled. In other words, these hills form in their sinuous outlines the boundaries of the true glacial Drift. Sugar Loaf Mountain, already referred to in another connection, forms the westernmost extension of this series of hills on the east side of the river, and bowlders are found half way up its northern slope.

The country north of this boundary has suffered a much greater abrasion and waste than that which lies south of it, and it is fair to refer the difference in this respect to the great difference in the later geological history of the two sections respectively. It certainly could not be without result that a slowly moving mountain of ice should advance over the face of a country composed of soft sandstones and softer shales.

A new valley of Paint Creek, lying a few miles to the west of Chillicothe, has been once or twice alluded to in the course of the preceding pages. The origin of this new valley is unmistakably connected with the Drift history of the county, and it is proper to treat of it at more length under this head.

The chief topographical features of the State, as is well known, are to be referred to periods long antecedent to the Drift. There is the best of reason for believing that Ohio was raised above the seas many millions of years ago. During all of the interval that has passed, it has been slowly acquiring its surface relief, under the atmospheric agencies to which it has been subjected. Cases are, however, sometimes met in which the old channels of drainage were so blocked by accumulations of drift, that the streams, on resuming their course after the height of the Glacial period had passed, found it easier to work out new channels than to clear the old ones. These new valleys agree in being narrow, in being shut in with precipitous walls of rock, and in being free from Drift deposits. Several instances of this sort have been given in the reports of the Survey, but the present case is by far the most striking yet found in the Third Geological District.

The Hillsborough and Chillicothe turnpike, which enters the county at the south-western corner, extends through the broad and fruitful valley of Paint Creek, which here has a north-easterly direction. The valley is perfectly defined by ranges of hills, about five hundred feet in height, on either side. The northern wall is broken for the passage of several tributaries, as Buckskin Creek, Upper and Lower Twin Creeks, etc., but the continuous outline of the southern wall is scarcely interrupted. The turnpike crosses the creek three miles below Bainbridge, and thenceforward for ten miles the stream is never out of sight upon the right hand. All at once, however, and as if by magic, it has disappeared. The turnpike still holds the valley, the boundaries of which are just as distinct as before. There is certainly no conspicuous notch in the southern wall through which one could guess that a stream of such volume could have found its way. By following the stream, however, instead of the valley, we learn the following surprising facts: The creek at the point above named, and at a comparatively recent date, left the broad valley which it had been working out for itself through unnumbered thousands of years, and turned sharply to the southward, flowing now in a narrow channel often not more than two hundred feet in width at the base, bottomed with rock, and bounded by precipitous cliffs not less than three hundred feet in height. After following a south-east course for three miles, it turns again to the north-east, and regains its old valley two miles west of the south line of Chillicothe.

The new channel, then, is about five miles in length, has an average width at base of about three hundred feet, is entirely free from Drift deposits, and is bedded and bounded by rock. As has been already said, the old channel is unmistakably distinct. The turnpike above named follows the old valley to the crossing of the North Fork of Paint Creek, and from that point the last named stream occupies the old valley alone for three miles, when the main stream returns from its detour to its former bounds. In other words, the former junction of the North Fork and the main creek was at the point where the turnpike now crosses the North Fork.

To the questions, when and how was this important change in the drainage of the county effected, it is easy to return a probable answer.

The old valley of Paint Creek, from Bainbridge to the crossing of the North Fork, above named, has a general course of 40° north of east. The valley of the North Fork, on the other hand, has a general direction of 25° south of east. They meet, therefore, at an angle of about 65°. The valley of the North Fork, bearing to the south-east, was in the general line of advance of the glaciers that covered this portion of Ohio, as is amply proved by the direction of the striæ and grooves which are still left upon the surfaces of the harder rocks over which these glaciers slowly traveled. The valley must then have been occupied by one of the southernmost prolongations of the continental glacier under which all of the northern portions of the State were buried. On the other hand, the north-easterly direction of the valley of main Paint Creek renders it impossible that it could have been thus occupied. When now the rigors of the long winter of the Glacial Drift began to be relaxed, and the swollen drainage of the country sought once more its former outlets, Paint Creek, both from its freedom from glacier occupation and from its more southern location, would first become filled with water. The ice-wall of the North Fork glacier must, however, have shut out the stream from its old channel, and, as a consequence, the waters would have set back from the western bank of the North Fork in a lake, the level of which would be sure to rise until they found an outlet. The heavy Drift terraces, not less than one hundred feet in thickness, that occupy this portion of the old valley, and which furnish in their broad and fertile plains some of the most attractive as well as the most productive farms of the county, are to be referred to this lake for their origin.

It is not necessary to suppose that the water, before finding its way southward, was raised to the height of the hills that bound the valley. It is altogether reasonable to suppose that it availed itself of one of the low divides, so many of which are now found in this part of the county, and which are so generally used for the roads that lead from one valley to another. A small stream probably flowed into Paint Creek from the southward along the line of the new valley, the source of which was separated by a low summit from another tributary of the main creek that flowed eastward—also by the line of the new valley. A stream that now enters the new valley at its southernmost point, from Huntington township, is probably the remnant of this last tributary. If once the level of the waters were raised above the height of this dividing ridge, the remaining work of excavation would be easy to follow.

The preceding discussion may seem, at first sight, to the general reader who has never given much thought to the solution of geological problems, to be venturesome and unwarranted speculation, but it is believed that it will commend itself to every one who gives it a candid and competent consideration, as not only a valid, but a highly probable explanation of the remarkable facts with which it deals.

IV. The soils of Ross county agree with those of Pike county, as far at least as the latter go. All of the varieties of native soils described as occurring in the last named county are also found in Ross, and possess the same general characteristics, but, in addition, there are large areas in Ross county, as has already been shown, covered with the deposits of the glacial and modified Drift. These areas furnish far more varied and more fruitful soils than the native rocks afford from the products of their disintegration and decay. The lands referred to in this general division in Ross county take their place among the best lands of Ohio. Its valleys, too, are unsurpassed. The general characteristics of the Scioto valley have been already given. The valley of Paint Creek is inferior in area alone to that of the river.

There are no peculiarities in the water-supply of Ross county. The same facts obtain in its different districts that have been described in the preceding section. Wells dug in the Drift beds of its northern townships very frequently disclose buried vegetation. The occurrence of wood, leaves, and an ancient soil has been shown in previous reports to be frequent in those parts of south-western Ohio that hold the southern edges of the true Drift. Ross County is no exception to this statement, but it must be added that there have nowhere within its limits been found such districts as those around Marshall and New Market, Highland county, in which almost every well strikes into buried vegetation.

V. DIP OF THE STRATA.

In concluding the discussion of this general area, a few facts will be given touching the dip of the strata that have now been described. The appended map, which takes in Highland, Pike, and Ross counties, furnishes the necessary data for determining approximately the amount and general direction of the inclination of the bedded rocks that underlie this district. The following points are used in this determination:

Near the village of Samantha, five miles north of Hillsborough, the westernmost outlier of the Huron shales, or great black slate, is found. The line of junction between the limestones and the shales is perfectly distinct, and its altitude above tide-water has been ascertained. This point constitutes an initial station, and dotted lines are drawn from it to various localities, the altitudes of which above the sea are also known, where the same geological boundary is shown, or where other horizons that stand in a known relation to this one are to be seen. We find thus five main lines along which the dip can be calculated, ranging from east 32° north to east 40° south.

The first of these lines is drawn from the initial station to a point in Ross county nearly opposite to Greenfield, a distance of fourteen and three-eighths miles. Its course is east 32° north. The fall of the limestone surface in that direction and that distance is two hundred and eight feet, which indicates an average dip of fourteen and a half feet to the mile.

The next line extends from Samantha to Chillicothe, a distance of thirty-three and three-fourths miles, in a direction 9° north of east. The junction of the limestone and shales has now been carried below the surface, but as the average thickness of the slates is known, it is possible to make their upper surface a basis for calculation. Allowing three hundred feet for the average thickness of this formation, the descent of the limestone in these thirty-three and three-fourths miles is found to be eight hundred and eighteen feet, or an average dip in this direction of twenty-four and one-half feet to the mile. Assuming the maximum thickness obtained from the shales, viz., three hundred and thirty-two feet, the dip would be increased by one foot—giving as the result twenty-five and one-half feet to the mile.

No advantageous station has been found in a due east and west line, but some approximate calculations on such a line gave about the same figures as the last line yielded.

The next line extends from Samantha to Piketon, in a direction 22° south of east. Still another line is seen bearing east 26° south, and terminating at Jasper. These lines run so near together that they give substantially the same results. The first one yields a dip of twenty-six feet, and the second of twenty-five and one-half feet to the mile, assuming, as before, the total thickness of the Huron shales to be three hundred feet. If this element is increased to its maximum, the dip will be increased by one foot in each instance.

Finally, a line is drawn from the initial station to Byington, passing through Slate Knob, in Highland county. From Samantha to Slate Knob the face of the limestone descends at an average of sixteen feet to the mile, while from the latter point to Byington the descent is more than twice as rapid, being not less than thirty-four feet to the mile. For the whole distance the average fall is twenty-four feet.

Various other combinations will be suggested to those who take an interest in such questions.

The facts enumerated above can be shown, perhaps, more clearly in tabulated statements.

The dip in a direction

East 32° north,	for a distance of	14⅜	miles, is	14½ feet to the mile.		
East 9° north,	"	33¾	"	24½ to 25½ feet to the mile.		
East 22° south,	"	36¼	"	26 to 27	"	"
East 26° south,	"	34½	"	25½ to 26½	"	"
East 40° south,	"	12½	"	16	"	"
East 40° south,	"	9¾	"	34	"	"
East 39° south,	"	21⅝	"	24	"	"

The following points will be noted:

1. The dip of the rocks is to the south of east. The greatest dip found along the main lines above given is in a direction 22° south of east, and is twenty-six to twenty-seven feet to the mile. There is some reason for believing that a line 17° or 18° south of east would be a nearer approximation to the line of greatest dip; but in default of other figures, the direction and amount given in this paragraph may be taken as the best statement that there is warrant for making at present.

2. There is great regularity in the inclination of the strata in this district. West of the Highland county line the amount is considerably less than to the eastward. The most signal deviation from the general

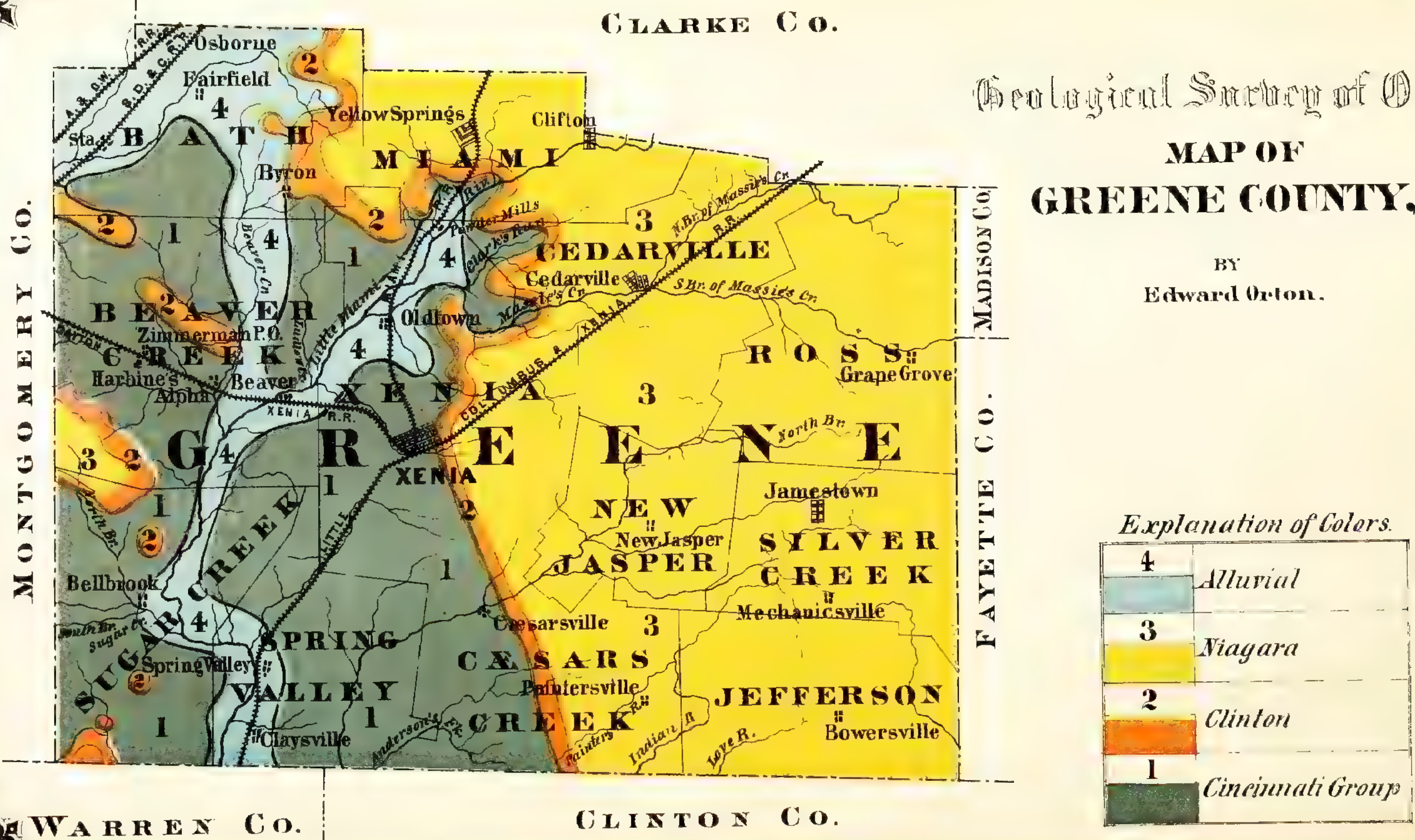
figures is found in the south-western corner of Pike county, where the dip rises for a few miles as high as thirty-four feet to the mile. It will be remembered that a remarkable fault exists to the southward of this immediate locality, and it is quite possible that the local increase in dip here mentioned is connected with this fault in origin.

Geological Survey of Ohio.

MAP OF GREENE COUNTY,

BY

Edward Orton.



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CHAPTER LIX.

REPORT ON THE GEOLOGY OF GREENE COUNTY.

Greene county is bounded on the north by Clarke, on the east by Madison and Fayette, on the south by Clinton and Warren, and on the west by Montgomery county.

I. TOPOGRAPHY.

The principal features in its topography are the valleys of the Little Miami River and of Beaver Creek. Cæsar's Creek also forms a considerable depression in the south-eastern townships of the county. To these three valleys all of the drainage of the county is directed, with the exception of a single township in the north-western corner, which lies within the valley of Mad River.

Contrary to what might be expected, the valley of Beaver Creek is a much broader and deeper trough than that of the Little Miami. The drainage effected by it is, however, insignificant in amount when compared with that accomplished by the river. Beaver Creek is a small and sluggish stream, that is almost lost in a wide and fruitful valley. No one can fail to recognize the disproportion that exists between the present stream and the valley which contains it. The truth is, Beaver valley was never excavated by Beaver Creek. It is the deserted channel of an old river that must have had greater volume and force than the Little Miami has to-day. Nor are we left in doubt as to the general course and connections of the river that did this work. The valley of Beaver Creek connects upon the north with the valley of Mad River. Whether the water of the head springs of Beaver Creek shall be delivered to the Little Miami or to Mad River, can be determined by the digging of a ditch, or even by the turning of a furrow. A protracted and expensive law suit has lately been decided in the courts of Greene county, in which the only question at issue was to which stream the head springs of Beaver naturally belong. It can, then, be asserted with all confidence that the valley of Beaver Creek is but an extension of the valley of Mad River, and was occupied by that stream at no very remote period. An examination of the geological map of Greene county which accompanies this report, and upon which the alluvial valleys of the county are also indicated, serves to bring out this point very distinctly.

It will be remembered that in the report upon Clarke county an older valley of the Great Miami River is shown to exist, connecting its present valley with that of Mad River. In other words, the junction of these streams was effected below Springfield, instead of taking place at Dayton, as at present. And thus it seems probable that the valley now under consideration, viz., the valley of Beaver Creek, was formerly occupied by the waters of the Great Miami after they had been re-enforced by the whole volume of Mad River. With such an origin, the present dimensions of the valley are easy to be understood.

The valley of the Little Miami, in Greene county, consists of two well-marked portions, the lowermost of which has been cut out of the shales and limestone of the Cincinnati series, while in the upper portion the river has been obliged to hew its way through the massive courses of the cliff limestone. The lower valley is, therefore, deep and capacious, while the upper part consists of a narrow gorge, bounded by precipitous walls. The first of the above-named divisions constitutes one of the most valuble tracts of the county, in an agricultural point of view; the second has no such economical applications, aside from the water-power which the river here furnishes in large amount, but which has not yet been utilized to any great degree. Indeed, it returns but little in dollars and cents, but it furnishes the most picturesque and attractive scenery not only of the county but of all the region around. There is but one point in all south-western Ohio where more striking scenery is shown than that furnished by the gorge of the Little Miami between Grinnell's Mills and Clifton. The limestone is cut down to a depth of from sixty to eighty feet, while the valley never exceeds a few hundred feet in breadth; and at Clifton it is contracted to a score or two of feet, being sometimes actually four times as deep as it is wide. The geological elements that are shown in the valley will be treated of in the succeeding pages of this report, and the influence of each upon the proportions which it assumes will be duly considered.

Several of the more prominent tributaries of the river exhibit features quite similar to those last described. The valley of Massie's Creek, below Cedarville, presents scenery almost as striking as that furnished by the Little Miami at Clifton. Clark's Run, near the south line of Miami township, shows another of these deep gorges, while the beautiful glen at Yellow Springs, which has had precisely such an origin, is known to thousands of people in south-western Ohio.

Cæsar's Creek flows in a much shallower trough than any of those already described. Its upper reaches occupy slight depressions in the Drift beds that cover so deep the eastern side of the county, and while at the western margin of the cliff limestone it is bedded in rock, it has wrought out no deep channel for itself.

Aside from these principal depressions the general surface of the county is a plain, having an average elevation above the sea of one thousand feet. Throughout the six eastern townships, and in Miami township on the north, the surface is quite uniform—one hundred feet, or one hundred and fifty feet at most, comprising the extreme range of variation in level. The remainder of the county lies, it is true, at a somewhat lower average elevation, but there are insulated summits all through it holding the general level above given.

By reference to the appended geological map it will be seen that these divisions agree exactly with the great geological divisions of the county, its northern and eastern portions being underlain with the Upper Silurian, or cliff limestones; while from the western half, though originally present, this formation has been carried away by long-continued erosion, only insulated patches of it now remaining to attest its former extent. It is to be remarked that the occasional summits, already spoken of, in the western half of the county, that are one thousand feet or more above the sea, are in all cases these outliers of cliff limestone, to which attention is now called.

By the removal of the protecting sheet of the cliff limstone, the softer beds of the Cincinnati series have been uncovered, and the wear and waste in them have been much more rapid than in the higher rocks.

The deposits of the Drift have been spread over all of the county, reducing the asperities of the surface and hiding many ancient channels, but after all only modifying and not essentially changing the great features determined by the underlying geological structure. So that here, as in other counties reported upon, a geological map becomes in great degree a topographical map, the areas of the cliff limestone comprising those districts of the county that have an elevation of a thousand or more feet above tide water, while all other areas belong to the Lower Silurian, or Cincinnati series.

The lowest land of the county is found on its southern boundary, in the valley of the Little Miami, and ranges between two hundred and seventy-five feet and three hundred feet above low water at Cincinnati, or between seven hundred feet and seven hundred and twenty-five feet above the sea. The highest land is found in Cedarville and Miami townships, along the water-sheds between the Little Miami and Massie's Creek, and the Little Miami and Mad River respectively. It may be safely estimated to be not less than six hundred and fifty feet above Cincinnati, or eleven hundred feet above the sea. There is but little difference in the elevations of these dividing ridges. The summits of each consist of stratified beds of sand and gravel belonging to the latest stage of the Drift period. The highest elevation held by the bedded rock is probably in Miami township, to the north and north-west of Yellow Springs.

The elevations of a few of the principal points in the county are here appended, almost all of which were determined for the Survey by Franklin C. Hill, Esq., of Yellow Springs. All are counted above low water at Cincinnati:

	Feet.
Xenia, grade of railroad at depot	491
Yellow Springs, grade of railroad at depot	541
Osborne, " "	410
Spring Valley, " "	333
Claysville, " "	321
Harbine's Station, " "	370
Oldtown, " "	396
Goe's Station, " "	427
Berryhill's Hill, Spring Valley township (outlier of cliff limestone)	560
Shoup's quarry, two miles south-west of Harbine's (outlier of cliff limestone)	519
Gravel bank, Yellow Springs, about	625
Railroad grade, one mile north of Yellow Springs (north line of county), about	600
Cedarville (railroad grade), about	550

Low water at Cincinnati is four hundred and thirty-two feet above the sea. By adding, therefore, four hundred and thirty-two feet to each of these elevations, the level above the sea is obtained.

II. GEOLOGICAL SERIES.

The geological scale of Greene county is identical with that of Montgomery and Clarke counties, already reported upon. Its rock formations are confined to two great series, viz., those of Upper and Lower Silurian age; and between them the surface of the county is almost equally divided, as is shown on the appended map.

A vertical section of the rocks of the county would be found to contain the following elements:

3. Niagara Group.
2. Clinton Limestone.
1. Cincinnati Series, Lebanon division.

The lowest division has an aggregate thickness of two hundred and fifty feet, the middle division of fifty feet, and the uppermost of one hundred and twenty-five feet, making the total section of the rocks of the county four hundred and twenty-five feet.

The best general section for the study of the strata of the county—and there is no better one for the same geological elements in the State—is found in the valley of the Little Miami River and its tributaries, between Goe's Station and Yellow Springs. At the first named point, Goe's Station, the Little Miami is bedded in the limestones and shales of the Cincinnati series. Fifty feet, at least, of this formation are here shown on the western side of the valley. The Xenia turnpike, the Little Miami Railroad, and the race for the Powder Mills have all required rock-cuttings. The streams, also, that descend from the uplands have their channels in the rock, so that the constitution and contents of the beds can be fully studied. The fossils of this portion of the series abound in these outcrops and sections. Among them are to be named *Rhynchonella capax*, *Trematospira modesta*, *Orthis occidentalis* (upper variety), *Strophomena planumbona*, and several of the corals.

The termination of the Cincinnati series is very distinctly shown in the ravine to the south of Mr. Goe's residence. This may, indeed, be considered a typical locality, for it is from this very point that the phenomena of the line of junction between the Lower and Upper Silurian formations have, in part, been described. Between the fossiliferous beds of the Cincinnati group and the overlying Clinton limestone there occur twenty to thirty feet of fine-grained shales in color, light blue or red, and destitute of fossils. Occupying as do these shales the place held by the Medina group to the eastward and northward, it has been suggested that they are a representative of that period. They are not, however, found at all sections of this horizon, the Clinton sometimes resting directly upon the fossiliferous beds of the Cincinnati series.

A fine display of the Clinton limestone is shown in the wall of rock that immediately overhangs the shales above described. The same limestone occurs in bold cliffs along the river valley, near Grinnell's Mill.

From this last named point the section is prolonged by the Yellow Springs branch, which shows, in the course of two miles, at least one hundred feet of rock. The artificial sections of the Yellow Springs quarries are now reached, which constitute, on the whole, the best point in the county at which to study the Niagara series.

There are other fine natural sections of the rocks of the county, but the one now described may be taken as a fair sample of them all.

The separate elements in the geological scale above given will now be briefly treated.

1. The uppermost two hundred and fifty feet, or thereabouts, of the

Lebanon division of the Cincinnati series underlie the western half of Greene county. This area comprises the more eroded portions of the county, as has been already stated, and, lying at a low level, is so heavily covered with the deposits of the modified Drift that the rocks are, for the most part, concealed. There are, however, numerous exposures of the series, especially in Spring Valley and Sugar Creek townships, in which all of its characteristics, both as to order of stratification and fossil contents, can be seen and studied to excellent advantage. One hundred feet are shown in the valley of Bear Branch, a small tributary of the Little Miami, which enters the valley opposite Claysville. There is no point in the State where finer specimens of some of the common fossils of the formation have been found than here. Among them may be named *Ambonychia radiata*, *Orthis sinuata*, *Leptaena sericea*, *Rhynchonella capax*, *Isotelus megistos*. Representatives of at least thirty species of fossils can be obtained from the section here shown.

The line of junction between the Lower and Upper Silurian formations is shown as distinctly in Greene county as in any section of the State. One of the favorable points for studying it has already been named, but others almost equally satisfactory are furnished in the neighborhoods of Franklin Berryhill and Thomas J. Brown, of Spring Valley township, on Cæsar's Creek where it is crossed by the Wilmington and Xenia Turnpike, and in the vicinity of Reed's Hill, in Bath township.

As elsewhere in south-western Ohio, this horizon is marked by copious springs, to which attention will be more particularly called in the subsequent pages of this report.

The same general order of facts described as occurring in the section at Goe's Station will be found at each of the localities here named.

The Cincinnati series in Greene county furnishes a small amount of building stone of fair quality, and this is, at present, its only economical application.

2. The Clinton limestone comes next in order, and its exposures in Greene county leave nothing to be desired. The fine displays of it along the Little Miami valley, from Goe's Station to Yellow Springs, have already been noted. In addition to the section near Mr. Goe's residence, the stratum can be seen to excellent advantage on the farms of Mrs. Bell, Messrs. J. H. Little, F. Grinnell, A. V. Sizer, and Wm. C. Neff, and in the cuttings for the Grinnell pike at the Little Miami bridge, and near the house of Dunmore McGwin. In Xenia township it is well shown in the banks of Oldtown Run and Massie's Creek, and also near the head springs of Ludlow Creek, on the farms of James Collins and others. In Bath township, however, there are miles of outcrops in which the whole forma-

tion is displayed with the greatest possible distinctness. Reed's Hill may be specially named in this connection. It is a promontory of cliff limestone overlooking the broad and fruitful valleys of Mad River, Bea ver Creek, already described, and the Great Miami valley. From its summit one of the most extensive and beautiful landscapes of south-western Ohio is shown. As is indicated upon the map, the Clinton formation is seldom found, except as a narrow margin to the Niagara group, by which it is overlain. There are, however, a few outliers in the south-western part of the county from which the Niagara rocks have been entirely removed, and where the Clinton has thus been left to form the surface for two or three square miles.

The Clinton limestone at all these points, as elsewhere, is mainly a semi-crystalline, crinoidal limestone. In its bedding it is uneven and interrupted, occurring in lenticular masses. A course can seldom be followed for twenty feet. Within this distance it is almost sure to terminate in a feather edge. In composition the limestone is quite uniform, consisting of about 85 per cent. of carbonate of lime and 12 per cent. of carbonate of magnesia. Even the lowermost layers, which are distinctly sandy in texture, and which are locally known as sandstone, do not deviate from this general formula. A notable percentage of peroxide of iron is of very frequent occurrence in the limestone, giving to it a deep red color. This is the nearest approach to the famous *Clinton ore* which the formation shows in Greene county. Just south of the county line, on Todd's Fork, near Wilmington, a considerable deposit of this peculiar and valuable limestone ore is found, and occasional outcrops of it are found all the way to the Ohio River, the most important, thus far noted, occurring near the north line of Adams county, in the vicinity of Sinking Springs. It will be remembered that this same stratum rises into immense economical importance as the *Dye-stone ore* of Eastern Tennessee and northern Alabama. The more common colors of the formation in Greene county are, however, light gray, yellow, and pinkish, the latter tint being specially characteristic. Its crystalline character is so well developed that much of the formation can be counted a true marble. It is susceptible of a high polish, and when some of the red varieties of the stratum are selected, it makes a highly ornamental stone, the sections of the white crinoidal stems giving a beautiful relief to the darker ground. It will, however, be seen from the facts already stated that the limestone can have no great value for any such application on account of its lenticular bedding.

The base of the Clinton limestone, or rather the summit of the Cincinnati group, is a notable water-bearer, as is shown by the fine line of springs that issue from this horizon wherever the drainage allows. It has already been remarked that the lower beds of the Clinton are sandy in texture. At many points they are extremely friable, and are, consequently, very easily removed by the underground streams that are flowing at this level, and, as a consequence, small caves frequently occur at the base of the series. In other cases sink-holes are found, which are due to the same general cause. By the solution of the rocks along the lines of the divisional planes or joints that traverse them, free way is opened from the surface to the water-bearing shales of the Cincinnati group, and streams of small volume sometimes drop suddenly to this horizon to emerge again along the outcrops of the formation, perhaps at a distance of miles even from the point of descent. One of the best known of these sink-holes is found very near the intersection of the Xenia and Fairfield Pike with the Dayton and Yellow Springs Pike. The stream that here drops from the light of day to these subterranean recesses comes out again a mile or more to the southward, re-enforced, doubtless, by others that have shared a like fate, as the head spring of Ludlow Creek—one of the finest fountains of the county. These sink-holes have been sometimes deserted by the water-courses that have helped to fashion them, in which cases they have frequently been construed, in the neighborhoods in which they occur, as abandoned "lead mines." Some portions of the county are full of circumstantial traditions of lead veins being worked by the Indians here. It is scarcely necessary to say that the civilized occupants of Greene county know a vast deal more of its geological structure and mineral resources than any of their uncivilized predecessors have done. There is not a shadow of reason for believing in the existence of metallic veins of any sort within its area.

The limestone terminates at its upper limit variously. The most characteristic mode is in a foot or two of very fine-grained, light-blue clay or marlite. This, it will be remembered, is the usual mode in Montgomery county, where the horizon is found to be one of great palæontological interest. In Greene county, however, when the marlite occurs it is sometimes destitute of fossils. It can be seen at the base of McDonald's quarry, south of Xenia, and at a few points along the Grinnell pike, near Yellow Springs.

When the blue clay is not shown there is no change in the composition of the limestone for its uppermost ten or fifteen feet, but there is always a very marked transition in passing to the lowest beds of the Niagara group.

The uses of the Clinton limestone are much less important now than they were in the earlier history of the county. It serves a very fair purpose as a building stone, but occurring, as it so generally does, in close proximity to the Niagara series, which yields some of the finest building rock of Ohio, it comes to be but little thought of when quarries of the latter are made accessible. In earlier times, however, the higher degree of accessibility of the Clinton beds caused them to be largely drawn upon.

In like manner the manufacture of quick-lime from the Clinton formation has been wholly abandoned. For many years the outcrops of this stratum on Reed's Hill supplied the Mad River valley and the western side of the county quite largely with lime. Lime was also burned from this horizon in Xenia township twenty years ago. It has, however, been fully established that in the manufacture of quick-lime none of the numerous varieties of calcareous rocks in south-western Ohio can enter into successful competition with the Guelph or Cedarville beds of the Niagara series, where the latter occur. The economy with which lime can be produced from this formation, and the manifest and decided superiority of the product, have ruled out all other sources.

In the vertical scale of the rocks of the county a thickness of fifty feet was assigned to the Clinton limestone. This measure is to be obtained in the first section described, namely, that from Goe's Station to Yellow Springs. It is, however, to be remarked that it is an exceptional thickness, and that the formation rapidly thins out to the southward, being reduced in Spring Valley township to less than half this measurement.

3. The last element in the geological scale of the county is now reached, viz., the Niagara series. It takes precedence among the formations of the county on several grounds. It occupies a somewhat greater area than the Cincinnati group, and it impresses much more distinct features upon the district in which it occurs than does the latter formation. Several of the more noticeable facts in the topography of the county are referable, as has been already intimated, to the presence and characteristics of the cliff limestone, of which the Niagara is the leading element. Its outcrop is a rocky wall, very often uncovered, and generally reached by quite an abrupt ascent at least one hundred feet above the level of the adjacent county. The picturesque gorges of the Little Miami and its tributaries are due to the order of stratification of the Niagara beds, and to the same order must be referred the water-supply of a considerable part of the county. The building stone and quick-lime of the county are almost wholly obtained from the Niagara beds; and, in addition to these home supplies, large amounts of each are exported to surrounding cities and towns.

The divisions of the Niagara group are well marked, and several of the individual members outrank in importance the last formation treated. A tabular view of these subdivisions is here appended:

SUBDIVISIONS OF THE NIAGARA GROUP.

		Feet.
5.	Guelph or Cedarville beds	0–45
4.	Springfield beds	30
3.	West Union beds	10
2.	Niagara shale	30
1.	Dayton stone	0–10
	Total	125'

The separate elements will be briefly noticed.

(*a.*) The Dayton limestone, which forms, wherever it occurs, the very base of the Niagara system, is an exceptional formation. It occupies isolated areas through three or four counties of the Third Geological District. Its place in the series throughout the district generally and the country at large is occupied with widely different kinds of deposits. The typical locality, as the name of the formation denotes, is Dayton, Montgomery county. For a detailed description of the formation, the reader is referred to the Report of the Survey for 1869.

The Dayton stone is found in great excellence and in considerable quantity in Greene county. Beginning on the western border, we find it capping the outlier of cliff limestone that lies south-west of Harbine's Station, in Beaver Creek township. Owing, however, to the greater accessibility of contiguous deposits—especially those of the Dayton district—these beds have been but little developed. Neighborhood supplies have been drawn for a long time from the farms of Moses Shoup, Archibald Huston, and others; but within the last two or three years larger quantities have been taken out and distributed from Harbine's Station, by the Dayton and Xenia Railroad. The stone, as here found, has all the characteristic excellence of the formation in thickness, homogeneity, durability, and color; but its value is somewhat reduced by the abundant crystals of sulphide of iron (known by the quarrymen as *sulphur*), which weather on exposure, and disfigure the surface by dark-brown stains. The area underlain is considerable, and every foot of the deposit is sure to come into demand with the increasing age and resources of the surrounding country.

The next outcrop of it is found on the farm of Mr. James Collins, Xenia township; but though the stone is unmistakable here in its general character, it is much reduced in thickness and, consequently, in value, and evidently marks the limit of the deposit in this direction. A mile or two beyond, to the east and north, the horizon of the Dayton stone is shown in many exposures with perfect distinctness; but its place is occupied by light-blue shale, or soapstone, as it is popularly called, and a worthless shaly limestone, yellow in color, and generally covered with fucoidal impressions, which are frequently rendered green by the presence of silicate of iron. This phase is well shown on the Grinnell pike, opposite the farm of Mr. A. V. Sizer, a mile below Yellow Springs.

By far the best known deposit of the Dayton stone in the county, however, is found on the McDonald farm, three and a half miles south of Xenia. The rock was originally exposed here along a tributary of Cæsar's Creek. When the quarries were first opened, but a light covering of glacial Drift, or bowlder clay, was found; but as the lines have been extended, the stripping has become heavier. The surface of the rock has been planed and polished by glacier agency. From four to eight feet of workable rock are here found, divided into courses varying from four to twenty inches in thickness. The stone finds market in Xenia, being quite widely distributed from that point by railroad.

The composition of the stone from the McDonald quarry is seen in the following analysis, made by Prof. Wormley:

Carbonate of lime	84.50
Carbonate of magnesia	11.16
Alumina and iron	2.00
Silicious	2.20
	99.86

(*b.*) The Niagara shale directly overlies the Dayton stone where the latter stratum is found, and the Clinton formation, in case the Dayton stone is wanting. It is a normal constituent of the general geological scale of the country. Eighty-five feet of it are found at the Falls of Niagara, and along the Appalachain Chain it is thickened to one thousand five hundred feet. Its maximum development in Greene county can be seen in the "Glen" at Yellow Springs, on the land of W. C. Neff, Esq., and at the locality already noted, in the cutting for the Grinnell pike, opposite the old water-cure gounds. It here attains a thickness of thirty feet. This member of the series increases rapidly as it is followed southward through the State, measuring in Adams county one hundred and six feet.

In composition it is not perfectly uniform, the two elements that enter into it being found in varying proportions in different sections. These two elements have been already named—a light-blue calcareous shale, and thin-bedded, yellowish shaly limestone. The shale is much the more constant and abundant of the two, the limestone layers coming in as a rule near the bottom of the series, at the same horizon where the Dayton stone is found when it occurs. In other words, the Dayton stone, in exceptional instances, replaces these shaly layers. The last named phase of the formation is shown very distinctly in the section on the Grinnell pike. The composition of the shale proper is shown by the following analysis, made by Prof. Wormley:

Carbonate of lime	34.40
Carbonate of magnesia	30.87
Silicate of lime	8.48
Alumina and iron	8.40
Silica	12.21
Water, combined	5.40
	99.78

There are occasionally found in the shale numerous crystals and nodules of sulphuret of iron. In some of the sections shown in the Glen at Yellow Springs such nodules abound. They are often construed by the ignorant as indicating mineral treasures in the rocks which are here shown. A pit near the mouth of the Cascade Branch, six feet in diameter, and certainly more than twenty feet in depth, walled with timber, and now partly filled with rubbish, the origin of which is unknown to the oldest inhabitants, seems to show that such deceitful expectations were awakened in the minds of the earlier occupants of the country. Such unsuccessful experiments serve to show that our predecessors knew less than we now know of the contents of the strata, rather than more, as the credulous sometimes believe. The excavation was carried down into the Clinton limestone, the whole thickness of which might have been seen and studied by passing down the valley for half a mile.

The surface of the Niagara shale is a very important water-bearer for this whole region, giving rise to a line of strong springs along its outcrops, and supplying the largest number of the drilled wells of the tableland. More extended mention will be made of this subject in a subsequent part of this report.

(*c*.) The next element in ascending order is the formation termed in the report on Highland county the *West Union Cliff*. This stratum would certainly not be erected into a separate division from any facts in its occurrence in this part of the State; but in Adams county it attains a thickness of ninety feet, and constitutes, in several of the southern counties, a very marked and important element in the Niagara series. In Greene county, as in Clarke, it does not exceed eight feet in thickness, and the principal interest in its existence here is a stratigraphical interest, viz., in the recognition of the constancy of the elements found in the expanded sections to the southward.

It is to be identified principally by its containing a fossil known as an elongated form of *Atrypa reticularis.* On the ground of its occurrence in Ohio strata, a distinct designation ought certainly to be given to this form, for it is never found above the horizon of the West Union cliff. The stratum is cliffy in its structure, generally showing but few lines of bedding, and weathering in a rough and ungainly form. The "Cascade" at Yellow Springs reveals this formation, the water of the stream being precipitated over it, while it in turn overhangs the easily eroded shales of the underlying division. The same elements—geological and physical—occur here that are to be found at the Falls of Niagara; and more truly than most waterfalls, the humble cataract here mentioned can be termed a miniature Niagara.

This element is also to be noted in Cedarville township, on the southern line.

(*d.*) The fourth element is economically more important than any yet mentioned in the geology of the county. It is the division from which the building stone of the county is largely supplied. The Dayton stone, on account of its high degree of excellence as a cutting stone, commands too high a price for all common uses, and finds its market, not in the country districts, but in the cities and larger towns of the State, and even of adjoining States. The new Chamber of Commerce in Chicago is built in part of Dayton stone. For all ordinary uses the stratum now under consideration is the principal dependence. In the report on Clarke county it received the designation of the *Springfield stone,* and by this name it will here be recognized. It furnishes all the building rock raised at Springfield, but does not, perhaps, make the most characteristic formation shown there, as the cap rock from which the well-known Springfield lime is so extensively burned, belongs to a different division, viz., the *Cedarville,* or *Guelph beds.* The reasons for this nomenclature were given in the report on Clarke county, and need not be repeated here.

The Springfield stone has a broad outcrop in Miami and Cedarville townships. It is much more largely quarried at Yellow Springs than at any other point in the county, but on Massie's Creek and its tributaries west of Cedarville it is also quite extensively worked, and the aggregate product of neighborhood quarries is also large. A description of this stratum at any one point applies very well to all other exposures. In the section at Yellow Springs twenty-four feet of rock are found that are referred to this division, though not more than twelve feet are ordinarily worked. At Holcomb's quarries, below Springfield, thirteen feet are shown in a full section of the series.

The courses vary in thickness from four to fourteen inches. Those which are most valued for building stone generally range between these extremes. Several of the courses answer a fair purpose for cutting stone. The same qualified commendation can be given to them for flagging. In neither of these respects has there been, as yet, sufficient inducement to fully develop the capabilities of the beds. But for general masonry they leave little to be desired. Easily raised and dressed, of convenient thickness and of ample surface, they are not surpassed by any stone in the State in economy of use.

In color they are either blue or drab. The blue courses frequently weather to drab on their exposed edges, but it is by no means certain that the drab beds have all been derived from the blue by this process of weathering. Slight differences in chemical constitution would serve to explain these differences in color.

In what has been said of the value of these beds for building stone, it has been, of course, implied that they are durable. Durability cannot, however, be asserted of all the courses without exception. As in Clarke county, the blue beds sometimes prove treacherous, and this important question for each particular course can only be determined by a practical test. The firm and massive appearance of the stone when raised from the quarry furnishes no safe guide in judging of its power to withstand atmospheric agencies. By far the largest portion of the stratum, however, has great excellence in this respect. The drab courses are, almost without exception, entirely satisfactory.

The composition of the Springfield stone has been incidentally alluded to. A sample of the blue rock taken from the quarries of W. Sroufe, Esq., of Yellow Springs, gave the following result. (Wormley.)

Carbonate of lime	51.10
Carbonate of magnesia	41.12
Sand and silica	5.40
Alumina, with trace of iron	1.40
	99.02

A magnesian limestone of France, cited by Vicat as furnishing an excellent hydraulic lime, was, by chance, noticed to have an almost identical composition. Experiments were instituted with reference to hydraulic properties in the stone now under consideration, and it was found to have great energy as a cement. It can scarcely be doubted that these home supplies will come to be utilized at no distant day. Attention is called to the fact that Greene county possesses an ample supply of hydraulic limestone fully equal in quality to the cement which serves a district of France most satisfactorily. The great obstacle to the introduction of a new cement lies in the fact that masons, after becoming used to one particular product, are very loth to adopt the changes in practice which a new article renders necessary. The product here furnished is a *hydraulic lime*, and not a *hydraulic cement.*

The silicious concretions and nodules often replacing fossils, and the silicious layers which are so abundant in the quarries of Clarke county, are almost entirely wanting here.

Shaly partings are occasionally found between the courses. At a depth of eight or ten feet below the surface of the stratum, a layer of shale, several inches thick, occurs, which, from its impervious nature, becomes an important water-bearer.

There is not the same paucity of fossils in this stratum which marks the Dayton stone or the Niagara shale, but compared with the limestones of the Clinton and Cincinnati groups, and also with the overlying division, it may yet be said to be poor in this respect. The most striking forms by far that it contains are the casts of the monstrous brachiopod shell, *Pentamerus oblongus*, which sometimes completely cover the surface of the layers. This interesting and characteristic fossil begins its great development in the rocks of the Mississippi valley at this particular horizon. At the east it characterizes the Clinton group, but it has never yet been found in the Clinton limestone of Ohio. A single overgrown specimen was obtained from the bottom of the Niagara series by the late Col. Greer, of Dayton, and a few specimens have been found in the West Union cliff of Adams county, but throughout the periods represented by this and the succeeding formation it had a wonderful expansion, literally paving the ancient sea-floor for hundreds of square miles through uncounted centuries. It often constitutes the substance of the rock for eight or ten feet in thickness. No more perfect internal casts of this shell seem possible than the quarries of W. Sroufe, Esq., of Yellow Springs, have furnished.

A few other brachiopod shells are occasionally met with in this division. Among them may be named *Pentamerus ventricosus*, *Orthis biforata*, *Atrypa reticularis* (shorter form), and *Meristella Maria*. None of these, however, are confined to this division. The Niagara trilobite, *Calymene Blumenbachii*, var. *Niagarensis*, is also of frequent occurrence.

(*e*.) Overlying the Springfield stone, there is found in southern Ohio the representative of a formation the place of which was a subject of much discussion in the earlier days of American geology. The discussion has terminated in its being assigned, without dissent, to the Niagara series. It forms the crowning member of this series in the northern and western portions of its widely extended field. It has received the names of various localities where it is distinctly shown, being styled the Guelph formation in Canada, the Racine beds, or Milwaukee beds, in Wisconsin, and the Bridgeport beds in northern Illinois. In southern Ohio no local name can be selected so appropriate and free from ambiguity as the Cedarville limestone, constituting, as it does, the only member of the Niagara series shown in the extensive quarries opened at this village. There is not, however, as great a thickness of the limestone shown at Cedarville as at Yellow Springs. The exposure of the Niagara rocks at this last named place has been repeatedly referred to, and now, since all the elements that enter into it have been given, a somewhat more detailed account will be supplied. It is decidely the best section of the Niagara series shown in Greene county, and is but little inferior to the section at Holcomb's lime-kilns, below Springfield.

The Clinton limestone follows up the Yellow Springs Branch to a point nearly opposite the extensive quarries of W. Sroufe, Esq. Starting from this well-settled base, eighty-four feet of the Niagara rocks are traversed in a very steep ascent. The uppermost thirty feet are shown in the quarries before referred to; the lowermost thirty feet are well shown in the adjacent banks of the Cascade Branch. Exposures of the intervening beds are not wanting in the immediate vicinity. The thickness here given is thus divided:

Cedarville beds	22	feet.
Springfield stone	24	"
West Union cliff	8	"
Niagara shales	30	"
Total	84	"

The twenty-two feet of the upper division are further re-enforced in the higher ground adjoining the ravine. It gains ten feet, at least, in the land immediately to the westward, and may be safely taken as not far below forty feet in its total thickness here.

The identification of this stratum has been made complete by the discovery of a considerable number of fossils in it that are peculiar to the above named horizon. A list of a dozen or more of these forms common to the Guelph and the Cedarville beds is given in the reports of Highland and Clarke counties. Of these the most prominent and characteristic are two great shells, the enormous and somewhat abnormal brachiopod *Trimerella*, and a lamellibranch shell of even greater bulk, *Megalomus Canadensis.* *Trimerella* is represented in these beds not only by the species *grandis* (Billings), but also by the still larger form, *Ohioensis* (Meek). It cannot, however, be said that either of these forms is abundant in Greene county, but their presence has been proved by a few specimens from both the Yellow Springs and Cedarville quarries.

The lithological characteristics of the formation in Greene county are quite marked. The lowermost ten or twelve feet consist of a massive rock almost destitute of the appearance of planes of stratification. When raised by blasting it comes out in large and ungainly fragments. In color it is a very light gray, and the numerous cavities, large and small, which are found in it, are all studded with minute crystals of lime. It is crowded with casts of fossils of all the groups represented in the formation, but often the forms have been rendered obscure by partial solution, and nothing remains but a confused mass of the firmer parts of the structures. Nothing can exceed the beauty which fresh surfaces of the rock sometimes disclose, the faces of the fossils being frosted with crystals. The heavy bed of *Pentamerus oblongus* referred to in the preceding section is found in this part of the series.

The most interesting series of fossils thus far obtained from any one locality was furnished by the quarry of Mr. John Orr, of Cedarville. Several specimens were yielded at this point which have been found nowhere else in Ohio.

The upper portions consist of a very thin-bedded and fragile limestone, often sandy in texture, and either light gray in color or yellowish. The latter is the predominant tint at Yellow Springs, the former at Clifton, while both appear at Cedarville. This portion is no less fossiliferous than the lower part, and both contain the same forms, though the proportions in which the separate fossils occur vary somewhat in the two divisions.

In composition, the whole formation is very nearly a typical dolomite. A few analyses are appended to show its constitution along the line of its outcrop, the range represented covering at least one hundred and fifty miles. The analyses were all made for the Survey by Dr. Wormley.

No. 1. Bierley's quarry, Greenville, Darke county.
" 2. Dugan's " Sidney, Shelby county.
" 3. Holcomb's " Springfield, Clarke county.
" 4. Sroufe's " Yellow Springs, Greene county.
" 5. Trimble's, " Hillsborough, Highland county.

	1.	2.	3.	4.	5.
Carbonate of lime	44.60	55.00	55.10	54.75	54.25
Carbonate of magnesia	50.11	42.92	43.05	42.23	43.23
Alumina and iron } Silicious matter }	4.60	1.60	1.70	2.00	1.80
		trace.	0 10	0.40	0.40
	99.31	99.52	99.95	99.83	99.68

But a single economical application is made of the Cedarville limestone. The facts already stated show how poorly adapted it is for use as a building stone, but as a source of quick-lime this stratum is without a rival in the markets of south-western Ohio. This subject has already been discussed at considerable length in the report on Clarke county. It was there shown that the Cedarville stone is to be equally commended for this use by the economy with which it can be manufactured, and by the great excellence in every respect of the product which it furnishes.

Lime is now burned in quantity at but two points in Greene county, viz., Yellow Springs and Cedarville; but equal advantages in every particular, except the all-important one of transportation, are furnished at many other points, and especially at and below Clifton, on the Little Miami River. The business at the two points named has attained quite important proportions, and is the source of a considerable income to the county. A few of the details are here appended.

At Cedarville lime is now burned by the five following firms: Wesley Iliff, Satterfield and Son, Shrads and Gibney, Orr and Son, D. S. Ervin. These parties are named according to the order in which they took up the business. Wesley Iliff has been engaged in burning lime at this point for thirty years. All of the firms but one use old-fashioned kilns, viz., those in which fifteen hundred to two thousand bushels of lime are burned at one time, the kiln being allowed to cool before it is emptied and re-filled. To carry on the business in a large way, each firm requires two or more such kilns, so that while one is burning lime can be drawn from another.

Mr. D. S. Ervin alone employs patent draw-kilns. The comparison of the two modes of burning was made at length in the report on Clarke county. (Geology of Ohio, Vol. I., p. 475.) No reason is seen for modifying the opinions there expressed.

The production for the year 1874 ranges as follows: D. S. Ervin, two hundred and eighty car loads, or eighty-five thousand bushels; Wesley Iliff, one hundred and thirty car loads, or forty thousand bushels; Shrads and Gibney, one hundred and thirty car loads, or forty thousand bushels; Orr and Son, seventy-five car loads, or twenty-three thousand bushels; Satterfield and Son, forty car loads, or twelve thousand bushels.

The average cost of wood is three dollars per cord, and one cord is used in the burning of fifty bushels of lime in the old pattern of kilns. In the patent kilns, Mr. Ervin reports sixty-six bushels to one cord of wood. The lime finds market mainly along the line of the Little Miami Railroad. The price for 1874 has been fifty-five dollars per car load, or eighteen and one-third cents per bushel. When retailed at the kilns, it is sold for twenty-five cents per bushel.

The Cedarville lime has the reputation of being "cooler" than the limes with which it comes into competition; that is, it does not give out as much heat in slaking, and slakes with more difficulty, or at least with less rapidity. Whatever differences of this sort exist must be referred to its physical state rather than to its chemical constitution, as it agrees in this respect perfectly with the Yellow Springs, Springfield, and Sidney limes.

At Yellow Springs the business of lime-burning is extensively carried on by W. Sroufe, Esq. Mr. Sroufe has not yet introduced patent draw-kilns, but is making preparations to do so. He gives the amount of lime produced at his kilns during 1874 as thirty thousand bushels. The cost of wood averages three dollars and twenty-five cents per cord, and one cord, as at Cedarville, is required for the burning of fifty bushels of lime. The lime is sold at fifty-five dollars per car load, as is that manufactured at Cedarville.

The Yellow Springs quarries reach down to the building-stone courses that underlie the lime-producing stratum. Mr. Sroufe reports the sale of five hundred perches of building stone during 1874. The average price of building stone is one dollar and seventy-five cents per perch. No courses well adapted to cutting have yet been worked here.

The Cedarville beds impress a peculiar appearance on the valleys in which sections of them are disclosed. They generally appear in a smooth, vertical wall, bluish-white in color, and overhanging the even courses of the Springfield stone. The latter are more easily eroded than the cap-rock, by reason of the shaly partings found between them. It therefore results that when a stream has once cut its way through the cap-rock the gorge becomes fully as wide, or even wider, at the bottom than at the top, as is the case at Clifton. As the work of erosion advances, large masses of the cliff are left unsupported, and are at last precipitated into the ravine, as is shown so abundantly in the valley of the Miami between Clifton and Grinnell's Mill. The present state of the valley at Clifton shows very clearly the manner in which the whole work has been accomplished. We can be certain that the valley has been growing through the illimitable past by the same stages that we can mark so clearly at the present day.

The springs that issue from the Niagara series are very important and serviceable, but attention will be called at this place to but a single point in connection with them, viz., the heavy deposits of travertine which some of them have made and are still making. The great fountain from which the village of Yellow Springs derives its name will be treated by itself, but all along the gorges in the Niagara limestone voluminous springs are issuing, which are making extensive calcareous deposits, sometimes in dome-shaped stalagmitic masses under the dripping of the springs, but more frequently mingled with the earthy and organic products over and among which the waters flow in short slopes to the valley. The vegetable, and sometimes the animal, matters that the water meets with are often incrusted by the travertine, and are then said in popular language to be petrified. A specimen submitted to analyses gave the following result (Wormley):

Carbonate of lime	95.70
Carbonate of magnesia	3.73
Alumina and iron	0.50
	99.93

Another specimen examined shows the following composition (Mees):

Carbonate of lime	97.60
Carbonate of magnesia	1.21
Silicious matter	0.60
	99.41

In this connection the very interesting fact is to be noted, that while the rocks from which the springs issue are dolomitic, containing nearly as much carbonate of magnesia as carbonate of lime, the travertine is almost purely calcareous. It therefore appears that in magnesian limestones permeated by atmospheric waters the proportions of magnesia must be constantly, though of course very slowly, increasing. The varying proportions of carbonate of magnesia in the limestones of the Cedarville division may be, in part, accounted for in this way. By reference to the table of analyses on page 675, it will be seen that this substance in one instance makes fifty per cent. of the entire weight of the rock. A greater exposure than ordinary to carbonated waters would serve to explain this increased proportion. It may be added that the location of the quarry from which the stone yielding this result was obtained, in the flat-lying tract of Darke county, would seem to indicate the long-continued presence of such carbonated water.

Further: as far as the explanation above given applies, it ought to be found that the more highly magnesian the limestone the less should be its specific gravity. A few facts under this head are here given. The determinations of specific gravity were furnished by Prof. Mendenhall, of the Ohio Agricultural and Mechanical College. The comparison is not limited to the different representatives of the Cedarville division, but various limestones of the State are included.

Locality.	Geological horizon.	Percentage of carbonate of magnesia.	Specific gravity.
Greenville, Darke county	Top of Guelph, or Cedarville	50	2.452
Yellow Springs..................	Bottom of Guelph...............	43	2.605
Greenfield, Highland county	Waterlime..........................	42	2.648
Yellow Springs..................	Clinton..............................	12	2.664
Columbus...........................	Corniferous........................	30 ?	2.664
Cincinnati	Cincinnati	5	2.700

III. DRIFT.

The Drift of Greene county agrees so closely in all particulars with that of the adjacent counties, already reported upon, that no extended description will be given in this place. All of the distinguishing features of this most interesting but perplexing formation are here shown with great distinctness. In other words, the materials for a perfect theory of the Drift are found spread over the rocky floor of Greene county.

1. In the first place, the face of the Niagara limestone has been universally planed and polished by glacier agency. It does not, it is true, show the marks of this agency every where, for the upper beds of the limestone have often been partially dissolved by the action of atmospheric waters infiltrating through the Drift beds; but wherever the surface has not been thus affected it exhibits the glaciated markings now under consideration. These markings have been noted in every section of the county in which the cliff limestone is exposed; but they are shown most plainly in the uncovered surfaces of the Yellow Springs quarry and of McDonald's quarry. The grooves and striæ have a direction in most instances of ten to fifteen degrees west of north. In the Yellow Springs quarry their line of direction cuts the line of direction of the Glen, which is immediately adjoining, at an angle of about twenty degrees, showing that even such deep furrows as this had no influence in changing the course of the abrading ice-sheet.

2. Over the polished surface of the rocks, as well as over those more extensive areas where the rocks retain no markings of this kind, lies, in deposits of varying thickness, a covering of *bowlder clay*. This is an

unstratified mass, thickly set with pebbles and bowlders of small size, many of which have rubbed or striated faces, like that of the rock on which they rest. In its original state it is a very compact formation, as is shown in the deeper sections of it; but where the deposit is shallow it has been considerably transformed by atmospheric agencies. The partial or complete solution of the limestone pebbles that make so prominent an element in it renders the whole bed more porous and permeable than the unaltered deposits are. With this transformation of texture a change of color is also connected, the lower oxides of iron in the bowlder clay being converted into peroxides by the presence of air and water, and the bed becoming a yellow clay instead of blue clay.

The unaltered blue clay is often struck in wells, and is also shown in the banks of streams where the weathered materials are removed as fast as formed.

As elsewhere, seams of sand and gravel are intermingled with the bowlder clay.

3. A third phase of the Drift formations is also abundantly shown in Greene county, in the beds of clean sand and gravel, which occur every where throughout its area, and especially on the highest lands of the county. These beds are distinctly stratified, oftentimes with conspicuous lines of false or uneven bedding, differing in composition from the bowlder clay in this respect, viz., that they contain water-washed instead of striated pebbles, and that they present unmistakable indications of having been sifted and arranged under water. Examples of these high-level grades can be seen at various points, but at none more clearly than in Miami township; as, for example, at the Yellow Springs gravel bank, at the banks of W. C. Neff, Daniel Jobe, and J. H. Little; and also in the Hamma neighborhood, along the Yellow Springs and Fairfield pike. All of these points belong to the high grounds of the county, and some of them constitute its summit levels. From some peculiarities in its structnre, the Yellows Springs bank deserves a somewhat more extended notice.

It is located to the south of the village, about half a mile from the railroad track. It rises forty feet in height above a very flat-lying area, and thus makes a conspicuous feature in the topography. Its summit is not far from ten hundred and sixty feet above the sea. It embraces an area of somewhat more than two acres. It is composed of sand and gravel, with considerable quantities of clay, the three orders of materials being, however, quite well separated from each other. Some bowlders are met with, the largest one now exposed measuring seven feet in length. Like almost all of the largest sized bowlders of southern Ohio, this one is composed of gneiss, conspicuously banded with rose-colored felspar.

The peculiarity of this gravel bank consists, however, in none of the facts already stated, but in the order of arrangement of the materials, which are aggregated in all sorts of irregular masses, while the bed-lines of the sand and gravel are curiously twisted and contorted, their section sometimes showing them to accomplish two-thirds of the circumference of a circle. The only satisfactory explanation of these facts would seem to be found in the deposit of these materials from melting ice. An iceberg breaking loose from the northern water-shed of the State, and loaded with glacial detritus, if stranded and slowly melted here, might account for these peculiarities of structure.

As to several of the other deposits referred to above, it is impossible for any one to examine them without feeling certain that they were sorted and sifted and arranged under water, and that their presence where we find them now is proof conclusive of the submergence of the country, at least to the elevations which they mark. The bank belonging to Daniel Jobe, Esq., and located near the intersection of the Grinnell pike with the Clifton and Oldtown pike, may be taken as a good representative of this class.

These high-level or bank gravels of the county furnish an inexhaustible supply of excellent materials for road-making; and, under the wise State legislation of the last ten years upon this subject, the county may be said to have been lifted out of the mud. This work of improvement is sure to go on with the increasing wealth of the country, until every public road is changed from a bed of miry clay—which, in its natural state, it becomes for about one-third of the year—into a solid and civilized highway all the year through.

The bottom lands of the county, in its western and south-western portions, are considerable. They do not, however, demand extended treatment here, agreeing as they do exactly with the similar areas already reported upon. They consist of first and second bottoms chiefly, the third terrace that appears in the lower reaches of the streams being either wanting or but indirectly shown here.

IV. SOILS.

A brief discussion of the soils of the county will here find place.

(*a*) *Origin.* The soils of Greene county may be said to be derived from the Drift. There are small tracts, it is true, scattered through the county in which the bedded rock has lately formed the surface, and by its weathering has given rise to the thin stratum of soil that now covers it. Examples of this sort may be seen on Reed's Hill, in Bath township, where the weathering of the Clinton limestone has furnished a very productive but shallow soil to quite a number of acres. Along the boundary of the Lower and Upper Silurian formations, again, little patches of these native soils are to be seen, as at Goe's Station, in Miami township, and on the farms of Franklin Berryhill and Thomas J. Brown, of Sugar Creek township; but the aggregate of all such cases is insignificant, and the statement that the soil of the county is derived from the Drift scarcely requires qualification.

There is a very important sense, however, in which the soils of Greene county may be said to be native soils. Naked beds of bowlder clay are no more soil than are raw shales or quarry spalls. All can be converted into soils by sufficient exposure to atmospheric influences. In point of fact, the shales that constitute so large a part of some Ohio formations, and notably of the Cincinnati series, are converted into soils far more rapidly than the bowlder clay. The soils of the county, then, have been formed where we find them by the same slow processes that are required to transform a stratum of limestone rock into soil. It is principally by the process that is termed "weathering" that the stubborn and impervious clays of the unaltered Drift are changed into the porous, light, and permeable layer that we call soil. The action of the atmosphere can be easily traced in such cases. There are always present in our Drift clays, grains, pebbles, and bowlders of limestone. In southern and central Ohio they constitute by far the largest proportion of the rocky fragments of the Drift beds. But limestone is soluble in rain and surface water. These fragments, then, both small and great, are slowly dissolved, their lime being carried away in drainage water, while the sand and clay and iron which made a part of their substance are left to contribute to the soil. Similar changes go on in other substances in the Drift bed, and the results of all are to open these stubborn clays to air and water, to change their color, to alter their texture, and thus, also, to alter their specific gravity. The incorporation of vegetable matter with the forming soil goes on through all the stages of its growth. Until the proportion of such matter reaches at least 5 per cent. of the whole mass, the clay is scarcely to be called a soil.

But in the final stages of its preparation, to another division of the living creation a very important office is assigned, one, however, which is seldom estimated according to its real value. The insect kingdom, beetles, ants, earth-worms, etc., bring up from below the surface, for very different objects in the econmy of their several existences, particles of sand, clay, and vegetable mold. The whole substance of the soil is honey-combed by their agencies and rendered vastly more permeable to air and water. To them, indeed, the fineness and homogeneity of the surface are largely due. Whoever thinks this agency an insignificant one has but to examine carefully the surface of any square rod of ground in early summer to be convinced of his mistake. Such an examination will show to any one who has eyes to see that an enormous amount of mechanical labor, most useful in its results to man, is being performed by these despised insects. The porosity of the ground, which is partly due to these agencies, is illustrated in the well known fact that the earth taken out from an excavation will never fill the space from which it has been removed. But the porosity that nature gives to soils is not produced in a day. It is the result of these seemingly insignificant agencies extended through periods of time sufficiently long.

This stratum of soil, thus prepared, is the sole dependence of the brick-kilns which are possible in almost every square mile of the surface of the county, and from it brick of excellent quality are cheaply produced.

Mention has thus far been made of the formation of soils from the bowlder clay alone, but processes precisely similar to those already described, only far more rapid in their action, are going on in the beds of modified or stratified Drift which make so important an element in the surface of the county. The opening of every gravel bank shows these processes with the greatest distinctness. The solution of the limestone pebbles has been carried on for one or two feet below the surface until most of them have entirely disappeared, the only pebbles that remain being the hard and stubborn greenstones and granites of northern origin. Vegetable mold has been mingled with these weathering products to the same depth to which the solution has advanced, and thus the boundary line between the soil and what it covers is marked by color as well as texture. The incipient stages of the solution of limestone pebbles can be seen below this boundary in the softened and corroded surfaces which they show, but the mass below is, after all, a gravel bank and not soil.

(*b.*) *Varieties.* The soils of the county may be divided into the following classes, which will be readily recognized by those familiar with the area under consideration:

1. The valley soils, consisting principally of the first and second bottom lands.
2. The soils formed from the high level gravels.
3. The yellow and white clays, the common upland soils of the county.
4. The black uplands or blue grass land, most largely shown in Ross,

New Jasper, Silver Creek, and Jefferson townships. Each of these divisions will be briefly considered.

1. The soils of the first division are principally confined to the main valleys of the county, viz., to the Little Miami, Mad River, and Beaver valleys, but some of the minor streams have bottom lands of limited extent.

There is a notable difference in constitution between the first and second bottoms, the former being strictly alluvial in character and receiving fresh accessions of matter with every flood, while the second bottoms are gravel terraces, the surfaces of which have been transformed into soils according to the processes described above. The latter areas constitute the most attractive, but not, perhaps, the most durable, farming lands of the county. The Oldtown flats may be taken as one of the very best examples of this class. We know that portions of this beautiful plain were the favorite corn-grounds of the Indians before the occupation of the country by the whites, to say nothing of the still earlier tenure of the mound-builders, whose works abound in this neighborhood. Since the occupation of the country by civilized man, the whole area has been constantly under the plow. There are large parts of it which have not failed for at least fifty consecutive years to produce a crop either of corn or wheat, without any application of manure or fertilizers. No charge can be made against this particular area as lacking in durability, for the average production is still very good, but other tracts of equal original fertility show themselves now to be in a state of incipient exhaustion. It is a disgraceful system of farming that brings lands like these to such a state within fifty years of the time when they were covered with primeval forests.

The first bottoms are sometimes so largely calcareous as to become partially unfitted to act as soils. Among other defects is this, that they are unable to withstand ordinary summer droughts. They are generally covered, however, with forest trees when in a state of nature, and when cleared they furnish pasturage for the spring and early summer.

Analyses are furnished of two soils and one subsoil belonging to this division. It so happens that all of the following examples were derived from Clarke county:*

Analysis No. 1 is of the Mad River bottoms of John Snyder, Esq., of Springfield. They were originally covered with the ordinary forest

* It is a matter of regret that the work of the chemist was arrested before he had completed the analysis of an equally interesting series of specimens from Greene county, the want of which impairs the value of this portion of the report.

growth of the first or lower bottoms. The excessive amount of carbonate of lime found in them (50.87 per cent.) will be noted. It is almost a matter of surprise that vegetation of any sort could be borne by such a mortar bank. The large amount of phosphoric acid will, however, give them high rank, so far as this priceless element of fertility is concerned, and the quantity of the alkalies (potash and soda) is also ample for all demands of vegetation.

Analysis No. 2 is of the Buck Creek bottoms (prairie lands) from the same locality. The large proportion of organic matter here (29.34 per cent.) will attract attention. A soil so loose as this must necessarily be would hardly enable trees to stand against our south-west winds, and it may be that its nakedness is due to such a cause rather than to any natural want of adaptation to the production of forests. The amount of lime falls considerably below that shown in No. 1, but is still excessive (35.85 per cent.). The other substances which constitute the fine gold of every soil, viz., the phosphates, sulphuric acid, the alkalies, are all here in large amount. The lime present, however, renders the land unfit for tillage. All crops burn out in the summer months. The application of this soil to the uplands would carry to them just what they most need. The lime in it would make it a full equivalent for shell marl, while the organic matter, which makes almost one-third of its entire substance, would wonderfully ameliorate their stubborn texture. There is little doubt that, load for load, this bottom land would prove, on many areas, a full equivalent for stable manure.

Analysis No. 3 is of the subsoil of No. 2, taken from a depth of two feet below the surface. It will be seen that this *subsoil* has all of the characteristics of a model *soil*. Its only obvious deficiency is in the soluble forms of the alkalies. Aside from this it would be hard to say what should be added or what taken away to increase its adaptations to all the uses of agriculture.

The proportion of carbonate of lime shrinks from more than fifty per cent. in the soil to four per cent. in the sub-soil. As both soil and sub-soil are supposed to be derived from the same source, viz., alluvial deposits, it may be asked how this great disparity is to be accounted for. In reply, it is suggested that, like many other important facts which at first sight have no connection with the cause assigned, it will be found traceable to the clearing of the country. By the clearing of the land, evaporation has been greatly promoted along all of the drainage courses, and the streams now sink to a point never known in the early history of the country. As they fall, pools of water, small and great, are left along their courses, which, when evaporated by a summer's sun, give rise to large amounts of calcareous travertine, which is deposited as an incrustation on pebbles, bowlders, shells, and vegetable growths. But since the drainage courses have all been opened out, a few hours' rain is often sufficient to produce a flood which easily sweeps away the light and porous travertine, to re-deposit it at lower points along the courses of the stream. It must also be added that the carbonate of lime in the soil is partly due to land shells which have lived and died upon its surface.

2. The soils formed from the high-level gravels are very closely allied in origin and character to those found on the gravel terraces or second bottoms of the rivers. They are not, however, underlain by as porous a subsoil as the latter, and therefore prove, as a rule, more retentive and durable. They are scattered through the highlands of the county in isolated patches, often of small extent. They are as plainly recognized before the country is cleared as after the soil has been exposed by the plow, for the natural growth of forest trees which they produce distinguishes them unmistakably from the colder lands adjoining and surrounding them. On the gravel points are found the black walnut, the sugar tree, the blue ash, the hickory, etc., while the clay lands show little but oaks.

In color they are reddish-brown, verging towards black in many cases. Under cultivation they are extremely productive, and always constitute the favorite portions for tillage of every farm on which they occur.

An analyses of one of these gravel point soils is given below (No. 4). The specimen submitted was taken from the farm of John Howell, Esq., in Mad River township, a few miles north of the Greene county line. It will be seen that the testimony of chemistry fully accords with that of experience with reference to these soils. Like analysis No. 3, this soil might almost be assumed as a model. Its seventy per cent. of silica, mixed with nine per cent. of alumina, render it certain that it will work light, especially when its nine per cent. of organic matter is taken into account. It contains over three and one-half per cent. of the alkalies, soda, and potash, while the supply of phosphoric acid is ample for generous harvests. Though derived from the decomposition of limestone pebbles very largely, but little lime remains in its composition (less than four per cent. of lime and magnesia). This fact seems surprising at the first statement, but a little reflection shows us that it is a necessary consequence of the mode of formation above described. The pebble that is to be turned into soil consists of carbonates of lime and magnesia in large proportion, and of sand, clay, iron, etc., in much smaller proportions. But these latter substances are all that are turned over to the forming soil, and they are set free only by the solution and removal of the lime and magnesia. The percentage given above is more than sufficient, however, for the demands of vegetation.

3. The next group to be treated constitute a much larger portion of the surface than either of the others already described. It comprises the light-colored clays, whitish or yellow, which make the common upland soils of the country. Being generally derived from the bowlder clay, nothing more needs to be said in regard to their mode of origin, as this topic has already been considered. They are strong and durable to a high degree, but under unwise or negligent husbandry they become stubborn and unproductive. On the other hand, there are no soils of the State that respond more kindly to a rational system of tillage. Their great lack is that of organic matter, which is needed even more to ameliorate their physical condition than to supply plant food. The system of farming, however, to which these clays are generally subjected robs them as rapidly as possible of the small amount of vegetable mold with which they are supplied at the outset. In this way their color is bleached to whitish, from their usual yellowish tint.

The native forest growths of these soils consist largely of oaks of various species, among which the white oak largely predominates. It gains here a magnificent growth, and supplies the country with invaluable resources in the way of staunch timber.

Several analyses are appended of this most important division of the soils of central Ohio.

The first of them, No. 5, is of a white clay on an overtaxed and temporarily exhausted farm (McClure farm, Mad River township, Clarke county). It is to be added that the soil of this area was never equal to that which immediately surrounds it.

The next analysis, No. 6, shows the composition of the subsoil of these same white clays, taken at a depth of fifteen to eighteen inches below the surface.

In examining these analysis, it will be noticed that the organic matter in the soil but slightly exceeds that in the subsoil (2.85 per cent. against 2.58 per cent.). It is safe to say that any process which should double the amount of organic matter in it would increase its productive power in a high degree. There is no lack of phosphoric acid, of potash, soda, or sulphur in either, the vital elements of all soils. On the contrary, the proportions which these substances attain in them would give them place among the fertile lands of the State. It is to their physical condition, principally, that their want of fertility must be ascribed. It is certainly assuring to find that even the poorest and most stubborn clays of the State possess untold capacities for the service of man. They hold, however, these treasures securely locked until a wiser system than ours shall find the key.

Attention is called to one or two other points in connection with these analysis.

(*a.*) The marked disparity in the amounts of phosphoric acid which soil and subsoil respectively contain is doubtless due, in part at least, to the abstraction of this substance from the surface by the crops that have been raised here. Of all the constituents of the soil, this certainly is the one that according to theory should be most reduced by the prevalent system of tillage. There is still left in the soil a large aggregate of this substance, it is true, but it is to be remembered that plants can not go on growing until all is removed. To make agriculture profitable, these mineral elements of plants must not only be present in the soil, but must be every where diffused, so that each rootlet of each plant shall be able to secure its share. It is altogether probable that the change of one-tenth of one per cent. is enough to make the difference between sterility and generous harvests.

(*b.*) The chief notable lack in these analyses is in the soluble forms of potash and soda, and in carbonate of lime. These are the very substances that would be furnished by the application of ashes and lime-waste from the lime-kilns of the country. Ten thousand cords of wood are burned every year at Springfield in the manufacture of lime; but until within the last two or three years not one bushel in a thousand of the ashes produced has ever been restored to the land. At Yellow Springs and at Clifton—both of which are surrounded with clay soils of this general description, and where large quantities of lime are annually burned—the same thing is true, though lime and ashes may be had for the carting.

Two other analyses are added, in this division, of soils of better grade than that already reported upon. No. 7 is from the farm of John Howell, Esq. (Mad River township, Clarke county), and No. 9 from the land of John Snyder, Esq., of Springfield. Both of these analyses represent the average yellow clays of this region. No. 8 represents the composition of the subsoil of No. 7; but there is some reason to distrust the results shown in this analysis. In the comparatively large proportion of organic matter it can hardly represent the average.

4. One variety still remains to be described, viz., the soil of the black uplands of this region, including the upland prairies that are occasionally met. This soil might with a measure of propriety be distributed among the two last named divisions, as it has differed in fortune from one or other of them in but a single particular. By the accidents of the later geological history of the country, these common deposits of bowlder clay and stratified sand and gravel have been left generally in

sloping and easily drained surfaces, but sometimes in flat-lying tracts, of greater or less extent. To the latter of these areas the black soils are confined. If the stratified Drift has furnished their origin, they will agree in character with the soils derived from the limestone gravel, as represented in analysis No. 4. If formed from the weathering of the bowlder clay, they prove to be the counterparts of the yellow clays last described. The difference is shown very plainly in the capabilities of the two kinds of tracts respectively. Both form blue-grass land, and furnish the best of pasturage, but only the former can be turned with profit into corn grounds. These constitute, indeed, the best corn ground of the county—the river bottoms not being excepted. A considerable area in the south-eastern part of the county, forming part of a much broader area which stretches through Madison and Fayette counties, belongs to this division, and numerous isolated tracts are scattered throughout the county. Frequently the most stubborn of the white clays will inclose some central area that lies at a lower level than the rest, and the drainage of which is consequently obstructed. This central tract has thus been changed in color from white to black, and has been charged with vegetable matter enough to ameliorate it for half a century at least. It rewards abundantly the labors of the husbandman, while the surrounding lands, that differ from this in no respect but one, viz., that their proportion of organic matter is smaller by five to ten per cent., are tilled without profit, or even at a loss.

There are no soils in southern Ohio that produce as fine blue grass—that great basis of agricultural wealth—as those varieties of the black lands that have been derived from the limestone gravels.

A single analysis is appended of an upland prairie soil from the farm of John Howell, Esq., of Clarke county (No. 10). Chemistry shows it to be extremely well equipped for all the purposes of agriculture—a fact which has been amply demonstrated by practical tests. It agrees very closely with analysis No. 4, as will be seen by a comparison of the results. All that was said of the limestone gravel soil will apply to the one now under consideration.

These analyses were executed for the Survey by Prof. Wormley. They are full of scientific interest, and, it is also believed, of practical value. Some of the inferences fairly deducible from these figures have been made in the foregoing pages, and others will suggest themselves to the intelligent reader.

No. 1. Mad River bottoms.
" 2. Buck Creek bottoms.
" 3. Subsoil of No. 2.

No. 4. Limestone gravel soil.
" 5. White clay—unproductive.
" 6. Subsoil of No. 5.
" 7. Yellow clay, or common upland soil.
" 8. Subsoil to No. 7.
" 9. Yellow clay, or common upland soil.
" 10. Upland prairie soil.

	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.
Soluble in hydrochloric acid	60.84	48.91	15.27	13.23	5.20	2.35	6.41	8.51	4.89	13.20
Organic matter and water	3.53	8.54	3.78	4.05	0.80	0.12	3.16	1.54	1.13	5.18
Silicic acid	0.23	0.06	0.06	0.06	0.06	0.05	0.31	0.10	0.08	0.08
Iron, sesquioxide	1.86	2.43	4.41	3.25	2.80	1.16	1.91	3.66	2.09	2.50
Alumina	0.90	1.05	1.70	1.65	0.50	0.10	0.30	1.52	0.02	1.85
Manganese	trace	0.07	trace	0.03	0.09	0.05	0.15	0.04	0.02	trace
Lime, phosphate	0.24	0.13	0.37	0.28	0.07	0.10	0.14	0.19	0.10	0.21
Lime, carbonate	50.87	35.85	4.10	2.77	0.21	0.23	0.41	0.37	0.35	2.48
Magnesia, carbonate	2.39	0.58	0.46	1.12	0.29	0.31	0.30	0.71	0.29	0.33
Soda and potash	0.53	0.10	0.06	0.10	0.10	0.10	0.04	0.09	0.10	0.10
Sulphuric acid	0.12	0.10	0.10	0.05	0.03	0.06	0.12	0.28	trace	0.06
Soluble matter found	60.67	48.91	15.04	13.26	4.95	2.28	6.84	8.50	4.41	12.80
Insoluble in hydrochloric acid	39.16	51.09	84.73	86.77	94.80	97.65	93.59	91.49	95.11	86.80
Organic matter	6.03	20.80	6.61	5.00	2.05	2.46	1.64	4.06	2.62	8.02
Silicic acid	26.05	20.79	62.41	68.91	85.52	83.95	79.26	70.60	80.12	64.12
Alumina and trace of iron	4.23	6.22	12.13	7.38	2.43	7.17	9.17	12.90	8.91	10.76
Manganese	trace	trace	......	trace	0.32	0.15	trace	trace	trace	trace
Lime	0.92	0.77	0.71	0.73	0.79	0.91	0 82	0.80	0.91	0.59
Magnesia	0.34	0.15	0.87	0.41	0.63	0.40	0.41	0.36	0.20	0.45
Soda and potash	1.40	2.27	1.20	3.58	2.62	2.62	2.19	1.66	2.84	3.00
Phosphoric acid	0.34	0.19	0.40	0.10	0.18	0.24	0.23	0.14	0.02	0.13
Insoluble matter found	39.31	51.19	84.33	86.11	94.54	97.90	93.72	90.52	95.61	87.07
Soluble matter found	60.67	48.91	15.04	13.26	4.95	2.28	6.84	8.50	4.41	12.80
Total matter found	99.68	100.10	99.37	99.37	99.47	100.18	100.56	99.02	100.02	99.87

V. WATER-SUPPLY.

Brief mention must be made, in conclusion, of the water-supply of the county. The subject is one of great scientific and practical interest. It falls strictly within the purview of Geology, while at the same time it has most important relations to sanitary science.

Greene county has certainly a fair water-supply. It is not quite equal in this respect to Madison county, which must be set down as having, on the whole, the best watered area of the Third Geological District, but, on the other hand, its natural supply is infinitely better than that of Clermont, Brown, and Hamilton counties. A larger proportion of the water used by man and beast is derived from springs and the streams flowing from them than is usual in this section of the State. The Drift beds give rise to a part of these natural fountains, but all of these will be left out of present account, and attention will be asked only to the springs that issue from the bedded rocks.

There are three prominent horizons of springs in the strata of Greene county. The lowermost of these marks the junction of the Lower and Upper Silurian formations. All the conditions that favor the existence of numerous and generous springs are found here. The Clinton limestone furnishes a porous and fractured cap of considerable thickness, and the terminal shales of the Cincinnati group supply the impervious stratum which must turn the water outwards. It must also be remembered that this horizon is shown only along the sides of valleys which in themselves tempt the outflow of subterranean water. This whole geological boundary is marked as a water-bearer. The fine spring at Goe's Station, which has been used as a source of railroad supply, may be taken as a representative of the class. The head spring of Ludlow Creek, on the line of the Xenia and Fairfield pike, is another that belongs to this belt. They are found by hundreds within the county. Occasionally springs issue from some point in the Clinton formation where its base is not exposed. There can be no doubt that in many such instances they have the same real source as those already named. Several fine springs near Grinnell's Mill belong to this category.

At a point about seventy-five feet higher in the scale the second of these water-bearing horizons is found. The summit of the Niagara shales is here reached, and throughout their whole extent in southern Ohio they make an important contribution to the natural water-supply. The springs issuing from this source are confined to two townships in Greene county, viz., Miami and Cedarville. Here, however, they are both numerous and important. Characteristic examples of them can be seen on the Water-cure grounds at Yellow Springs, now the farm of A. V. Sizer, Esq., along the gorge of the Little Miami from Grinnell's Mill to Clifton, and in the valley of Massie's Creek for two miles below Cedarville.

The third and last of these water-bearing beds is found from twenty to thirty feet above the one last named, in a shaly seam in the Springfield division of the Niagara series. It is of much less importance than either of the others in every way. The seam of shale is too thin to make an effective stop to the descending water. Many fine springs, however, especially in the vicinity of the village of Yellow Springs, must be referred to this horizon. The most remarkable of all, that from which the village of Yellow Springs derives its name, appears to issue from this level. There is good reason, however, for believing that its source lies deeper, and that its outlet is obstructed at its true horizon. In other words, it is probably derived from the greater belt of shales below. Its temperature varies but little with the change of seasons, and its volume is not affected by drought or flood. Neither of these things could be true if its underground channel lay as close to the surface as its point of emergence would seem to indicate. According to measurements made twenty years ago under the direction of Hon. William C. Mills, at that time its proprietor, its volume of water is one hundred and seven and one-half gallons per minute. From some chemical examinations also made at the date above given, the statement has been published that the spring "deposits bicarbonate of soda, magnesia, and iron, and is charged with carbonic acid gas." There are such obvious sins of omission in this statement that it fails to inspire confidence. Its water contains, as will be seen, in addition to the usual impurities of limestone springs, a notable quantity of peroxide of iron. The ochreous travertine deposited by it has formed a bank in front of its point of issue that may be roughly estimated at seventy-eight thousand cubic yards. This deposit has doubtless raised the level of the spring to the point were it now appears. Its composition is shown in the appended analysis (Mees.)

Carbonate of lime	92.97
" magnesia	2.42
Sesquioxide of iron and alumina	3.80
Silicious matter	80
	99.99

A heavy bed of the same ochreous travertine that the spring is now depositing, roughly estimated at fifty-five thousand cubic yards, is found two hundred yards to the north of the present point of outflow, showing that in the course of its history the spring has been shifted laterally as well as vertically. The raising of the spring vertically must have been a gradual process, due to the blocking up of the outlet by the slow accumulation of travertine, but the transfer of its waters to a lower point of the glen must have been made at once.

Much of the surface of the main bank is covered with red cedar trees, some of which are at least a century old. From the relation that the parts so covered bear to the rest of the formation, we can see how insignificant an item a century is in the ages of its growth.

No clue can be given as to the source of the iron of the spring. There is certainly no *unusual* amount of iron ore shown in any of the neighboring rock sections. Iron occurs quite abundantly in the state of sulphuret throughout the Niagara shales, but other springs of the region that traverse the same rocks and issue at the same horizon, contain no noticeable quantity of iron. If the waters of the spring were slowly infiltrated through some large deposit of ochreous gravel, such as the later stages of the Drift produced through all of this country, an adequate source for its mineral matter would be provided. There is room enough in the highlands to the northward for such deposits, but none can now be pointed out. If, on the other hand, the deposit is derived from the bedded rocks, we can be sure that cavernous spaces must be left underground by the removal of so much material.

So generous a fountain could never fail to attract to itself the human occupants of the country. Accordingly, we find that the earliest race of which we have any traces in the Mississippi valley, viz., the Mound-Builders, established themselves here. A symmetrical pile of earth and stone attests their interest and occupancy.*

That the Indians who displaced and succeeded the Mound-Builders set a high value on the spring, is also amply attested. The spring lies about equidistant between two famous settlements of the Miamis, viz., Oldtown, above Xenia, which was one of their most valued corn-fields, and the Mad River Village, below Springfield, where Tecumseh was born. The trail connecting these points passed by the spring, and fifty years ago, according to the testimony of the earlier white settlers, it was worn as deep as a buffalo path. It passed very near the present site of Antioch College, and descended into the glen by a break in its rocky wall, which is still used for a foot-path.

At a later date this site was selected by the followers of Robert Owen for their socialistic experiment. A phalanstery was built, the chimney of which is still standing, but the location was soon abandoned for some reason, and the organization was transferred to New Harmony, Indiana.

For the last forty years the spring has been the most notable place of summer resort in south-western Ohio, and justly so, for there is no other location within this region that unites so many attractions and advantages as this immediate neighborhood. A large hotel, capable of accommodating several hundred summer guests, now occupies the grounds adjacent to it, and its waters seem certain to dispense health and happiness in an increasing ratio for the years to come.

The main supply of water for human uses in Greene county is, however, as elsewhere, derived from wells. Wherever the Drift beds are heavy enough, they yield an abundant and, on the whole, an excellent supply; but in points of Cedarville and Miami townships the Drift beds are too shallow to furnish an adequate amount, and it becomes necessary to penetrate the rocky floor in order to secure wells on which reliance can be placed. These wells generally obtain water when they strike the

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* The mound is now crowned with a summer-house. It may not be out of place to add that, from the summit of the mound, Daniel Webster and Henry Clay addressed a great audience on the same afternoon in the political campaign of 1840.

first of the water-bearing horizon named above, but it has been learned that this vein is uncertain, and the drilling is now continued until the great vein, or that borne by the surface of the Niagara shales, is reached.

To one or two points of practical importance in this connection attention is here called. The veins, or rather sheets, of water found under ground are fed from no mysterious sources, but receive their supply, in considerable part at least, directly from above. Surface waters traverse the shallow, gravelly clay that covers the rocks easily and rapidly, and they descend through the porous limestone with almost equal facility. But it is often forgotten that all of the water descends, water from drains and cess-pools as well as from summer showers or winter snows. In point of fact no more effective drain is required for the discharge of ordinary household water waste than an opening into these gravelly clays affords and when the excavation is carried to the surface of the limestone, the drain discharges its contents with great promptness. The case is bad enough as already stated, but in point of fact it is even much worse than it is here represented. If the descending sewage and cesspool water were all obliged to traverse the porous limestone before entering the veins from which wells and springs are fed, we could be certain that it would be quite thoroughly filtered. But the cap rock is not only porous, it is also fractured. Like all massive limestones, it is traversed by two sets of joints, which divide it into blocks of quite regular shape. But partly by solution and partly by contraction and settling, the faces of these divisional planes are no longer in contact. Crevices varying from an inch to a foot in width intersect the strata. They are generally filled with gravelly clay, but they allow a very free transmission of liquids from above. A very gross and dangerous communication is thus established between the neglected or polluted surface and the water veins depended on for daily use.

It has been abundantly demonstrated that drinking water contaminated with even a very minute proportion of undecomposed excretory matter becomes a common carrier of disease. Cholera and typhoid fever in particular are known to be very largely distributed in this manner. The addition of one grain of sewage defilement to the gallon was found, in the cholera epidemic of 1866, in London, to be directly connected with 71 per cent. of the whole mortality. The fact that cholera has wrought its worst ravages in this country in places quite similar in geological structure to the areas now under discussion is well known. The names of Sandusky, of Nashville, of Murfreesboro, of Paris, Kentucky, of Covington, Indiana, will recur to the minds of all. There is weighty reason for believing that the fatality of the disease in all these widely separated points is due to the geological structure which they have in common. The blocky limestones which underlie them all, taken in connection with the arrangements of well and cess-pool that ordinarily prevail, renders not only possible, but, in many cases, necessary, the defilement of drinking water with the products of disease.

There are two village sites in Greene county which, however attractive and advantageous in other respects, must be considered as positively unsafe with respect to their natural water-supply. The village sites referred to are those of Yellow Springs and Clifton.

In the former the danger of contaminated wells is rendered less from the fact that the dwellings are so widely separated from each other, but a very free connection between the privy vault and well of the same premises must certainly exist in many instances. Happily, on account of the trouble and expense of getting wells, cisterns have been a large dependence of the village from the first, and it is not known that any outbreak of disease can be traced to contaminated drinking water, but it cannot be amiss to call attention to the elements of danger involved.

The village of Clifton, unfortunately, has not as good a record. No town of Ohio suffered more severely, in proportion to its population, from the cholera epidemic of 1849, than this little village. To any one acquainted with its geological structure, and at the same time with the results of modern inquiries in regard to the distribution of cholera, the suspicion that the water-supply was largely connected with the fatality of the disease cannot be repressed, and the history of the spread of the pestilence points to the same cause.

The village is located on the north bank of the Little Miami River, which here occupies a deep and narrow gorge, wrought out of the Niagara limestone, as has been before stated. For forty or fifty rods back from the gorge there is but a shallow earthy covering of the rock, but beyond this the Drift increases in thickness until it is not less than fifty or seventy-five feet in depth. The village is mainly built upon the first named tract, but quite a number of dwellings are located on the higher ground. The latter derive their water-supply from the ordinary Drift wells of the country, while in the closer-built portions of the village on the low ground the wells descend from fifteen to twenty-five feet into the rock, probably deriving their water from the same horizon, viz., the summit of the Springfield division of the limestone.

The cholera was confined to the lower part of the village, not a single case occurring in the higher ground. The disease made its appearance in the hotel or village tavern, a stranger who came into the village in the evening being attacked in the night and dying the next morning.

Seven deaths in all occurred in the tavern, and two also took place in a dwelling directly opposite to the hotel, and others in the neighborhood, the whole number amounting to forty. *The water used in the tavern was derived from a street well, to which the occupants of adjacent dwellings also resorted to a considerable extent.* If the facts could all be reached, it is quite probable that this street well would be found responsible for the violent outbreak and terrible fatality of the disease.

These "limestone wells," in all thickly settled areas, as towns or villages, must obviously be looked upon with grave suspicion. The water which they furnish is very grateful to those who use it, it is true, for it is cool because of the depth from which it comes, and clear because it has been filtered efficiently enough, at least to remove all grosser impurities, but despite its clearness and coolness it may be laden with the germs of the deadliest pestilence. Clear water is not necessarily pure water.

A word of warning needs to be given in the same connection against the common Drift wells of the country. An ordinary well serves a twofold office—it is a way to water and a draining-pit besides. Because the first office only is regarded in its construction, it is too often forgotten that it must, of necessity, discharge the latter function. Great care needs to be exercised over the area that can be influenced by this deep excavation. Certainly the drainage of privy-pits, barn-yards, and kitchen-waste ought to be most carefully excluded from the household water-supply. Too often water from all of these sources contributes to the contents of wells, and they thus become, in an evil hour, fountains of disease and death.

One purpose, however, they sometimes serve, which, though not designed or recognized, may be a source of positive advantage. When placed near dwellings they do much toward draining the building site, and thus add to its healthfulness. Of course this incongruous work ought not to be required of them, but in default of other provision for it the well assumes the office vicariously. A question may be raised as to where such water would do the greater harm—in a damp foundation and a wet cellar, or in the household well. If choice must be made between such unseemly alternations, probably the latter would be found the less of two evils. But water-supply is altogether too important an element in the health of a community to be safely left to accident or to a short-sighted economy. It ought to be guarded with conscientious and intelligent care from possible contamination.

INDEX.