ECONOMICAL

GEOLOGY OF ILLINOIS.

REPRINTED FROM THE ORIGINAL REPORTS OF THE GEOLOGICAL SURVEY, WITH ADDITIONS AND EMENDATIONS.

BY

A. H. WORTHEN,

STATE GEOLOGIST.

VOLUME 1.

PUBLISHED BY AUTHORITY OF THE LEGISLATURE OF ILLINOIS.

1882.

H. W. ROKKER, STATE PRINTER AND BINDER.
SPRINGFIELD, ILLINOIS.

TABLE OF CONTENTS.

CHAPTER VIII.

CHEMICAL REPORT.

CHAPTER IX.

GEOLOGY OF RANDOLPH COUNTY.

CHAPTER X.

GEOLOGY OF ST. CLAIR COUNTY.

CHAPTER XI.

GEOLOGY OF MADISON COUNTY.

CHAPTER XII.

GEOLOGY OF HANCOCK COUNTY.

CHAPTER XIII.

GEOLOGY OF HARDIN COUNTY.

CHAPTER XIV.

GEOLOGY OF JOHNSON COUNTY.

CHAPTER XV.

GEOLOGY OF PULASKI COUNTY.

CHAPTER XVI.

GEOLOGY OF MASSAC AND PART OF POPE COUNTIES.

CHAPTER XVII.

CHAPTER XVIII.

CHAPTER XIX.

CHAPTER XX.

To the Hon. SHELBY M. CULLOM,

Governor of the State of Illinois :

SIR—I have the honor of submitting herewith, for publication, the first volume of the Economical Geology of Illinois, the publication of which was provided for by an act of the Thirty-second General Assembly, approved May 26, 1881. This act required, and provided for, the republication, in three volumes, of all that portion of the six volumes of the original reports that related to the Economical Geology of the State, and I have made such additions and emendations as time and circumstances permitted. The succeeding volumes are now ready for the press, and will be printed as rapidly as possible.

I have the honor to remain

Your obedient servant,

A. H. WORTHEN.

CHAPTER I.

PHYSICAL FEATURES, GENERAL PRINCIPLES, AND SURFACE GEOLOGY.

PHYSICAL FEATURES.

It is an axiom of general application in geological science, that there is an intimate relation existing between the physical geography and the geological history of every portion of the earth's surface; and in all cases the topographical features of a country are moulded by, and therefore must be, to some extent at least, a reflection of its geological structure, and the changes it has undergone from the surface agencies of more modern times. The varied conditions of mountain and valley, deep gorge and level plain, are not the results of chance, but, on the contrary, are just as much due to the operations of natural laws, as the rotation of the earth, or the growth and continued existence of the various species of animals and plants which inhabit its surface. Moreover, all the varied conditions of the soil and its productive capacities, which may be observed in different portions even of our own State, are traceable to causes existing in the geological history of that particular region, and to the surface agencies which have served to modify the whole, and prepare the earth for the reception and sustenance of the existing races of beings. Hence we see that the geological history of a country determines its agricultural capacities, and also the amount of population which it may sustain, and the general avocations of its inhabitants.

The State of Illinois embraces a geographical area of about 56,000 square miles, and is bounded on the north by the State of Wisconsin, on the east by Lake Michigan, the State of Indiana and the Wabash river, on the south by the Ohio, and on the west by the Mississippi. For nearly three-fourths of its entire circumference it is bounded by navigable waters, which afford facilities for the cheap transportation of its products equaled by few of the neighboring States and surpassed by none.

In general form this State approaches an irregular ellipsoid, truncated at its northern extremity. Its extreme length, from north to south, is three hundred and seventy-eight miles, and its greatest breadth two hundred and ten miles. It embraces a climatic range of five and a half degrees of latitude, and consequently comprises a greater variety in its zoölogical and botanical productions than can be found within the area of any other State in the Union. In the extreme southern part of the State, both the animal and vegetable productions partake of an almost semi-tropical character, while in the northern portion we find mostly those forms which characterize the northern temperate zone. Hence it affords an exceedingly varied and interesting field of exploration to the botanist and zoölogist, and it is a matter of regret to every lover of natural science in this country, that a State holding the proud position in wealth and intelligence now sustained by Illinois, should have taken no steps to secure a more complete knowledge of its indigenous productions in these departments of natural history. Many species of mammalia are now exceedingly rare, or no longer exist within the limits of the State, and the labor of making a complete collection of living species is every year becoming more difficult, and will, ere long, be quite impossible. Much has already been done, by the industrious naturalists of the State, at their own expense; and a very moderate expenditure of money, on the part of the State, would enable them to complete the work, and to place the results, in a useful form, in the hands of the people.

The general slope of the water shed, and the course of the interior system of drainage, is to the southwest; and nearly all the principal streams in the interior of the State, after a general course in that direction, empty into the Mississippi. The Illinois, which is formed by the junction of Des Plaines and the Kankakee, the former rising in Wisconsin and the latter in Indiana, traverses the northern half of the State diagonally in a southwesterly direction, and empties into the Mississippi forty miles above St. Louis. Rock river rises in Wisconsin, and, after it enters Illinois, has a general southwest course, and empties into the Mississippi just below the Upper Rapids. It drains one of the most beautiful and fertile regions in the State. The Okaw or Kaskaskia river rises near the eastern boundary of the State, about midway between its northern and southern extremities, and, after a general southwest course, flows into the Mississippi about one hundred miles above the city of Cairo. South of the Okaw the streams are comparatively small. Those on the eastern borders of the State empty into the Wabash, while those on the west find an outlet in the Mississippi.

Although the face of the country is generally level or gently rolling, there are some portions of the State considerably more elevated than others. The highest lands in the State are those along its northern limit, between Freeport and Galena, where the elevations, locally known as the "*mounds*," culminate in points of elevation from eight hundred and fifty to nine hundred feet above the level of the river at Cairo, and from five hundred and twenty-five to five hundred and seventy-five feet above Lake Michigan, and from eleven hundred to eleven hundred and fifty above the ocean's level, and from two hundred to two hundred and fifty feet above the level of the surrounding country.

From Freeport southward, along the line of the Illinois Central railroad, there is a gradual descent to the valley of the Big Muddy river, in Jackson county, where the level of the railroad grade is only fifty-five feet above that of the river at Cairo. From this point there is a rapid rise in the country toward the south, and at Cobden the railroad intersects a mountain ridge crossing the southern portion of the State, with an elevation of five or six hundred feet above the river level at Cairo.

This ridge is the eastward extension of an axis of elevation or uplift, which brings the St. Peters sandstone of the lower Silurian, above the surface at Bailey's Landing, on the west side of the Mississippi river, tilts up the Devonian limestone at the "*Bake Oven*" and "*Bald Bluff*," in Jackson county, at an angle of about 25°, and after elevating the upper portion of the lower Carboniferous limestone above the surface, entirely across the southern portion of the State, finally crosses the Ohio in the vicinity of Shawneetown, and is lost beneath the Coal Measures of Kentucky.

The elevations already mentioned in Northwestern Illinois, known as the "*mounds*," are no doubt the result of denuding forces acting upon the surface, which have swept away the surrounding strata, leaving these isolated hills as the only remaining indications of the former level of the adjacent region. On the contrary, the mountain ridge last described as extending across the southern portion of the State, has resulted from the dislocation and upheaval of the strata by forces acting from beneath; and these two causes—upheaval and denudation—have produced all the principal mountain chains upon the surface of our globe. The determination of the point as to which of these causes a mountain elevation is due, is by no means difficult. If the strata forming the elevation lie in their original horizontal position, the mountain owes its existence to the first named cause, or the removal of the surrounding strata by denuding forces;* but if the strata are dislocated and tilted at a high angle from their original horizontal position, then the elevation may be attributed to upheaving forces, or, perhaps, as is sometimes the case, to the conjoint action of both causes. Mound-like elevations are very common on the prairies in some portions of the State, and some of them attain to a height of fifty or a hundred feet above the general level; they are often covered with a fine growth of timber, and appear like island groves in an ocean of prairie. These may be due to the removal, by erosion, of the surrounding superficial deposits, or to the uneven character of the underlying strata before the drift was deposited, resulting from similar causes.

There are four other principal axes of disturbance along the western and northern borders of the State, in addition to the one just mentioned, besides several of minor importance. The most northerly one crosses the north line of the State, in Stephenson county, and intersects Rock river at Grand de Tour, and the Illinois at Split Rock, between LaSalle and Utica. This uplift brings the St. Peters sandstone to the surface on Rock river, and the lower Magnesian limestone (Lower Silurian) on the Illinois. Its general trend is from N. N. W. to S. S. E., and its extent southward beyond the Illinois has not yet been determined. It elevates the coal measures to the surface, in the vicinity of LaSalle, from a depth of from three to four hundred feet, thus showing that the disturbance took place at a period subsequent to the deposition of the coal formation.

On descending the Mississippi from the north line of the State, the first important disturbance met with is at *Cap au Gres*, in Calhoun county. Here we find a dislocation of the strata and a downthrow of the beds on the south side of the axis, of at least a thousand feet. The bluff known as the *Cap au Gres*, or *Sandstone Cape*, is formed by the St. Peters sandstone and a magnesian limestone, probably representing the base of the Trenton or the Black river limestone. These beds have a gentle inclination or dip to the northeast of about 6 to 8°. Immediately below this bluff, and separated from it only by a narrow ravine, we find the Burlington limestone of the lower Carboniferous series, with the strata in a nearly vertical

*There may be a few exceptions to this general rule—such as, for instance, where a mountain mass has been bodily elevated without tilting its strata. Such cases are not common, and the exception would never apply to mountain chains.

posture, and dipping in a nearly opposite direction from the sandstone of the bluff above. This limestone, if occupying its normal position above the sandstone, would be separated from it by a part of the Lower Silurian and the whole of the Upper Silurian and Devonian systems, comprising a thickness of nearly a thousand feet of rock strata. When this sandstone bluff was first elevated above the surface, it was no doubt a mountain mass of from twelve to fifteen hundred feet in height, but has been subsequently reduced to its present elevation by denuding forces. This axis crosses the Illinois about five or six miles above its mouth, in Jersey county, and brings to the surface from forty to fifty feet of the upper part of the Trenton limestone in the bluffs on the eastern bank of the river. It forms an anticlinal axis, with a double line of bluffs, separated by a narrow valley, on that side of the river, for a distance of three or four miles, when it again strikes the Mississippi by the eastern bend of the river and is lost in the river valley. Its trend is W. 10° N. by E. 10° S.

Below St. Louis we find another axis, near the south line of St. Clair county, where the strata have been again dislocated, leaving the St. Louis limestone, on the lower side of the axis, inclining to the southwest at an angle of about 20°. The trend of this axis is from N. 20° W. to S. 20° E., and it passes about half a mile east of the town of Columbia, in Monroe county.

At Salt Lick Point, in Monroe county, we find another dislocation and downthrow of the strata, which is no doubt a continuation of the axis which crosses the Mississippi at Platin Rock, in Missouri, bringing up, at that point, a portion of the St. Peters sandstone to the surface. In the bluffs, on the Illinois shore, the nucleus of the axis is formed by the Trenton limestone.

Passing the axis already mentioned at the "*Bake Oven,*" in Jackson county, we find the next important point of disturbance crossing the Mississippi at the "*Grand Chain,*" in Alexander county. Here the Trenton limestone is again elevated, forming a dangerous reef of rocks, extending entirely across the river, and also a limestone bluff on the Illinois shore, about seventy feet in height. The trend of this axis appears to be from N. W. to S. E., and it probably crosses the Ohio a few miles above Caledonia, in Pulaski county, where the St. Louis limestone forms a reef of rocks, known as the "Grand Chain," entirely across that stream.

It is quite impossible, with the evidence before us at this time, to fix with certainty the relative date of these disturbances; but it seems quite probable that none of them date back to a period anterior to the Carboniferous epoch; for we find, in general, no want of conformity between the uplifted strata and any of the superincumbent paleozoic beds.

If we could strip off from the surface of the State the superficial deposits of sand, clay and gravel which now cover it to the depth of ten to one hundred feet, or more, we should find it intersected by broad and deep valleys, cut into the solid rock strata to a depth varying from one to three hundred feet. These valleys were probably excavated, in part, at least, by streams of water, but may have been greatly enlarged by the joint action of ice and currents of water, perhaps during a period of submergence, and these valleys were afterwards filled, either wholly or in part, by the superficial material called drift, which now occupies them. They form, as it were, the entire system of river drainage for the State, being occupied by the principal streams within its borders. That they were not formed entirely by the streams that now occupy them is indicated by several well known facts. In the first place, the streams themselves are entirely inadequate to the formation of such broad valleys, excavated as these are, to the depth of several hundred feet in hard limestone rock. In the second place, the breadth of the valley which our rivers now occupy bears no relative proportion to the size of the stream or the force of the current, as may be seen by comparing the relative size of the valleys of the Illinois and the Mississippi. The former, though comparatively of small size, and with a sluggish current, occupies a valley scarcely less in breadth than the latter, which contains a volume of water at least six times as great as the Illinois, and a current of at least twice the velocity of the latter stream. They therefore seem to be ancient valleys, formed, mainly, at a period anterior to the Drift epoch. The alluvial valley in which the Mississippi now winds its southward course along the western borders of the State, varies in width from five to ten miles, with only a few points, at wide intervals, where its waters are circumscribed by the approach of limestone bluffs on either side. In the vicinity of Fort Madison, Iowa, the western part of the valley, for two-thirds of its entire width (which is here from six to seven miles), is filled with unaltered drift deposits to the depth of more than one hundred and fifty feet, and there are many other points where the same phenomenon may be observed. Along the principal streams we also find terraces of *modified drift*. This term is applied to those drift deposits which have subsequently been subjected to a sifting process by the action of the waves or currents of water, and this change was probably effected while the water in these valleys flowed at a considerably higher level than the highest water-mark of the existing rivers. The cities of Peoria and Havana, on the Illinois, and Oquawka and New Boston, on the Mississippi, are built upon terraces of *modified drift*.

Most of the smaller streams, especially those in the central and southern portions of the State, traverse valleys filled with superficial material to such a depth that the comparatively small streams which now occupy them do not cut through this drift material, and consequently the stratified rocks are but rarely exposed in some portions of the State, and in many cases it becomes exceedingly difficult to trace out the sequence of the strata from the meagre exposures of the subordinate beds to be found along the streams.

The amount of erosion which has been accomplished by the Mississippi, within a comparatively recent time, is well illustrated, on both the upper and lower rapids, by a band of bleached fresh-water shells, that may be seen on both sides of the river, appearing, from a distance, like a chalk line drawn along the river shore, and extending the whole length of the rapids on either side. It is from six inches to two feet in thickness, and from ten (10) to twenty (20) feet above the present channel of the river. It is composed entirely of the water-worn shells of the existing species of mollusks still found in the river, and no doubt marks an original horizon of the river bed. This gives us a channel in the limestone rock from ten to twenty feet in depth, and about three-quarters of a mile to a mile in width, as the maximum result of the erosive power of the Mississippi, under such favorable conditions as an accelerated current fully twice as great as the average velocity, either above or below the rapids, and in limestone strata not very much harder than the average of the rock formations of the Mississippi valley; and these observations will, perhaps, enable us to realize, to some extent at least, how inadequate the erosive power of the present river currents would be to excavate the entire valley, which it now but partially occupies.

The *prairies* form one of the most notable features in the topography of the State, and the phenomena connected with the general distribution of the prairie and timbered lands present many curious and interesting facts. As a general rule, the prairies occupy the high lands, and the timber the low grounds along the breaks and valleys of the streams. But we find there are frequent exceptions to this rule, as may be seen in the frequent mound-like elevations which often occur in the middle of a wide prairie, and are covered with a heavy growth of timber—showing that our forest growths are not determined by the elevation of the surface, but are due to some other cause.

Much has been written, in the last few years, on the *formation of prairies;* but we do not propose to discuss, at the present time, the comparative merits of the various theories which have been promulgated by different authors in regard to their formation, but rather to refer the reader to the very able chapter on this subject, in another part of this report, by Prof. LEO LESQUEREUX, whose thorough acquaintance, both with fossil and recent botany, and the general laws which govern the distribution of the ancient as well as the recent flora, entitles his opinions upon this subject to our most profound consideration.

GENERAL PRINCIPLES.

Geology is that department of natural science which treats of the earth's structure and development, and it carries us back, through a regular sequence of cause and effect, to a period when the material of which it is composed existed in a state of fusion, or in other words, when the earth was a globe of liquid fire. The radiation of heat from the surface resulted in the gradual cooling of the mass, and thus the first rocks were formed, as modern igneous rocks are now formed, by the cooling of molten mineral matter ejected from existing volcanos.

According to the teachings of Geology, the earth has been in process of creation through countless ages, and has arrived at its present condition by regular stages of growth or development, in some respects analogous to those which characterize the life of an animal; and these have been effected by the same general laws of progressive development which characterize every department of nature, and apply with equal force to the mineral, the vegetable, and the animal kingdoms.

All matter, from the minutest globule, revealed to the eye of man by the microscope, to the grandest world which revolves in the regions of space around the great central sun of the universe, is alike subject to the control of unchanging laws, and through these laws are each and all made subservient to the great end for which they exist. Through the operation of these laws order has been evolved out of chaos, and the earth has been fitted and prepared as a fitting habitation for the existing races of beings, with Man at their head.

Viewed in this light, and accepting all the demonstrable facts of natural science, how grand does the scheme of creation appear, and how eminently worthy of the conception of the *Divine Mind.*

These changes have been going on from a time that, to our conception, is inconceivably remote; and the human mind utterly fails to grasp the immense duration of the periods in the earth's history, which have preceded the creation of the existing races of beings. We might as well attempt to enumerate the grains of sand required to form a solid globe like the earth, or the drops of water contained in all the oceans upon its surface, or the number of cubic inches in the regions of infinite space, as to calculate the number of years that have rolled away since the earth commenced its revolutions round the sun. Hence geological time is estimated by periods only, and each of these periods is of immense duration, according to our limited ideas of time.

The eternity of the past is as incomprehensible to the finite mind as the eternity of the future. We can conceive of no time in the past when the material which constitutes the earth did not exist, in some form; and we can conceive of no period in the future when it will not exist. Human ingenuity has never been able to devise the means whereby the smallest particle of matter can be annihilated. The chemist may resolve a grain of sand into its original elements, but it still exists in another form, and its elements constitute a part of the universe just as much, after it has been subjected to his manipulations, as before. A mineral, when subjected to intense heat, may often be resolved into a gaseous or a liquid form, but no part of it is destroyed by the process; its condition only has been changed.

The organic being, whether animal or vegetable, may *die*, and the constituent materials of which it was composed be returned to the earth and the atmosphere from which they were derived; but no portion is lost or destroyed in the process. So, throughout the entire realm of nature, the great law of change is unceasingly at work, and through its operations the grandest developments of the material universe are accomplished; but nowhere does this law of change necessarily involve the destruction of the smallest particle of matter, and no natural law has yet been discovered by which such a result can be accomplished. Hence, to our finite conceptions, the matter which constitutes the material universe is eternal, and can no more be annihilated than that *Infinite Spirit* which pervades all things, and which we recognize as *God.*

Natural forces are manifested by motion, and various effects produced—such, for instance, as the attraction between particles of matter in solution, by which they are caused to assume a definite form of crystalization. Perhaps the thought may be a new and startling one, to the reader, that the forces which give form to the crystal are living forces, and that, in this sense, life really pervades *all* matter. Hence we see that every mineral invariably assumes its own peculiar form of crystalization, and that, too, with unerring certainty. The formation of the crystal may be regarded as the first effort of nature towards organic creation—the first result of a great law that has culminated in the creation of all the higher forms of organized beings.

The time that has elapsed since the creation of the present races of beings is very much greater than the popular mind has been prepared to admit; and recent investigations have brought to light certain facts bearing upon the question, which it may be well to notice here. Prof. AGASSIZ, in his admirable paper on the growth and formation of the coral reefs of Florida, clearly establishes the fact that the living species of corals, which have built these immense reefs, have been at work on that coast for more than 70,000 years; and Capt. E. B. HUNT, of the U. S. Corps of Engineers, who was stationed, for many years, at Key West, in Florida, and whose opportunities for observation were uncommonly favorable in relation to facts bearing upon this point, expresses the opinion, in a communication published in Silliman's Journal, for March, 1863, that the existing species of corals which have built the limestone formations of the Florida coast, have been at work on that coast for at least 5,400,000 years. This estimate, enormous as it may seem to us, is predicated upon well demonstrated facts in relation to the rate of growth of these coralline structures, derived from observations and measurements made upon the spot.

Again, it is well known to all those who have kept pace with the advancement of science, in this direction, for the past few years, that facts have been constantly accumulating going to show that *Man* has been an inhabitant of the earth for a much longer period than has usually been admitted; and finally, Sir CHARLES LYELL, who, heretofore, had been eminently conservative on this question, frankly admits, in his last work, on the "*Antiquity of Man*," published in 1863, that the evidence accumulated on this point is quite sufficient to justify the conclusion that the human race have inhabited this continent for more than 100,000 years.

These estimates, taken as a moiety of the time allotted to the existing races of animals and plants, and multiplied by the number of extinct creations which have preceded the present in the vast geological periods of the past, will give us at least some faint conception of the immense periods of time that have elapsed since the first appearance of life upon the earth.

The earliest formed rocks having resulted from the cooling of mineral matter existing in a state of fusion, are termed primary igneous rocks. They occur, without regularity of form, as amorphous masses; but they have been so deeply covered by the sedimentary accumulations of later times, that they are only to be seen, now, in those localities where they have been protruded up through the more recently formed strata by igneous forces, acting from beneath; and, consequently, they constitute, in most countries, only a very small proportion of the rock formations now accessible to human observation.

When the surface of the earth had become sufficiently cooled, the aqueous vapors of the atmosphere were condensed into water, and the oceans and streams were formed. The waters, by their solvent and eroding influence, aided by other atmospheric agencies, acted upon the hardened rocks, wearing them away; and the disintegrated material, being carried by the streams to the bottom of the ocean, were there deposited to form the stratified rocks. These two causes—the igneous and the aqueous—together with the modifying influence of living creatures, have given origin to all the rocky masses at present known upon the earth's surface.

The rocks formed by sedimentary accumulations beneath the water are usually termed stratified rocks, because they are generally found in regular beds or layers, as our limestones, slates, sandstones, etc. Sometimes the sedimentary rocks are subjected to the action of heat, water, and other agencies, by which their original condition is changed, and they are then termed *metamorphic rocks*. The effect of metamorphic action upon the stratified rocks is to obliterate, either wholly or in part, the original lines of stratification, and to give them a more or less highly crystalline structure. Thus sandstone is converted into a quartz rock or quartzite, limestone into crystalline marble, etc. Many of the rocks in this country that a few years ago were supposed to be of igneous origin, are now known to be altered sedimentary strata, for in some cases they still retain distinct traces of the original line of stratification; and where these are quite obliterated, it is by no means safe to conclude that the rock is of igneous origin, for sometimes these beds of apparently unstratified rocks may be traced continuously into beds where, the metamorphic action having been less intense, the lines of stratification are still preserved.

Metamorphism usually obliterates all traces of the fossils that may have been originally embedded in the altered strata, and hence it is often difficult to determine the relative age of the metamorphic rocks, when they are not found in connection with fossiliferous beds. But it is by no means safe to infer, because a rock contains no trace of fossils, at the present time, that, therefore, it was formed before the existence of organic beings, or that it has not, at one time, contained their fossilized remains.

Thus we have three distinct classes of rocks which enter into the formation of the earth's crust—the igneous, formed by the cooling of melted mineral matter; the aqueous or sedimentary accumulations beneath the ocean; and the metamorphic, resulting from the conjoint action of igneous and aqueous agencies. But it seems that metamorphism is sometimes produced by other causes than direct contact with igneous conditions, for we frequently find that beds of metamorphic rock are underlaid by sedimentary strata that have not been affected by metamorphic action—showing that the altered condition of the strata has resulted from some other cause than dry heat alone. It has been suggested that hot water, charged with alkaline, or, in certain cases, acid solutions, would be fully adequate to produce metamorphism under favorable conditions; and through the action of these agents permeating the porous strata without penetrating those more compact, we may understand how a superincumbent rock may become metamorphosed, while that below it still remains unchanged.

There are few points in the State of Illinois where any indications of metamorphic action have been observed, and these are confined to a very limited thickness of strata and to a few localities in the southern part of the State, in the vicinity of some of the principal axes of disturbance. In Saline and Gallatin counties, according to the observations of Mr. Pratten, heavy beds of altered shales and quartzites, sixty or seventy feet in thickness, are underlaid by limestones and sandstones that are unaffected by metamorphic action. In the hills, a mile and a half back of Santa Fé, in Alexander county, there is an outcrop of very hard quartzite that, from its position, seems to be of Tertiary age.

From the manner in which sedimentary strata are formed, it must appear evident to the observer that the successive beds accumulating in regular order, one above another, must necessarily represent distinct periods in the chronological history of the earth; and this history becomes doubly interesting from the preservation, in the rocky strata, of the fossilized remains of the animals and plants that flourished during the vast period of time consumed in their formation. Thus the geological chronology of the earth is not only a correct history of the formation of the various strata that constitute its crust, but it is, also, the only possible history (that is accessible to us) of the various creations of animals and plants that, through the successive periods of the past, have inhabited its surface.

The ancient oceans, like those of the present day, were filled with organized beings, and the shell of the mollusk and the hard, calcareous habitation secreted by the coral, become embedded in the constantly accumulating sediment at the bottom of the ocean; and when this sediment was hardened into rock, these organic remains were preserved, in a fossilized condition, so perfect and entire that the general character and habits of these ancient animals may be studied and determined in a most satisfactory manner. These fossils, though belonging to species that are now extinct, and, in many cases, to genera that are no longer represented among living species, are nevertheless referable to the four great sub-kingdoms of existing animals, and many of them to the same families, and sometimes the same genera, with existing species. This shows a general plan in the creation of all organic beings upon the earth, which includes the various creations of all past time, from the earliest corals of the primeval ocean down through all succeeding periods to the present time.

Some of the stratified rocks, especially the limestones, are composed almost entirely of the calcareous habitations and bony skeletons of the marine animals that lived in the ocean during the time these beds were in process of formation, with barely enough mineral matter to hold the organic materials together in a cemented mass. Thus we find that these simple types of life have played an important part in the formation of the solid framework of the globe. The same process is now constantly being repeated, and year after year the shell-fish and the coral contribute their calcareous portions to swell the amount of sediment that is constantly accumulating beneath the bed of the ocean, and this will eventually become hardened into solid rock strata. These fossils are the true "*Medals of Creation*," and in this way nature preserves her own records of succeeding creations, linking them all together by the unerring characteristics of a common origin, and weaving them into one complete chain of organic existence, which, beginning with the lowest and simplest form—*Protozoa*—culminates in the final appearance of *Man* upon the earth, as the highest and complete result of creative energy. Nature's laws are eternal and unchangeable, always producing like effects from like causes.

Where sediments are accumulated in mid-ocean, far from land, and where there are no currents to bring the remains of land animals and plants from a distant shore, the strata which are formed will contain only marine fossils; but if they accumulate near the shore, the streams from the adjacent land will bring on their swollen and turbid waters terrestrial plants and animals, which being intermingled with the marine remains, will be embedded in the same strata.

Again, sediments accumulate in lakes and other large bodies of fresh water, and these, when hardened into rock, may easily be distinguished by the fresh water and land animals which they contain; and sometimes strata may be found which contain the remains of only such animals as inhabit brackish waters, and these have undoubtedly been formed from sediments accumulated in bays or estuaries, as they alone present the necessary conditions for the growth of these peculiar forms of life. Thus we find that, in the different strata of the earth's crust, a magic key may be obtained which, if rightly applied, will open wide the door to nature's most wonderful and secret works, and enable us to read, as in an open book, a history, more or less complete, of the varied and striking changes in the past history of the globe and its varied forms of life.

Many beds of stratified rocks are formed by the breaking up and redepositing of the material derived from pre-existing rocks, as the sandstones, conglomerates, breccias, etc. As the dashing waves upon the rock-bound coasts of our continents and islands, at the present day, wear away portions of the solid rocks, the material is by currents carried out into the ocean's depths, and redeposited, to become, by and by, hardened into rock. So, through the countless ages of the past, the same laws of destruction and re-formation have been in constant operation, and, through them, important modifications of the earth's structure have been effected, and marked changes have been wrought in the physical conditions of its surface.

From the published results of the Canada survey, under the direction of Sir WILLIAM LOGAN, it becomes necessary to modify, somewhat, the views hitherto held by American geologists in relation to the character of the oldest rocks at present known on this continent. Hitherto these rocks have been classed by themselves, under the general term of "Azoic," which term simply signifies *without life*, on the supposition that they were formed anterior to the existence of organic life upon the earth. It had very generally been admitted that the lower Silurian formation, which overlies unconformably these so-called *Azoic rocks*, contained the remains of the earliest forms of animal life; and, although that apparent beginning of organic forms did not correspond to the recognized laws of development observed in all succeeding strata, yet geologists seemed disposed to accept the apparent facts, rather than to indulge in such speculations as the collateral evidence seemed to warrant. But the discoveries in Canada have apparently lifted the veil from the primeval creation of animal life, and revealed to us its apparent earliest dawn, under conditions entirely in harmony with the laws of progressive development.

These so-called *Azoic* rocks in Canada are found divisible into two distinct systems, called the Huronian and Laurentian systems, by the Canadian geologists, with an aggregate thickness of more than 30,000 feet. The Huronian, which is the upper or newer of the two systems, has not as yet afforded any fossils; but in the lower part of the Laurentian system, Sir WILLIAM LOGAN discovered what appeared to be fossil corals, though from the highly metamorphic character of the strata in which they were embedded, their true character was not at first generally recognized. But on submitting them to Prof. DAWSON, who subjected them to a critical structural examination under the microscope, they were found to be, beyond doubt, of animal origin, and the name *Eozoon Canadense* was given to this remarkable fossil. It was found to belong to the very humblest type of animal existence known—that of the Rhizopods—standing, as it were, nearly upon the dividing line between the animal and vegetable kingdoms, and consequently may be accepted as among the earliest of created beings. This may very properly be considered one of the most important and interesting discoveries in paleontology that has been made in the last decade of years. It carries the dawn of life backward through an area represented by more than 30,000 feet of strata, and shows us its commencement with one of the lowest forms of the animal kingdom.

That there was a true Azoic age in the earth's history no one can doubt, but it would seem highly probable that all the sedimentary rocks of this age are either now so deeply covered by the superincumbent strata of more recent date, that they are not accessible to human observation, or from metamorphic action, they are now undistinguishable from igneous material. The true igneous rocks are frequently met with upon the earth's surface, but they generally occur in the form of dikes, filling rents or fissures in the stratified rocks, showing that they are of more recent origin than the beds which they penetrate. When we ascend above the highly metamorphic strata, we find each geological system characterized by a distinct creation of animal life so entirely unique and unlike all preceding or subsequent creations, that it is rare to find more than a single species out of hundreds peculiar to each geological system, that pass from one into another. So complete, generally, is this change in organic life, in passing from one formation to another, that the practical geologist is enabled to determine at a glance, in most cases, where fossils abound in a strata, the exact position which a formation may hold in the geological series, even when the exposure is an isolated one, and no other rock is found near by to aid him in the determination.

Hence, the reader may understand why fossils are so eagerly sought after by those engaged in geological investigations—not as matters of mere curiosity, but because they furnish the most reliable evidence that can be obtained for determining the horizon to which the rocks belong. Here we have a striking example of the intimate relation which exists between the several departments of natural science, zoölogy coming to the aid and illustration of geology, the organic aiding in the study and illustration of the inorganic kingdoms of nature.

The stratified rocks, including the metamorphic, heretofore regarded as *Azoic*, constitute ten distinct geological systems, all of which, except the two lower, are easily recognized wherever they appear by the fossil remains which they contain. The Huronian and Laurentian systems are composed of beds so highly metamorphic that nearly all traces of the fossils originally embedded in them have been obliterated, and their true position was first determined by finding them actually underlying the Silurian strata.

The following section represents the relative position of the various geological systems recognized at the present time, and also the equivalent systems represented in Illinois:

Section of the Geological systems at present known.	Section of the Geological systems recognized in Illinois.
QUATERNARY.	QUATERNARY.
TERTIARY.	TERTIARY. ?
CRETACEOUS.	
JURASSIC.	
TRIASSIC.	
CARBONIFEROUS.	CARBONIFEROUS.
DEVONIAN.	DEVONIAN.
SILURIAN.	SILURIAN.
HURONIAN.	
LAURENTIAN.	

By an examination of the foregoing section, it will be seen that the Cretaceous, Jurassic and Triassic systems have no representatives in Illinois; and as the systems above and below are already recognized, it seems probable that these systems have never been deposited within the limits of the State, its entire area being probably above the ocean level during these epochs. As all stratified rocks are formed beneath the ocean, or some other large body of water, their absence in any locality may be accounted for on the supposition that the surface was elevated above the water level, and remained dry land during the entire period while the missing strata were being deposited over those portions of the earth's surface that were submerged. Again, their absence might be accounted for by supposing that the strata, having been originally deposited here, were afterwards swept away by denuding agencies; but in that case it seems hardly probable that their destruction would have been so complete as to obliterate all trace of their former existence.

The Huronian and Laurentian systems are not represented in Illinois, not because they were never deposited here, as they probably underlie the entire area of the State—but because there has been no disturbing force in operation, within the limit of the State, sufficiently powerful to elevate them to the surface, and hence they are concealed by the overlying strata. Even in those portions of the

—2

State where the disturbing influences have been most powerful, there is from four to six hundred feet of Silurian strata below the surface that overlie the systems above named.

Some of the richest deposits of metallic wealth yet discovered on this continent are in the Huronian system—as, the iron ores of Marquette, and the deposits of native copper and silver on the south shore of Lake Superior; and it seems probable that the "*Iron Mountains*" of Missouri are of the same age.

Metallic ores occur either in beds, which are spread horizontally under the surface—as a bed of coal or of iron ore—or in veins. Veins are fissures in the rock strata which are afterwards filled with crystallized mineral matter. They usually traverse the strata in a direction more or less nearly perpendicular to the lines of bedding, and may result from the shrinking of the beds, or from any disturbing cause of sufficient power to dislocate the strata. They are usually partly filled with crystallized minerals, as calc spar, fluor spar, quartz, etc., which form a matrix for the metallic ores which they contain; and the material with which they have been filled has been, in most cases, introduced into them by infiltration either from above or from the surrounding strata.

Where the fissures result from the shrinking of the strata, they do not usually extend below the set of strata in which they originate, and are termed *gash veins;* whereas, if they result from the dislocation of the strata by forces acting from beneath, they must extend downward indefinitely.

It was formerly believed, by geologists generally, that nearly all metallic veins were of igneous origin, and that the crystallized minerals and ores with which they were filled were derived from igneous conditions; but this opinion is now held to be erroneous, and it is very generally conceded that aqueous causes are entirely adequate to account for their occurrence. That the native metals—as gold, silver and copper—owe their occurrence, in that form, to metamorphic agencies, is no doubt true; but most of the ores at present known appear to have resulted from aqueous conditions.

Dikes are wide fissures in the stratified beds which have been filled with igneous rocks, such as basalt, porphyry, trap, etc., which have been protruded upward from beneath while in a molten condition. These are sometimes several miles in width, and the igneous rocks which have been protruded through similar openings, now often form mountain chains. Dikes differ from veins in this, that they are entirely filled with the same kind of material which is of volcanic origin, while veins are filled oftentimes with several distinct crystallized minerals, resulting from aqueous solutions.

SURFACE GEOLOGY.

Under this general head we design to treat of the present surface conditions and phenomena, as they appear in this State, and to describe the accumulations of clay, sand and gravel which overlie the stratified rocks, and are known under the general name of *drift*, including also the more recent deposits resulting from lacustrine conditions, as the *loess* and other *alluvial deposits*—the whole comprising what is known as the *Quaternary system*.

The beds of superficial material are spread unconformably upon the older rocks, and cover them to the depth of from ten to more than two hundred feet. The *drift*, proper, may generally be divided into, first, blue plastic clay with small pebbles, often containing fragments of wood and sometimes the trunks of trees of considerable size, which forms the lower division of the mass; second, buff and yellow clays and gravel and irregular beds of sand, with boulders of water-worn rock of various sizes interspersed through the whole; and, lastly, reddish-brown clays, generally free from boulders, and forming the subsoil in those portions of the State remote from the streams, and where the loess is wanting.

No general description of the mass would be applicable to all portions of the State, inasmuch as it varies considerably in different localities. At some points in Northern Illinois it consists entirely of a bed of clean gravel resting directly upon the Silurian limestone, and overlaid by the black subsoil of the prairie. At others the gravel bed is underlaid by the blue plastic clay before mentioned, which usually forms the base of the Quaternary system. In some of the counties on the eastern borders of the State the blue clay has been penetrated to the depth of eighty feet, or more, without reaching the bottom, and it seems probable that its maximum thickness is fully one hundred feet. It is generally impervious to water; and in some portions of the State, where it comes near the surface, considerable difficulty is experienced in obtaining good wells.

Along the western borders of the State it generally consists of a bed of blue clay, or *hard pan*, at the bottom, which is overlaid by brown clays with gravel and boulders. In the vicinity of the river bluffs it appears to have been partially modified by the action of lacustrine forces. A section of the bluffs on Main street in Warsaw, Hancock county, gives the following section:

Ash-colored marly clay resembling loess	10 feet.	
Brown drift clay	12 "	
Brown sands, partly stratified	8 "	
Bluish-colored sandy clay	2 "	6 inches.
Clay and fine gravel	2 "	6 "
Yellow sand, stratified	2 "	
Clean gravel and boulders	8 "	
Blue clay, or hard pan	6 "	

In the bluffs at Quincy the true drift deposits are entirely wanting, and are replaced with a heavy bed of loess from thirty to forty feet in thickness, underlaid by a few feet of local drift, consisting of fragments of chert intermingled with brown clay, derived, evidently, from the cherty limestones upon which it rests. Everywhere along the Mississippi and Illinois rivers, where the lacustrine conditions prevailed at a period subsequent to the drift, we find the latter deposit more or less modified, and in some cases entirely removed by the action of the currents. To these conditions the deposit of the loess is probably due, and it is found along all our principal river bluffs and valleys throughout the State. It consists of beds of imperfectly stratified marly sand and clay, containing at some localities great numbers of land and fresh water shells.

The term "*Loess*" was originally applied, by European geologists, to certain deposits of comparatively recent age, and of fresh water origin, consisting of partially stratified marly sands and clays, containing the remains of fresh water and land shells of the same species with those now found living in the adjacent region, indicating its sedimentary accumulation in fresh water lakes at a comparatively recent period, or since the creation of the existing species of molluscus animals.

On this continent similar beds are found holding the same stratigraphical position, and American geologists have generally accepted the synchronism of the American with the European deposits, and adopted the same name. In this country the deposit is mainly restricted to the vicinity of our great river valleys, which, no doubt, were occupied by lakes during the period in which the loess was deposited, and were subsequently drained by the gradual elevation of the surface. Its thickness is very variable, averaging from twenty to sixty feet, in the river bluffs, and thinning out rapidly as we recede from the river towards the summit level of the interior.

Where this deposit is well developed, the bluffs usually present a series of bald knobs, forming a marked feature in the topography of the country. A series of chemical analyses have shown the deposit to consist of from sixty to seventy per cent. of sand and clay, with about twenty-five per cent. of the carbonates of lime and magnesia, and about five per cent. of oxide of iron. Its chemical constituents, however, must necessarily vary in different localities, and even from different parts of the bed at the same locality, because it is not a completely homogeneous mass, but varies somewhat in its constituent elements in different portions of the deposit.

Resulting from the same cause, but formed at a later period, are the raised beaches or terraces of *modified drift*, common on the borders of the lakes and large rivers throughout the State. They are elevated from twenty to sixty feet above the water level, at the present time, and show that the water line remained at that elevation for a long time after the lacustrine conditions under which the loess was formed had passed away.

A large proportion of the material composing the drift deposits have been derived from regions far beyond the limits of the State, and consists of rounded and water-worn masses of granite sienite, porphyry, amygdaloid, etc., together with the red sandstone and native copper of the Lake Superior region, all of which have been swept southward from their native beds with a force sufficient to obliterate the angles from the hardest fragments; and these have been intermingled with the detritus of the later formations over which they have been transported.

It undoubtedly owes its origin to the combined action of ice and water, and the material of which it is composed has been transported by these agencies, while the whole area over which it is now spread was submerged beneath the waters of a vast sea, covering almost the entire area of the Mississippi valley north of the Ohio. Its southern boundary in this State appears to be the mountain chain, already mentioned, which crosses the southern portion of the State from Grand Tower, on the Mississippi, to Shawneetown, on the Ohio.

The scratched and grooved surfaces presented by the underlying limestones, at many localities, and the smoothly worn and polished surfaces that may be seen at others, and the immense size and weight of many of the transported boulders, which have been carried for hundreds of miles from the nearest outcrop of the metamorphic beds to which they belong, alike preclude the idea that such results have been produced by the action of water alone. Huge masses of moving ice, like the icebergs of the present day, loaded with the mineral detritus of the far northern lands, with angular fragments of hard, metamorphic rock firmly embedded in the solid ice to act as a graver upon whatever rock surface they might come in contact, are the only known agencies that seem adequate to the production of the phenomena characteristic of the drift deposits in the Mississippi valley.

In addition to the area in the extreme southern portion of the State over which the drift deposits do not extend, there is also a limited extent of surface in the northwestern corner of the State that seems, also, to be almost entirely free from these accumulations; and as it is surrounded on all sides by territory that is covered with heavy deposits of this material, it forms an anomalous feature in the surface geology of that region.

This *driftless region* in the northwest also comprises a limited area in Wisconsin and Iowa, and was first noticed by Dr. J. G. PERCIVAL, during his labors in the geological survey of Wisconsin, and more recently by Prof. J. D. WHITNEY, in his able report on the geological survey of that State, and, according to the last named author, its extent is almost exactly coincident with the productive lead region of the northwest.

The views of these distinguished geologists, in relation to the causes which have produced this anomalous feature in the surface geology of this region, seem to be quite at variance with each other, and we will here state, in a brief manner, the views advanced by each with the main arguments and facts by which they are sustained, adding thereto such remarks as our own observation in the lead region of Illinois enable us to make.

Immediately south of the Wisconsin river there is an elevated plateau, having a nearly east and west trend, and extending for a distance of at least fifty miles to the eastward from the mouth of that river, and forming a water shed which separates the streams running south into the Mississippi, from those emptying into the Wisconsin. This plateau culminates in the peaks known as the *Blue Mounds*, which are elevated about eleven hundred feet above the waters of the Wisconsin, and constitute the most elevated points to be found in this region.

Dr. PERCIVAL supposed that this elevated plateau might have formed a reef, during the drift period, against which the icebergs impinged as they floated southward loaded with detritus, and by which they were diverted from their direct southward course into the valleys of the Wisconsin and Mississippi, which then existed as deep channels in the inland sea that then covered the northwest; and consequently none of the coarse drift material could pass over this barrier and be deposited upon the region directly to the south of it, and only the finer sediments which were held in suspension in the water were precipitated over the so-called *driftless region* immediately south of this barrier. This view explains the phenomena observed on the south of the Wisconsin in a very satisfactory manner, but is not, of course, applicable to any part of the region north of that stream.

On the contrary, Prof. WHITNEY contends that this region was elevated above the ocean immediately after the deposition of the upper Silurian limestones, and has not since been submerged; and that all the phenomena exhibited in its surface geology, at the present time, have resulted from the action of the rain and frost upon the surface since its elevation above the water level. In confirmation of this view he cites the following facts:

"1st. The entire absence of boulders or pebbles, or any rolled and waterworn materials which, by their nature, would indicate that the region in question had been exposed to the action of those causes by which the drift phenomena were produced."

"2d. The absence of any signs of stratification in the superficial detritus covering the district indicated on the map, and designated as the driftless region."

"3d. The entire absence of all traces of marine or fresh-water animals in the superficial detritus of the region in question."

In answer to the first proposition cited above, it may be only necessary to say that the absence of boulders and pebbles, in the region south of the Wisconsin river, is accounted for in a very satisfactory manner by adopting the views of Dr. PERCIVAL, while some of the phenomena which are presented in this region are totally inexplicable, on the supposition that the surface has not been submerged since its original elevation above the Silurian seas.

2d. The finer sediments, or brown clays, which overlie the coarser drift material, over a large portion of this State, do not usually present any appearance of stratification; and yet their sedimentary origin has never been questioned, so far as we are aware, and they present the same general appearance and cannot easily be distinguished from those occupying the surface of the lead region.

3d. The brown clays of the drift do not contain the remains of marine or fresh-water animals, in any portion of the State, where they have fallen under our observation, while fresh-water and land shells are often abundant in the marly beds of the loess which overlie the brown clays of the drift in the same portions of the State; so that the absence of fossils from these clays will hardly be accepted as conclusive evidence that they are not of sedimentary origin.

We shall now proceed to notice, briefly, some of the facts observed in this region which have led us to believe that this whole region has been subject to influences which, in their effects, cannot be distinguished from those now generally accredited to drift agencies.

1st. The river valleys which traverse this *driftless region*—especially those of the Mississippi and Wisconsin—present the same general appearance that characterizes the river valleys of the entire northwest, and have apparently been produced or greatly modified by causes far more potent than the eroding agencies now in operation upon the surface. They are undoubtedly ancient valleys, cut into the solid limestone strata by long continued agencies, but were subsequently modified and extended by the action of later agencies during the submergence of the whole region, and subsequently partially filled with superficial material, upon which the rivers now run in channels far above the rocky bottom of these ancient troughs.

2d. From Prof. WHITNEY's report, it will be seen that the land adjacent to this driftless region, both on the east and on the west, is really elevated above it, as is proven by the course of the streams, which have their sources in the region now covered by drift deposits, both east and west of the Mississippi, and their outlets at a necessarily lower level into that stream and within the limits of the so-called driftless region. This is especially to be observed in that portion north of the Wisconsin and west of the Mississippi, and how these lower lands could have been elevated above the level of the waters of the drift era, while the higher lands of the surrounding region were submerged, is a problem we are unable to solve.

3d. The occurrence of northern drift in the river valleys in this region, either in its original or modified form, cannot be accounted for in a satisfactory manner on the supposition that the surface has not been submerged since the Silurian epoch. According to the observations of Mr. KIMBALL, as cited by Prof. WHITNEY in the Wisconsin Report, true northern drift *was* observed by him in the valley of the Wisconsin; and we have observed beds of modified drift in the valley of the Mississippi, as well as some of the small tributaries running into it in the region under consideration. The town of Bellevue, in Iowa, a few miles below Galena, is built upon a terrace of modified drift, which is at least forty feet above the river level; and in the valley of the Small-pox, which empties into the Mississippi just below the mouth of Fever river, a deposit of modified drift may be seen extending up the valley of that stream for a distance of two or three miles. At the lower end it is elevated some ten or fifteen feet above the high-water level of the river, while its elevation at the upper end is considerably greater.

In the bluffs of the Mississippi, about two miles below the mouth of Fever river, at the California diggings, we obtained some small boulders of greenstone and porphyry from the *talus* of the bluffs, at an elevation of from twenty to thirty feet above the river level, and smaller pebbles of the same kinds of rock were quite abundant. We are also permitted to state, on the authority of Capt. E. H. BEEBE, of Galena, that several specimens of native copper have been found, at this locality, in the crevices of the Galena limestone, at an elevation of forty or fifty feet above the river level.

4th. The removal of the great thickness of strata, consisting, for the most part, of hard dolomitic limestones, which were once continuous over this whole region, and have been subsequently swept away by denuding forces, cannot be explained in a satisfactory manner by the action of existing surface agencies. Prof. WHITNEY admits, in the report above referred to, that the amount of denudation to which this region has been subjected was equal to the removal of three hundred and fifty feet in thickness of solid rock strata, the greater part of which were hard calcareo-magnesian rocks, and this is proven by the existence of the isolated mounds of Niagara limestone now remaining as outliers of this formation and indicating the former level of the whole region. It seems to us that the existing surface agencies are entirely inadequate to the production of such results, no matter how long the period may have been through which their operation extended.

5th. The deposits of red and brown clay which cover this whole region, except the points and steep escarpments of the hills, to the depth of from ten to twenty feet, present the same general appearance as the brown clays of the upper part of the drift deposits, and appear to have originated from similar causes. Above this clay deposit, along the river bluffs, we find mounds of marly sand exactly like those of the loess; and as these are often selected by the aborigines as places of burial, they have been regarded by many as artificial mounds, raised by them for that purpose. We regard them, however, as natural mounds of loess, formed in the same manner as the mounds of Niagara limestone, by the removal of the surrounding strata by denuding forces, and conclude, consequently, that the loess was originally a continuous deposit along the river bluffs in this portion of the State. We cannot believe that the beds of clay or the marly sands above them have been formed by the decomposition of the underlying rock strata, but, rather, that they are derived from transported material that has been accumulated while the whole surface was submerged.

Now, whether we accept the views of Dr. PERCIVAL, or not, as sufficient to account for the general absence of coarse drift material in the region under consideration, we shall at least be obliged to attribute this peculiar feature in the surface geology of the northwestern portion of the State, to some other cause than that of a continuous elevation of the surface above the water level, ever since the formation of the upper Silurian limestones. It seems highly probable, at least, that the drift accumulations were never so thick in this region as in other portions of the northwest, perhaps for the reasons suggested by Dr. PERCIVAL; and that these deposits were afterwards modified or entirely removed, by the action of sub-aqueous currents, before the final elevation of the surface above the water level.

We have dwelt somewhat at length upon the surface geology of the State, because these deposits are so generally disseminated that they are, *per force*, brought under the notice of almost every inhabitant, while there appears to be a very general lack of anything like correct views, in the minds of the people, in relation to the conditions under which they have been formed, or the causes to which they owe their origin. Every man who digs a cellar or sinks a well, necessarily penetrates into these deposits, and in every cut upon our railroads the passing traveler has an opportunity of examining, to some extent, the peculiar features of the drift; and yet, how seldom do we hear an inquiry made or a passing remark to indicate that the mind takes hold of the phenomena thus presented, or is incited thereby to investigate the natural causes to which their origin may be attributed.

Moreover, these deposits are of the greatest importance to the agricultural interests of the State, because the soil is predicated upon this superficial detritus, and owes its productive qualities, in part at least, to its homogeneous character. We find in the dynamic laws, which have resulted in the accumulation of the superficial material with which the stratified rocks are generally covered in this State, all the essential conditions necessary for the production of a soil possessing great uniformity of texture and almost unexampled fertility over wide areas of territory. All the various stratified rocks and other mineral masses which go to make up the solid strata of the earth's crust, have been brought together from an area of several thousand square miles in extent, and in a finely comminuted condition have been intermingled in a common mass, already prepared for the production of a soil containing all the essential mineral ingredients for the sustenance and growth of vegetable life, and preserving a remarkably uniform character over a wide extent of territory.

Soils are mainly composed of mineral matter in a finely comminuted condition, to which is added, from year to year, the vegetable and animal matters which accumulate upon the surface. If the superficial deposits are absent, the soil is formed by the decomposition of the stratified rocks upon which it rests, and is subject to abrupt local changes, as we pass from one geological formation to another of a different character. If the rock is a sandstone, it will form a light sandy soil; if a clay shale or other argillaceous rock, a heavy clay soil will be the result; and if a limestone, it will produce a calcareous soil, and so on; and there will necessarily be a marked change in the soil with every variation which occurs in the character of the underlying rock strata.

From what has been already said in regard to the general character of the drift deposits, and the conditions under which they have been accumulated, it will be apparent to every reflecting mind that no valuable deposits of mineral wealth could be expected to occur in them. Nevertheless, the fragments of native copper, lead, iron and bits of coal which they contain are often regarded, by the superficial observer, as indicative of valuable deposits of these minerals, whereas the fragments themselves have been transported perhaps for hundreds of miles from their original beds.* As well might they expect to find a bed of granite or porphyry in the vicinity where boulders of these rocks occur, for the metallic ores, the coal and the copper have been transported from distant localities, and by the same agencies that brought the boulders. These specimens are only interesting or valuable as going to show the direction from which the drift has come. The native copper has come from the shores of Lake Superior, the ores of lead from the Galena lead region, and the iron and coal from the Coal Measures of our own State, over which the drift currents have passed.

But these deposits are by no means destitute of useful and valuable material for industrial use. The clays and sands so universally used for the manufacture of brick are mainly furnished by them, and they are also the great reservoir from which our wells are supplied with water. The blue clay at the base of the drift forms a good material for the manufacture of coarse pottery and drain tile, when mixed with a portion of the brown clays above it; and the gravel beds

* In a few instances minute particles of gold have been found in the drift, and sometimes charlatans, professing to be geologists, have availed themselves of this fact to proclaim to the world wonderful and valuable discoveries of gold in our State.

furnish an inexhaustible supply of material for the construction of roads. Extensive beds of peat are known to exist in Northern Illinois, resting upon the drift clays; and as they occur in a region destitute of coal, and but poorly supplied with timber, this resource for fuel promises to be one of considerable importance.

Since the above was written, we have examined the peat deposit on what is known as the *Cat-tail Slough*, in Whiteside county. This *slough* is in a low swail or swamp that intersects the highlands between the Mississippi and Rock river, and that portion of it in which the peat is deposited is situated about eight miles a little north of west of Morrison. It was first discovered by Mr. FRANKLIN DODGE, about the year 1856, when he commenced working it, and it has been used as a fuel for burning lime, and for heating and cooking in the adjacent farm houses, from that time till the present. The deposit has been explored and proved over a surface about four miles in length and three-quarters of a mile in breadth. It has already been dug, in some places, to the depth of nine feet, and is thought to be even much thicker than this. Iron rods have been sunk in it to the depth of twelve feet, without any perceptible change in the general character of the deposit. When dried it is of a dark-brown color, quite free, apparently, from all earthy matters, and burns freely. It is cut from the bed in brick-shaped pieces, about eighteen inches long, four inches wide and four inches thick. It is said to coke well, and if so, it becomes a very valuable fuel for the manufacture of iron and steel. This material, when dried for use, is worth, on the ground, about four dollars per cord, or the same price as ordinary hard wood.

"A patent has been obtained by Mr. WILLIAMS,* Managing Director of the Dublin Steam Navigation Company, for a method of converting the lightest peat into the following products: 1st, a brown combustible solid, denser than oak wood; 2d, a charcoal twice as compact as that made from hard wood; 3d, a factitious coal; and, 4th, a factitious coke—each of which possesses very valuable properties. This turf charcoal of Mr. WILLIAMS has been demonstrated to be 20 per cent. more combustible than that made from oak wood; but one of the most important results of this invention, to the interests of steam navigation, is, that by adding 25 per cent. of the factitious coal made from peat to the ordinary pit-coal used on these steamers, a saving of 30 per cent. is obtained in the stowage of fuel, 1,250 pounds of the mixed fuel being equivalent, for the generation

---

*See Ures' Dictionary of Science and Arts, vol. 2, p. 873.

of steam, to 1,750 pounds of pit-coal. Experiments have also proved that the coke from ordinary turf seems to be capable of producing a far more intense heat than common charcoal. It has been found preferable to all other fuel for case-hardening iron, tempering steel, forging horseshoes, and welding gun barrels."

Peat is no doubt formed from a succulent vegetation, such as the grasses, marsh plants and mosses that accumulate, year after year, on the surface of swamps and low marshy lands. According to Dana, (Manual of Geology, p. 613,) "the peat of temperate climates is due to the growth of mosses belonging to the genus *Sphagnum.* This plant forms a loose turf, and has the property of dying at the extremity of the roots as it increases above; and it thus may gradually form a bed of great thickness. The roots and leaves of other plants, or their branches and stumps, and any other vegetation present, may contribute to the accumulation of the bed."

Certain antiseptic conditions are almost always observed in peat swamps, by which any animal matter that becomes embedded in them is sometimes preserved for ages without undergoing decomposition; and the preservation of the vegetable matter that forms the peat may be, in part, due to the same cause. Human bodies are said to have been exhumed from the peat-mosses of England and Ireland, where they had been buried for centuries, and yet decomposition had not taken place, though the flesh had been transformed into *adipocere.* The remains of the great Irish elk, an animal now extinct, is often found in the peat bogs of Ireland, associated with the canoes and stone implements of the savage islander, and hence these deposits become of great interest to the antiquarian; and the evidences which these fossils afford, in relation to the character of the early inhabitants of the island, are both interesting and instructive.

No animal remains have, as yet, been discovered in the peat-beds of Northern Illinois, so far as we have been able to learn; but it is quite likely that, when these beds come to be more extensively worked, such fossils will be found; and it is very desirable that all persons engaged about a peat-bed should understand the importance of preserving every bone, or other relic of the animal kingdom, that may be met with in the prosecution of their labor, and especially any remains of *man,* or his works, that may be there embedded, and to note with care the position they hold, or the depth at which they are found below the surface. And I would desire to impress this fact upon the citizens of all portions of this State, that all fossils of this kind, found within our own borders, are of much greater value and interest to the people of our own State than they possibly can be to the owners of any eastern museum.

The conditions which prevailed during the drift period do not appear to have been favorable for the preservation of the remains of organic beings, and hence fossils are of rare occurrence in the true drift. The trunks and branches of coniferous trees, belonging, apparently, to existing species, are quite common in the blue clays at the base of the drift; and in the brown clays above, the remains of the Mammoth, the Mastodon and the Peccary are occasionally met with. The fine fragment of a Mastodon's jaw, with the teeth, found at Alton, was obtained from a bed of local drift underlying the loess of the bluffs, which, at this point, was about thirty feet thick, and remained *in situ* above the bed from which the fossils were taken. Stone axes and flint spear-heads are also found in the same horizon, indicating that the human race was contemporary with the extinct mammalia of the Quaternary period.

The remains of a Mammoth were found, a few years since, at Peoria, in the modified drift gravel that forms the bluffs back of the city, and a part of a tooth, with a portion of the jaw-bone to which it was attached, was presented to the State Cabinet by the discoverer, where it is still preserved. A fine tooth of a Mastodon was also found in Gallatin county, and presented to the State Cabinet, but under what conditions it was found, is not at present known. A tooth of a Mammoth was found by Mr. David Miller, in a sand drift, near the South Fork of the Sangamon river, in Christian county, and was presented by him to the State Cabinet. This specimen is of a chalky-white color, and does not appear to have been impregnated with any mineral substance since it was embedded in the earth.

In the Galena lead region, the remains of extinct mammalia have been found, in considerable abundance, in the brown clays that overlie the limestones, and also in the crevices of the limestone, into which they have been drifted by aqueous agencies. Nearly all the specimens found in this region have been sent to eastern cabinets.

It is a matter of regret that the original position in which these fossils are found, is so seldom determined with accuracy by those who accidentally discovered them, as every fact of this kind, if carefully noted, tends to throw some additional light on the question as to when these animals finally became extinct, and is of scientific value to the practical geologist. They appear to be most generally obtained from the upper part of the drift, on the highlands, or from the modified drift of the river valleys.

CHAPTER II.

STRATIGRAPHICAL GEOLOGY, TERTIARY DEPOSITS, AND COAL MEASURES.

STRATIGRAPHICAL GEOLOGY.

The subjoined vertical section (Sec. 1) is given to illustrate the order of succession and comparative thickness of the several formations which have been discovered and identified during the progress of the geological survey, and will be found to comprise all the important sub-divisions of the strata, that appear above the surface, within the limits of the State.

For the sub-divisions of the Silurian and Devonian systems, we have adopted the nomenclature of the New York Reports, so far as we could positively identify our strata with those of that State, because the latter are generally understood by all students of geological science, both in this country and in Europe. For the different members of the lower Carboniferous limestone series, we have accepted, in part, the names proposed in the Missouri and Iowa Reports, with such changes as we believe the interests of science demand. In regard to these sub-divisions, a few words of explanation and a simple statement of facts may not be out of place at this time.

In the Spring of 1853, while acting as Assistant Geologist in the Illinois Survey, I was directed by Dr. Norwood, at that time the State Geologist, to go to Randolph county, and determine, if possible, the relative position of the St. Louis limestone and the beds forming the river bluffs at Chester; and it is, perhaps, proper to state that, up to that time, the former were supposed to overlie the latter beds.

At Prairie du Rocher, in the northern part of the county, I found the St. Louis limestone *in situ*, forming the entire bluff, and two miles below I saw this limestone passing under a massive brown sandstone, more than a hundred feet in thickness. Six miles below

VERTICAL SECTION OF THE ILLINOIS STRATA.

	Thickness.	
Quaternary.	50 to 150 Ft.	Alluvium, Loess and Drift.
Tertiary.	150	Eocene?
COAL MEASURES AND CONGLOMERATE.	600 to 1200	Coal Measures and Conglomerate.
LOWER CARBONIFEROUS.	500 to 800	Chester Group.
	50 to 200	St. Louis Group.
	100 to 150	Keokuk Group.
	25 to 200	Burlington Limestone.
	100 to 150	Kinderhook Group.
DEVONIAN.	10 to 60	Black Slate.
	10 to 120	Devonian Limestone.
	40 to 60	Oriskany Sandstone.
UPPER SILURIAN.	300 to 350	Clear Creek Limestone.
	50 to 200	Niagara Limestone.
LOWER SILURIAN.	60 to 140	Cincinnati Group.
	200 to 300	Galena and Trenton Limestone.
	150	St. Peters Sandstone.
	100–220	Calciferous or Lower Magnesian Limestone.

Prairie du Rocher, this sandstone also passed below the surface, and was succeeded by another limestone formation, which was traced continuously to Chester, and from there south along the river bluffs into Jackson county, where it was overlaid by the sandstones that form the base of the Coal Measures. I returned to New Harmony, Indiana, the headquarters of the Survey at that time, and communicated the results to Dr. NORWOOD, with a copy of my notes and a section, in which I designated the beds at Chester as the *Chester* limestone. He expressed some doubts as to the correctness of the conclusions to which I had arrived, because they conflicted with the views of most Western geologists, especially those of Missouri, and he proposed going over the ground with me, for the purpose of reviewing the section I had made. Accordingly, in the autumn of the same year I revisited that region in company with Dr. Norwood, and we re-traced the bluffs from the Big Muddy River, in Jackson county, to Prairie du Rocher, in Randolph county, confirming to his entire satisfaction the correctness of the section previously made. Holding a subordinate position in the Survey, I did not feel at liberty to publish the facts I observed in the prosecution of my labors in the field, and as they were not announced by the Chief of the Survey, who alone had the authority to make known the scientific results attained in the prosecution of the work, these facts remained unknown, except to the members of the Illinois corps.

On the appearance of the Missouri Report, in 1857, in which all the limestones containing the screw-shaped fossil known as Archimedes, were grouped together under the name of Archimedes limestone, and placed below the St. Louis limestone, I informed Prof. HALL, with whom I was then engaged in the Iowa survey, of the result of the observations I had previously made in Illinois, and the true sequence of the strata, as determined in the section above named; and he at once proposed that at the conclusion of our field labors in Iowa, for that season, we should go to Randolph county, that he might verify, by personal observation, the conclusions at which I had arrived. Accordingly, in October of that year we went together to that county, and for the third time I traced the bluffs, on foot, from Prairie du Rocher to Chester, and for the second time verified the results of my first examination. In the following year (1856), Prof. HALL read a paper before a meeting of the Albany Institute, in which the sub-divisions of the lower Carboniferous limestone are given substantially as they subsequently appeared in the Iowa Report. His reasons for substituting the name of *Kaskaskia*

—3

for Chester limestone do not appear, and we prefer to retain the name first given to it when its true position in the series was determined.

The name Ferruginous sandstone was first used in the Missouri Report, and was indiscriminately applied to the conglomerate at the base of the Coal Measures, and to the massive sandstone deposits which separate the Chester from the St. Louis limestone, the authors mistaking the marked differences presented in the character of these beds for lithological changes in the same formation. In the Iowa Report, this name was retained for the last named sandstone, but as it really belongs to the Chester group, and the term *ferruginous sandstone* being applicable to the other arenaceous members of the group as well, we have rejected it, and in our general section include this sandstone as a lower member of the Chester series, using the term lower Chester sandstone to designate it from the other sandstones of this group.

The argillaceous shales and magnesian limestones exposed above the geode bed at Warsaw, in Hancock county, and the oolitic limestone three miles above Alton, in Madison county, and similar beds at Spergen Hill, and three miles west of Bloomington, in Indiana, were regarded by Prof. Hall as forming a separate division of the lower Carboniferous series which, in the Iowa Report, was designated the Warsaw limestone. The organic remains of these beds, on further examination of many localities, show them to be so intimately related to the St. Louis limestone, that we have included them together, in our general section, under the name of the St. Louis group. The varied lithological characters presented by the different divisions of the groups, at different localities, no doubt resulted from the local conditions under which the sediments of which they were formed accumulated, and were not such as to effect that marked change in the conditions of organic life which characterized the main divisions of the lower Carboniferous series.

In the Iowa Report, published in 1858, Prof. Hall referred the arenaceous and calcareous beds at Burlington, Iowa, which underlie the Burlington limestone and overlie the black slate formation of the West, to the age of the Chemung group of New York, and subsequently in the Thirteenth Report of the Regents of the New York University, published in 1860, he referred the equivalent beds at Rockford, Indiana, to the Marcellus shale which forms the base of the Hamilton group of the New York series.

In a paper on the age of the Goniatite limestone of Rockford, Indiana, by Meek and Worthen, published in the American Journal of Science for September, 1861, the name *Kinderhook Group* was proposed to include not only the Goniatite limestone of Rockford, but all the equivalent strata in the West hitherto referred to the age of Chemung. We also showed, in the paper above referred to, that the Rockford beds could not belong to the horizon of the Marcellus shale, because they overlie not only the Hamilton limestone, but the Black slate, which was then regarded as the equivalent of the Genessee slate. During the same month Prof. HALL issued a supplementary note to page 95 of the Thirteenth Report of the Regents (which, by the way, was only inserted in a part of the edition), in which he modified his previously expressed opinion in regard to the age of the Goniatite bed at Rockford, Indiana, and carried it up to the age of the Chemung group, and at the same time admitted that the underlying black slate might be the equivalent of the Genessee slate, instead of belonging, as he had previously supposed, to the Marcellus shale. The reason assigned for this change of opinion is the discovery of a Goniatite in bed in Ohio, supposed to represent the Chemung, identical with a Rockford species. It is now generally admitted that there is no specific identity between the fossils of the Chemung or any other division of the Devonian system in New York, and the Kinderhook group in the West; and believing the latter to be Carboniferous, and not Devonian, we have retained the name originally proposed by us for this group, and placed it in the general section at the base of the Carboniferous series, where it evidently belongs.

In describing the several formations represented in the foregoing section, we shall take them up in their regular order of sequence, from the newest or uppermost downward, just as they would present themselves before us in a single vertical section.

TERTIARY. ?

This system has only been identified in the southern portion of the State, and appears to attain its greatest development in Pulaski county, where it is represented by a series of stratified sands and clays of various colors, with beds of siliceous gravel, often cemented into a ferruginous conglomerate by the infiltration of a hydroxyd of iron. A marked feature of this system, in Pulaski county, is the presence of a bed of *green marly sand*, which, from its lithological characters, was at first supposed to be the equivalent of the cretaceous green sand of New Jersey. An examination of the fossils which it affords, however, seem to leave but little doubt of its Tertiary age. They consist of marine shells, belonging to the genera Cucullea and

Turritella, in the form of casts, the shell itself having been dissolved and entirely removed, so as to preclude the possibility of specific identification. A single shark's tooth was obtained from this bed near Caledonia. Along the edge of the Ohio, at Caledonia, there is a thin bed of *lignite* to be seen, at extreme low water. It is only a few inches thick, and forms the lowest stratum of the Tertiary exposed in that vicinity.

At Fort Massac, on the Ohio, just above Metropolis, the ferruginous conglomerate already mentioned is from forty to fifty feet in thickness, and a similar bed caps some of the highest hills in Union county, from which they have derived the local name of Iron Mountains. This conglomerate is made up of cherty pebbles, cemented with iron ore or "*limonite*," the latter in some cases constituting as much as one-half the entire mass. If the enclosed pebbles were limestone, to act as a flux to the ore, it would, no doubt, prove a valuable deposit of iron; but as they appear to be entirely siliceous, it can scarcely be made available for the production of metallic iron.

In Alexander county, near Santa Fé, there is a bed of soft quartzose sandstone exposed in the river bluff, which we regard as of Tertiary age; and in the hills, about a mile and a half back of the town, there is an exposure of very hard quartzite, which appears to be of the same age. Some excellent clays for potters' use occur near the river, just above Santa Fé, from which an excellent article of stone-ware has been made. Siliceous wood, in a fine state of preservation, has been found quite abundant in the Tertiary beds in Pulaski and Alexander counties.

Although no Tertiary beds have been identified north of Union county, yet certain facts have been observed which indicate their occurrence, in local patches at least, as far north as the mouth of Skunk river, in Iowa. We have obtained four specimens of shark teeth, belonging to as many different species, all apparently of Tertiary types, three of which were found in the alluvial sands of the Mississippi and Des Moines rivers, in the vicinity of Warsaw, in Hancock county, and the fourth from Skunk river, in Iowa, a few miles above the mouth of that stream. These fossils were not found in the original matrix in which they were embedded, it is true, but their perfect condition, taken in connection with their fragile character, renders it almost certain that they have not been transported from remote localities by ordinary drift agencies. They must have come from some patches of Tertiary beds, originally deposited in this region, and perhaps still remaining hidden beneath the alluvial beds of the Mississippi valley.*

In Hancock county, a thin bed of ferruginous conglomerate was observed *in situ* at one or two localities at the base of the drift, which can not be distinguished, in hand specimens, from the Tertiary conglomerate of Southern Illinois; and fragments of a similar kind of rock are common in the drift in that part of the State. From these facts it seems probable that the waters of the Tertiary ocean once extended up the valley of the Mississippi at least as far as the mouth of Skunk river, in Iowa, and that rocks of Tertiary age have once been deposited at least three hundred miles further north, in that valley, than they are now known to occur.

Leaving the Tertiary beds, and passing downwards in the geological scale, we find, on comparing the section of the geological systems of our own State with that where the sequence of strata is complete, as shown in a former chapter, that there is a hiatus in the Illinois section, embracing three entire geological systems. Their absence would indicate that the surface of this State was elevated above the ocean's level during the whole period of time that was consumed in the deposition of the Cretaceous, Jurassic and Triassic systems in other portions of this continent.

In March, 1858, Dr. J. G. Norwood, the former director of the Geological Survey of Illinois, read a paper before the St. Louis Academy of Science, announcing the discovery of Permian rocks in Henry, Bureau and LaSalle counties, in Northern Illinois. Upon what evidence his conclusions were based does not appear, for there certainly were no fossils in the State Cabinet at that time, from Northern Illinois, that indicated the existence of any stratified rock in that portion of the State above the horizon of the true Coal Measures.

In May, of the same year, the writer exhibited, at the Baltimore meeting of the American Scientific Association, a collection of fossils from Gallatin county, in Southern Illinois, some of which were admitted to present as strongly marked *Permian* features as those from beds referred, by Prof. Swallow, to the lower Permian series of Kansas, which were there present for comparison. These fossils were collected by Dr. Norwood and myself in the summer of 1853, and had, ever since that time, been in the State Cabinet, and were recognized as Coal Measure fossils.

* Since the original publication of the first volume of the Geological Reports, several species of characteristic Cretaceous fossils have been found in the region where the shark's teeth above mentioned were obtained, and it is possible that they may also belong to the Cretaceous instead of the Tertiary formation.

In the discussion of the *Permian* question, at Baltimore, we contended that the paleontological evidence presented even by the Kansas specimens themselves, taken as a whole, was not sufficient to establish the existence of a system distinct from the Coal Measures, but, on the contrary, tended to prove that the so-called Permian system of Europe was the equivalent of a series of strata in this country in no way separable from the true Coal Measures. Holding, still, to this view of the question, we have omitted the name, Permian, in our general section, believing that the beds from which the fossils from this State exhibited at Baltimore, were obtained, do not come properly within the division of the series to which that name has been applied in Europe, though evidently of the same age as the beds called lower Permian by Prof. SWALLOW, in Kansas.

COAL MEASURES.

This term is applied to a certain series of strata which contain all the principal coal beds or seams, and form the upper division of the Carboniferous system. These measures consist of repeated alternations of sandstones, shales, bituminous slates, thin bands of limestone, and seams of coal, with the under-clays which usually accompany them. In Southern Illinois they attain an aggregate thickness of twelve to fourteen hundred feet, while in the Northern portion of the State their entire thickness does not exceed six or eight hundred feet.

This division of the Carboniferous system is a grand repository of mineral wealth, by far the most important and valuable at present known within the limits of the State. It affords an inexhaustible store of mineral fuel, in addition to the valuable deposits of iron ore, potter's clay, fire clay, and building stone, which abounds in it at some localities.

The steam engine has become the indispensable agent of productive industry throughout the civilized world, and that country which possesses the greatest facilities for the cheap generation of steam power, all other things being equal, will inevitably take the advance in commerce and manufactures, and must, consequently, progress with rapid strides on the highway to national wealth and power. Coal is the cheapest fuel at present known for the generation of steam, and as the population of the State increases, and its commercial interests are more fully developed, creating a greatly increased demand for mineral fuel, the value of our coal mines will be more highly appreciated, and the important bearing of these fuel resources on our future prosperity will be better understood.

In our general description of these measures, we shall include with them the conglomerate sandstones at the base of the true Coal Measures, which have heretofore been called "barren measures" or Millstone-grit. We do so for the reason that they contain, in this State, coal seams of workable thickness, and shade into true Coal Measures in such a manner that it is quite difficult to fix any dividing line between them—thus showing that they were deposited after the commencement of the peculiar physical conditions that characterized the great coal forming era. In the southern part of the State these "barren measures" are from two to three hundred feet in thickness, and at some points contain well defined coal seams, though they are generally local in their character.

From borings reported in certain portions of the Illinois coal field, however, it appears that there are probably some limited areas where no coal exists in sufficient quantity to be mined with profit, and it is to be expected that future experiments with the drill will clearly define the extent of these barren areas. But a single boring cannot be relied on to settle this point at any given locality, for the drill might strike a spot where the coal was replaced with clay or shale, forming what the miners term a "horseback," as was probably the case in the boring made in the city of Springfield in 1858. Here, although the drill was sunk to the depth of nearly 1,200 feet, the record showed no coal more than a few inches in thickness, while subsequent investigations have demonstrated that coal No. 5, one of the most important and reliable seams in the State, underlays nearly the whole area of Sangamon county, with an average thickness of about six feet, and at a depth of one to four hundred feet below the surface.

The productive Coal Measures, where fully developed, even as far north as Fulton and Peoria counties, contain at least five or six workable beds of coal, having an aggregate thickness of nearly twenty feet. In a section, made by Dr. D. D. Owen, of the Coal Measures of Southern Illinois, and published in his report for the Shawneetown Mining Company, there are twelve coal seams, with an aggregate thickness of about thirty-five feet. These are included in about eight hundred and sixty feet of strata, immediately above the Conglomerate sandstone, and extending upward to what is known, in the Kentucky section, as the Anvil-rock sandstone.

The fact was already generally known that during the deposit of the whole series of strata underlying the Coal Measures, from the top of the lower Carboniferous limestone to the base of the upper Silurian, the northern shore of the paleozoic ocean was gradually rising above the water level, in consequence of which the boundary of each succeeding group of rocks was curtailed in its northern extension before reaching the limits attained by the preceding one; and the whole surface being again brought to the ocean level and frequently submerged during the coal era, the Coal Measures were found to overlie unconformably all the subordinate formations, successively, from the St. Peters sandstone of the lower Silurian era to the Chester limestone, which is the upper member of the lower Carboniferous limestones, and which would have formed the substratum on which the Coal Measures would have rested over the whole area of the State, but for the elevatory process already mentioned.

But it was not known, until the facts were brought to light by the recent investigations of the Geological Survey, that this subsidence of the coal era was as gradual as the preceding elevation had been, and in consequence of this the upper portion of the Coal Measures only had been deposited in the northern portion of the State. This will, perhaps, also account for the apparent unequal distribution of the coal in different portions of the coal field, because the coal seams occur at certain horizons in the measures, and are separated, in some cases, by one or two hundred feet of strata that contain no workable coal, as may be seen by reference to the sections given in the detailed surveys of the various counties, as well as in the report of the writer on the general distribution of the coal, in a subsequent chapter.

The opinion has been entertained and expressed by some geologists that the Illinois coal field was not a continuous basin, but, rather, a series of small basins, which were separated from each other by outcrops of the older rocks. This opinion I believe was first advanced by Dr. R. P. Stevens, and afterwards received the indorsement of Dr. Norwood,* and, more recently, has been repeated by itinerant lecturers and amateur geologists, who attempt to explain in this way the irregular distribution of the coal in different portions of the State. If this were really the case, then we should expect to find these lower Carboniferous rocks outcropping at various localities within the limits of the coal field, in the anti-clinal axes separating these coal basins. But no localities have been cited, so far as we know, by those professing to entertain these views, where such outcrops can be seen, and we have not been able to discover, in our investigations in various portions of the State, a single locality of this kind.

---

*See Dr. Norwood's Report on Illinois Coals, page 91.

From the northern boundaries of the field, in LaSalle and the adjoining counties, to its southern limits, near the Ohio river, and from its western boundary to the Wabash, no such axis has been seen. And moreover, every boring attempted in the State, within the recognized limits of the coal field, has revealed the existence of the Coal Measure strata, although not always showing the presence of the coal beds. It is true that we find, in some of the river valleys, exposures of lower Carboniferous rocks, while coal is found on either side of the valley; but it is always at its proper and higher level, and its absence in the valley is simply due to the erosion and removal of the strata, by the denuding forces which excavated the valley to a lower level than that occupied by the Coal Measures.

It is also true that the limestones, on which the Coal Measures rest, presented an uneven surface for the reception of the coal-bearing strata, but this was probably due rather to denuding influences, which had worn the surface into shallow troughs or valleys, than to the upheaval and dislocation of the strata, and it is not uncommon to find thin outliers of coal along the borders of the coal field that have been deposited in such shallow troughs in the limestone, caused by the erosion of the strata. We have seen but one locality in the State where the Coal Measures appeared to have been disturbed after their deposition, and that is on the northern borders of the coal field in LaSalle county, where they have been elevated as much as four hundred feet by the uplift which brings the lower Magnesian limestone to the surface between Split-rock and Utica. It is proper to state, however, in this connection, that the probable age of the uplifts along the southern and southwestern boundaries of the coal field have not been accurately determined, and it may be that the Coal Measures have been locally disturbed by these influences in that part of the State, but certainly not to the extent of breaking the continuity of the coal strata into isolated basins.

The following section of the Coal Measures, as they appear in Northern Illinois, was obtained from the exposures of the strata in Peoria county, including, also, the beds entirely below the surface, which were penetrated at the boring of Voris & Co., on the east side of the river, opposite Peoria, and affords a satisfactory idea of the series in this part of the State:

Compact gray limestone	10	feet.	
Argillaceous shale, with iron nodules	50	"	
Coal, No. 7	1	"	6 inches
Fire clay	2	"	
Shale	25	"	
Limestone	4	"	
Shaly clay	0	"	8 "

	Coal, No. 6	3 to 4 feet
	Shale and sandstone	35 "
	Hard sandstone	22 "
	Bituminous shale	10 "
	Coal, No. 5	5 "
Voris & Co's Boring.	Hard clay shale, passing into limestone	4 "
	Sandstone and shale	105 "
	Bituminous shale	3 "
	Argillaceous shale	15 "
	Coal, No. 3 (?)	4 "
	Sandstone and shale	108 "
	Coal, No. 1	3 "
	Sandstone and shale	122 "
		533 feet 2 inches

This section gives the horizon of seven of the principal coal seams, with five of them well defined, and the whole included in a total thickness of about 533 feet.

By referring to the LaSalle section, given in a subsequent chapter, it will be seen that at that locality the measures have been still further extended upward, with a corresponding diminution of the lower members, so that coals Nos. 2, 5 and 7 are the only ones exposed, in the various borings made at that locality, of sufficient thickness to be worked with profit, and these are found near the base of the Coal Measure strata as they are developed in that portion of the State.

We thus find that the unequal distribution of workable coal beds in different portions of the State, even where the coal strata themselves appeared to be equally well developed, is now in a fair way of solution, and without resorting to so unreasonable a hypothesis as that of "internal convulsions," which formed "irregular valleys and basins," in which the Coal Measures were subsequently deposited. The detailed county surveys, as they are completed in various portions of the State, will throw additional light on this question, and tend to its final and satisfactory solution.

On the extreme northeastern border of the coal fields, in Grundy, Will and Livingston counties, the measures contain a single seam of coal, averaging about three feet in thickness, which is overlaid by a heavy bed of clay shale or soapstone, that passes upward into a sandy shale or sandstone. In the vicinity of Morris this seam is about thirty feet below the surface, and averages about thirty inches in thickness. It is overlaid there by about twenty-five feet of blue clay shale, the lower part of which contains several species of ferns in a beautiful state of preservation. The underclay has been penetrated to the depth of four or five feet, without reaching the bottom. The principal openings are about a mile and a half east of Morris.

and the dip (perhaps local) is westerly at the rate of about twenty feet to the mile, which carries the coal sixty feet below the surface at Morris. The quality of the coal afforded by this seam near Morris is quite variable, even where the openings are near each other. At Mr. WARNER's opening the coal appeared to be of good quality, and quite free from pyrites, while at some other openings, in the same neighborhood, the coal was so highly charged with sulphuret of iron as to seriously injure it for market.

Four miles southeast of Morris, on Mazon creek, there is an outcrop of about twenty feet of sandy shales overlying this coal, with nodules of argillaceous iron ore that contain many species of fossil ferns, with some crustacea, and a few fossil shells. This locality has also afforded a single species of *Salamander* and a *Caterpillar*. These nodules have likewise been found to contain two or three species of fishes and insects, and some interesting crustacea.*

Along the line of the St. Louis, Alton and Chicago Railroad, below Wilmington, this seam has been reached at many points by boring, and its proximity to Chicago renders this locality a very important one to the coal interests of that city. The following sections of the borings in this vicinity were carefully compiled by Mr. ALVIN MATSON, and were kindly furnished for this report by RICHARD P. MORGAN, Jr., Esq., of Wilmington:

"The borings made in this vicinity are as follows, commencing four miles southwest of Dwight, Sec. 25, T. 30, R. 6:

Drift	100 feet.
Clay shale and sandstone	100 "
Bituminous shale	0 " 6 in.
Shale	54 "
	254 feet 6 in.—no coal.

Sec. 9, T. 30, R. 7—Dwight Station.

Drift	100 feet.
Shaft	65 "
	165 feet.

At this depth a vein of artesian water was struck, flowing through a tube three or four feet above the surface.

S. E. qr. of Sec. 4, T. 31, R. 8—Gardner Station.

Drift	100 feet.
Shale	65 "
Coal	3 "
	168 feet.

*The scientific world is indebted to Mr. Joseph Even, of Morris, for the discovery of this interesting locality.

S. E. qr. of Sec. 26, T. 32, R. 8—Augustine's Shaft.

Drift	42 feet.
Shale	62 "
Coal	2 ft. 10 in. to 3 " 2 in.

Five feet of coarse sandstone immediately under the coal, about the character of ordinary sandstone grit.

N. W. qr. of Sec. 25, T. 32, R. 8—Braceville Station.

Drift	40 feet.
Shale	60 "
Coal	2 ft. 8 in. to 3 " 4 in.

West part of Sec. 8, T. 31, R. 9.

Drift	37 feet.
Shale	30 "
Coal	3 " 2 in.

On the east side of this section no coal was found.

East part of Sec. 30, T. 32, R. 9.

Drift	35 feet.
Shale	43 "
Coal	3 " 4 in.

Sec. 28, T. 32, R. 9.

Drift	43 feet.
Shale, etc	67 " —no indication of coal.

Middle of Sec. 17, T. 32, R. 9—Stewart's Grove Station.

Drift	43 feet.
Shale	41 "
Coal	3 " 2 in.

Near this point the east line of the coal field crosses the railroad, running nearly due north and south.

S. E. qr. of Sec. 13, T. 32, R. 8.

Drift	50 feet.
Shale	48 "
Coal	3 " 3 in.

S. E. of Sec. 12, T. 32, R. 8.

Drift	50 feet.
Shale	40 "
Coal	2 " 2 in.

West part of Sec. 1, T. 32, R. 8.

Drift	60 feet.
Shale	50 "
Coal	0 " 4 in.
Shale	1 "
Coal	3 " 2 in.

Middle of Sec. 31, T. 33, R. 9.

Drift	25 feet.
Shale	15 "
Coal	3 " 2 in.

On the N. E. part of the same Section.

Drift	28 feet.
Coal	3 "

East part of Sec. 32, T. 33, R. 9.

Drift	18 feet.
Coal	3 "

"In addition to these borings and shafts there are the Robbins' shaft, on the N. E. qr. of Sec. 5, T. 32, R. 9, about 70 feet deep, and the Wilbur shaft, on the S. W. qr. of the same section, the details of which were not obtained.

"Although the coal runs out, working east, in one shaft on the N. E. qr. of Sec. 5, T. 32 R. 9, it again appears, 3 ft. 2 in. thick, at a point on the railroad due east; but that is evidently a spur or small deposit, as it disappears in a short distance, going north and south on the railroad, and also going east and west.

"The borings indicate that the general course or trend of the eastern boundary of the coal field, as near as can be ascertained, and only varying from it by small indentations, is due north and south from the middle of Sec. 8, T. 31, R. 9, to the easterly part of Sec. 8, T. 32, R. 9, and thence to the N. E. qr. of Sec. 5, T. 32, R. 9, and thence northwesterly to the S. W. qr. of Sec. 30, T. 33, R. 9. The coal at the various openings made in this vicinity averages about three feet in thickness, and dips slightly to the west."

The specimen of this coal, sent by Mr. Morgan, was taken from the shaft at Braceville, and was considered to be not better than a fair average of the coals of this vicinity, and if so, it is one of the best coals yet found in Northern Illinois. The specimen before us is very bright, hard and compact; fracture partly conchoidal; layers thick, and intersected by thin vertical plates of carbonate of lime, evidently deposited from a solution in cracks or joints. The general appearance of the coal is very much like that from DuQuoin, with which it seems to be identified by the fossil plants that are found associated with it. According to the statements of the engineers, who have used this coal, on the St. Louis, Alton and Chicago Railroad, it is nearly or quite equal, for locomotive use, to that obtained from DuQuoin.*

Although this seam averages considerably less, in thickness, than those wrought at LaSalle, and some other points in the northern portion of the State, yet its proximity to the Chicago market, the ease and cheapness with which it can be reached by shafts, varying in depth from thirty to two hundred feet, and the superior quality of the coal it affords, renders this a very valuable and important deposit. This is probably the nearest point to Chicago where workable coal can be found on any direct line of railroad communication with that city. At all the sections, but one given of the foregoing shafts and

* Subsequent investigations have shown that this seam is the equivalent of that at Murphysboro, in Jackson county, or No. 2 of the general section of the Illinois Coal Measures.

borings in this vicinity, the coal appears to have a clay bottom, which, at one locality, had been penetrated to the depth of four or five feet, but no examination has yet been made to determine its fitness for the potter's use or the manufacture of fire-brick. A fine article of common stoneware is manufactured at Goose Lake, in Grundy county, from a clay which appears to belong near the horizon of the under clay of this coal seam.

The following section, compiled in part from surface exposures, and in part from the coal shaft at Highland, gives a general idea of the lower Coal Measures, as they are developed in Madison and St. Clair counties, from the limestone above coal No. 9, of the Illinois section, to the base of the series:

Dark bluish-gray and brownish-gray compact limestone, variable in thickness, but usually from	4 to 6	feet.	
Bituminous shale	6	"	
Gray shale, with fossil shells and a few plants	11	"	
Coal No. 9	1	"	6 in.
Gray shale	21	"	6 in.
Calcareous shale, with fossils	2	"	
Bituminous shale, with 6-inch seam of coal	22	"	
Sandstone and shale, with two or three bands of black shale	103	"	
Limestone, upper bed, at Belleville	5 to 8	"	
Coal No. 7 (?)	2	"	
Fire clay	(?)		
Calcareous shale and limestone	16	"	
Bituminous shale, sometimes absent	1 to 3	"	
Coal, Belleville seam, No. 6 (?)	5 to 7	"	
Fire clay and nodular limestone	5	"	
Shale	5 to 10	"	
Limestone, sometimes replaced by shale	3 to 4	"	
Coal, No. 5 (?)	2 to 4	"	
Fire clay	1 to 3	"	
Clay shale and sandy shale	40 to 50	"	
Coal, No. 1—(Alton coal)	3 to 4	"	
Fire clay	4 to 6	"	

In the vicinity of Alton, and through several of the more northern counties, this lower seam (No. 1) immediately overlies the lower Carboniferous limestone, though at one or two localities we found a local development of conglomerate associated with another thin seam of coal that, we have no doubt, represents one of the conglomerate coals of the more southern portions of the State. This section, taken in connection with the preceding one in Northern Illinois, will give a correct general view of the distribution of the coal seams along the western borders of the Illinois coal field.

The coal seams are usually underlaid by a bed of fire clay, which varies in thickness from a few inches to ten or twelve feet. This was the original soil and sub-soil on which the vegetation that formed the coal grew, and it is often penetrated by the rootlets of the ancient carboniferous trees whose trunks and branches have contributed to form the coal. As this clay is often quite pure, it forms a valuable material for the manufacture of fire bricks and pottery, and sometimes is fully equal in value to the coal seam which it underlies. The best fire-clays contain from 60 to 70 per cent. of silica, from 25 to 35 per cent. of allumina, and sometimes 1 to 2 per cent. of oxide of iron, lime or magnesia, with from 5 to 10 per cent. of water. They are usually of a light gray or nearly white color, though they are frequently more or less stained by iron oxide.

The layer of rock strata immediately above the coal is termed the roof, and the economy and safety with which a seam of coal may be worked depends very much upon the character of the roof. A regular bedded limestone forms the best roof, though a hard bituminous slate, or a compact sandstone, is nearly as good. Clay shale forms the poorest covering for a coal seam, and such seams require a much greater outlay for cribbing and supports, in order to work the mine safely, than those which have a more compact and solid roof. Sometimes it becomes necessary, in working a seam of this kind, to leave a portion of the top coal to strengthen the roof.

The Coal Measures afford valuable beds of building stone, especially limestone and freestone, though the beds of limestone are seldom of great thickness. The State House quarry, on Sugar Creek, in Sangamon county, from which the material for the old State Capitol was obtained, is a highly fossiliferous limestone, from five to ten feet thick, which is usually divided about the middle by a seam of clay shale, a foot or two in thickness. A similar rock, holding about the same stratigraphical position, occurs at LaSalle, and is extensively used as a building stone. The specific identity of the fossils from these two localities would seem to leave but little doubt of their equivalent position.

The analysis of the State House rock by Mr. Pratten gave the following results:

Carbonate of lime	68.73
Carbonate of magnesia	5.07
Carbonate of protoxide of iron	14.62
Alumina	.70
Insoluble in chlorohydric acid	10.27
Water and loss	.61
Total	100.00

According to the views already expressed in regard to the distribution of the coal seams in Illinois, these limestones overlie the horizon of the Anvil-rock sandstone, and probably represent the same geological horizon as the great limestone formation of Pennsylvania, which is there about 70 feet thick, on an average, consisting of limestones of variable characters, separated by shales and shaly sandstones. The most characteristic fossils of these limestones in Illinois are *Productus punctatus*, *P. Nebrascensis*, *Pinna pe-acuta*, *Petalodus destructor*, *Chomatodus angularis*, and *Sandalodus carbonarius*. In addition to these, the quarries on Sugar Creek, in Sangamon county, afford fine specimens of *Syringopora multattenuata*.

In Scott and Greene counties the sandstones which intervene between coal seams No. 1 and No. 2, occur in massy beds, and, judging from the surface exposures, would make a reliable building stone.

There are many other points in the State where the Coal Measures afford good building stone, which will be described more fully in the detailed report on the several counties than they could be here.

For a summary view of the conditions under which the coal has been formed, and the manner in which the vegetable substances which enter into its formation have accumulated, the reader is referred to the report of the writer, in a subsequent chapter.

Bands of carbonate of iron are common in the Coal Measures, some of which promise to become valuable for the production of metallic iron. Iron, in the form of a sulphuret, is also almost universally distributed through the coal itself, either as crystals or as nodules, often of many pounds weight. This mineral is utterly worthless for all purposes except for the manufacture of vitriol (sulphuric acid) and copperas (sulphate of iron), and its general dissemination through a coal seam renders the coal itself almost valueless. It is the great bane of our western coals, rendering them often almost useless for working iron, until the sulphur is expelled by coking, which is sometimes rather difficult to do successfully. Where this sulphuret occurs in balls or masses of any considerable size, it should be carefully separated from the coal at the mouth of the shaft or in the adit; but where it is disseminated through the coal in thin scales, or in minute crystals, it can only be expelled by the process of coking. Many coals are made to retain a fair reputation by being carefully freed from this material before the coal is sent to market. Sometimes it is confined to a particular portion of the seam; and where this is the case, the portion containing the pyrites should be mined and sold by itself, or, if worthless, thrown aside. It is usually of a bright yellow or silver-white color; effloresces, on exposure to the atmosphere, generating thereby heat that sometimes results in spontaneous combustion, and ignites the bituminous shales or the coals themselves. There is also another substance found in our coals, traversing the layers in very thin plates of a white or glassy transparency. This is lime, either in the form of a carbonate or sulphate, most frequently the former, and does not affect injuriously the quality of the coal.

The carbonate of iron is a dull, earthy-looking ore, of a brown color, often occurring in nodules or concretions, disseminated through the shales of the Coal Measures or in regular beds or seams, like the coal itself. These ores are not as rich in metallic iron as those usually found in the metamorphic rocks, but they are more easily smelted, and make a softer and more malleable iron. An ore of this kind, that yields from 30 to 40 per cent. of protoxide of iron, is valuable if found in sufficient quantity to sustain a furnace.

Black slates are common in the Coal Measures, and as they were formed under conditions very analogous to those which formed the coal seams, the latter are sometimes replaced by or pass into the former. The conditions necessary to the formation of a black slate only differ from those forming a coal seam in the preponderance of earthy material added to the carbonaceous deposits. Or, in other words, if the conditions were so changed at any given locality, during the accumulation of the vegetable matter necessary to form a coal seam, that a superabundance of mud was introduced, a black slate would be the result. Some of these slates are highly charged with bituminous matter, and when thrown on a brisk fire, burn readily until this is consumed, when combustion ceases, and the residue resembles a pile of burnt stones. It may easily be distinguished from coal by its thin, slaty cleavage, whereby it readily separates into thin plates. Some of our principal coal seams are covered with a roof of this material, showing a gradual passage from the coal to the slate, and evidencing the analogous conditions under which they were both formed. Sometimes the coal seam is separated into several distinct beds by thin bands of black slate.

Although black slates are almost always found in connection with the coal seams, and are more abundant in the Coal Measures than elsewhere, they are not confined to any particular geological horizon, but are met with in all the various systems of stratified rocks. The coal miner, being unacquainted with the science of geology, and relying entirely on the accuracy of his own observations, decides at once that wherever a black slate is found, there you may reasonably expect to find coal, as well; and hence many persons are induced to spend both time and money in a vain search for coal, in strata many hundreds of feet below the horizon of any known coal seam; and they do this on the assurance of "old coal miners," who assume to be fully competent to determine where coal is to be found. There is scarcely an outcrop of black slate or bituminous shale in this State, either in the lower Carboniferous, Devonian or Silurian rocks, where such explorations for coal have not been prosecuted, and almost invariably by the advice of those whose practical acquaintance with coal mining is supposed to render their opinions reliable. But the merest tyro in geology, if he could have seen a few fossils from the slates themselves, or the rocks connected with them, would have decided at once, and correctly, that they did not belong to the Coal Measures, and therefore were not indicative of the existence of workable coal seams. Fortunes have, in this way, been squandered in the fruitless search for coal in regions where it does not exist, and where a few hours' labor of a competent person would have made the fallacy of the search apparent.

Cannel coal is found in limited quantities, in various portions of the State. and most commonly forming a portion of a seam of ordinary bituminous coal. It differs from the common coals in its even, compact structure and conchoidal fracture, duller lustre and greater richness in bituminous matter. It is lghter than a black slate, does not usually split into thin plates, and will be entirely consumed when once ignited, if pure. A splinter of it will take fire and burn like a candle until it is entirely consumed, and hence its original name "candle coal," which was afterwards corrupted to cannel coal. It is supposed to have resulted from the highly resinous character of the vegetable substances of which it is formed, and hence if, during the accumulation of the vegetable matter necessary to the formation of a coal seam, the conditions were favorable for the production of highly resinous woods in abundance, a cannel coal, forming either the whole or a part of the seam, would be the result. The passage from a cannel coal to a bituminous slate is also a very gradual one; and, indeed, all these varieties of bituminous material shade into each other in such a manner as to leave no doubt of their common origin.

Anthracite is a metamorphic coal, originally formed as a bituminous coal, from which the volatile matters have been, to a great extent, expelled by metamorphic agencies. It belongs to the same geological period as the common coals, and the anthracite beds of Pennsylvania are the altered representatives of the bituminous seams of the same

State. The anthracite character seems to be confined to those regions where the strata have been more or less disturbed, and it is said that in Wales the same bed may be traced from a bituminous to a true anthracite coal, and all the gradations of the change can be distinctly seen. No anthracite coal has yet been found in Illinois.

The character of a coal bed, and its comparative value for the production of coal, is a point easily determined by any one at all conversant with the subject. Where the coal appears at the surface by its natural outcrop, it may be readily examined by drifting for a few feet from the surface into the seam, so as to see the coal in its normal condition, where it has not been subject to the influences of surface exposure. A drift of ten feet from the surface will generally be sufficient to enable the explorer to judge of the quality and value of the coal which the seam contains, though, as a seam of coal, like any other bed of rocks, is subject to considerable variations in the thickness of the strata, it would be necessary to examine the seam at several points along its outcrop, in order to determine its average thickness, and the amount of coal it would yield to a given surface.

The usual mining estimate for the productive capacity of a coal seam, gives one million tons of coal to the square mile, for every foot in thickness that the seam will measure; so that a seam three feet thick would be estimated to yield three million tons of coal to every square mile or section of land under which it extends. Now, if we take a single county, like Peoria, which has at least four seams, underlying nearly the whole of its surface, varying from three to five feet in thickness, the amount of coal that may be obtained from that county alone is simply enormous, and would supply the entire State for many years to come. If we estimate the value of this coal, in the mine, at no more than 25 cents per ton, its aggregate value would far exceed the present estimate of the entire real and personal property of that county. But it will perhaps be said that the coal, in the mine, has little or no value, because the coal is worth but little more than the actual cost of mining, after paying a fair interest on the outlay of capital required for mining operations. This may be true at the present moment, but the time will surely come when the mining privilege, on all our best coal lands that are contiguous to railroad or river facilities for transportation, will be worth and readily command far more than the present estimated value of these lands in fee simple. In the present undeveloped condition of our manufacturing interests, the intrinsic value of our immense deposits of mineral fuel is but poorly understood or appreciated.

In searching for coal, the first and all important point is to ascertain, from some competent authority, that the region under examination is within the limits of the coal field, or, in other words, that the rocks which outcrop in the vicinity where the examinations are to be made, actually belong to the Coal Measures. This can only be determined by a competent geologist. Having determined this point, then the outcrop of the coal seams may be looked for along the slopes of the hills and in the valleys of the streams, where the coal, if above the surface, will probably be exposed by the erosion of the valleys. The surface indications of the presence and outcrop of a coal seam is a streak of black dirt or smut, which will appear along the hill sides, generally at a level a little below the coal, and resulting from the decomposition of the coal by the surface agencies to which it has been exposed. Where the coal strata lie in a nearly horizontal position, as they do generally in the Illinois coal field, there is no difficulty in tracing the coal from one hill to another, even when the outcrop is obscured by the sliding of the superincumbent strata; and a seam appearing on one side of a valley will usually be found by drifting at about the same level into the opposite hill. If it should be found that the dip or inclination of the coal seam is regular and persistent in one direction, and not undulating, as is often the case, then the direction and amount of dip should be carefully noted and taken into the account in prosecuting the search for other outcrops of the seam.

If no coal seam appears upon the surface, and it is desirable to ascertain the amount of coal underlying the surface at a particular point, this should be first determined by boring; and if the coal is found of suitable thickness, then a shaft may be sunk and the coal mined in the usual way. But in boring for coal or other mineral deposits, it is a matter of the first importance that the work should be under the charge of a competent and reliable man—otherwise no reliance can be placed on the reported thickness or value of any of the deposits passed through with the drill. Specimens of the material, at every change in the character of the strata, should be carefully washed and preserved, and a record kept of the thickness of the strata, and the depth below the surface at which it was found. Serious losses must generally be the result in cases where unskillful or dishonest persons are placed in charge of a work of this kind.

Every coal seam possesses some well marked characteristics that will enable even a good practical miner, who will exercise the ordinary powers of observation, to identify it in its various outcrops, at least within limited areas. Then, again, they are enclosed between strata of various kinds, and the character of the roof and the thickness and general aspect of the underclay, if carefully noted, will greatly aid in the identification of the coal seams at different points. But these stratigraphical and lithological features are only applicable to outcrops occurring over comparatively limited areas; and when we come to the identification of beds at localities hundreds of miles apart, these characters fail us, and we are forced to fall back upon the development of animal and vegetable life, as illustrated in the department of paleontology—or, in other words, to the fossil plants and animals that are found embedded in the rocks connected with the coal seams—as the only means for determining the identity of coal beds outcropping at remote localities. From what has already been said in relation to the formation of the different varieties of coal, the reader will understand how a seam may afford common bituminous coal at one locality, and both common bituminous and cannel coal at another, and black slate at a third, and, at the same time, its true horizon and identity can be fully determined by the general character of the strata between which it is inclosed, and their included fossils.

By referring to the general section introduced at the commencement of this chapter, it will be seen that the Coal Measures overlie all the great limestone formations of the State; and hence, in boring for coal, if specimens of the material are carefully preserved, they will show, to the practiced eye of the geologist, exactly at what point these rocks are reached by the drill, and where the search for coal should end. In the Central and Southern portions of this State the measures rest upon some member of the lower Carboniferous limestone series, while in the Northern part of the coal field they rest upon Devonian or Silurian strata; but these are all quite unlike the rocks of the Coal Measures, and would not be confounded with them by any one acquainted with their lithological characters.

It is now generally admitted and believed that coal is the carbonized residuum of vegetable matter that grew upon a low, swampy surface, during the Coal Measure epoch; and being subsequently submerged and covered by deposits of sand and clay, the vegetable accumulations underwent the necessary chemical change and were transformed into coal, while above the coal, sandstones, shales and limestones were slowly accumulating. Subsequently these marine formations were raised above the ocean's level, and another growth of vegetable matter accumulated to form another bed of coal; and this process must have been repeated as often as successive seams of coal and the intervening marine deposits were formed.

The occurrence of numerous beds of calcareous shales and limestones, filled with the remains of marine animals, and extending through the whole thickness of the Coal Measure strata of Illinois and other Western States, is a very interesting feature in the structure of our coal field; and there is probably not one of our principal coal seams that has not, at some locality in the State, a bed of calcareous shale or a limestone associated with it containing the fossilized remains of marine animals, in such a perfect condition as to leave no doubt on the mind of a careful observer that they lived on the spot where their remains are now found embedded. Crustacea, mollusca, crinoidea, corals and bryozoa, with the teeth and spines of cartilaginous fishes, are among the fossils that abound in these calcareous deposits throughout the Coal Measures of the Western States. These fossiliferous strata occur between the different beds of coal, so as to show that if the coal was formed in fresh water marshes, at the sea level, as is generally supposed, there must have been an elevation and subsidence for every bed and seam of coal, as the intervening marine beds attest the presence of the sea, at the time of their deposition, as clearly as the marine types in any of our paleozoic rocks prove them to have been formed by marine agencies.

Coal is simply carbon combined with hydrogen, which combination gives it its bituminous character, a small per cent. of oxygen, and more or less of earthy admixtures, according to the purity or impurity of the coal. DANA says, in his "*Manuel of Geology*," page 361: "Where vegetation decomposes in the open air, all the carbon enters into gaseous combinations and is lost in the atmosphere, only traces remaining to give a dark color to the soil. Hence forests may, with each autumn, drop tons of solid material to the ground, age after age, and yet little remain behind to indicate the existence of that vegetation; but where the bed of leaves and other relics of the plants is covered by water, so that the air is mostly excluded, the decomposition is less complete—precisely as when wood is charred in a half smothered fire, a part of the carbon remains behind and forms coal."

As we have before remarked, the coal seams are usually underlaid by a bed of fire clay, which formed the soil for the growth of the carboniferous vegetation that grew, perhaps, under conditions analogous to those observed in the peat bogs of the present day. But in the Illinois coal field we find localities where the underclays are wanting, and the coal rests directly upon shales, sandstone or limestone, as the case may be. This seems to indicate that the vegetable matter which forms the coal did not, in every case, necessarily grow immediately on the spot, but was transported from some adjacent locality, to where it was finally buried and transformed into coal.

Coke is the solid portion of the coal, the carbon and the ash after the volatile matters are driven off by heat. Coal is not lessened materially in bulk by coking, but decreases in weight about one-half, according to the proportion of carbon and earthy matter which it contained. LESLEY, in his "*Manual of Coal*," gives the following remarks on coke, and the usual method of obtaining it:

"The bulk of coke varies with the method of obtaining it. A quick fire, under heavy pressure, makes a hard, firm, heavy coke, silvery-white, and ringing when struck. A slow, smouldering fire makes a light, spongy coke. By firing slowly at first, with a moist heat, and afterwards, when the sulphur is gone, by firing up rapidly, both purity and weight are obtained. OVERMAN recommends coking in rows (p. 121) or heaps a hundred feet long, seven or eight wide, and three feet high, in a level yard, surrounded by a ditch always full of water. Coarse brick chimneys, with holes, are built along the center of the row, coarse coal piled around them, draft channels left along the ground, and the whole covered with coke dust. In a few hours the whole will be ignited, and a few air-holes made in the coverings will allow the sulphurous acid and other fumes to escape. Tapered posts, stuck in the ground every seven or eight feet, and withdrawn after the coarse coal has been piled around them, wlll serve instead of chimneys. The firing takes place when the row is—say twenty feet long. Before the row is finished and fired at the far end, the coke may be drawn away from the beginning, and the process be perpetual. When the white fumes of corbureted hydrogen cease, the fire must be closely covered up and the mass left to cool. In coking high bituminous coals, the fire should spread through the whole mass before the covering is put on; otherwise the swelling of the softened lumps will coke out the fire. For the same reason, the more bituminous the coal the larger should be the first pieces laid down, and care should be taken to stand them on their ends.

"The principal object of coking is to free the coal from *sulphur* for smelting iron—most coals being sulphurous, and sulphur ruining the malleability and tenacity of the iron. The object is effected by piling the coal on moist earth, or filling it into ovens with a sand floor, kept moist, and firing it slowly, so that the sulphur may escape first. If a dry heat be applied at once to the mass, the water, hydrogen and bituminous compounds will be driven off first, leaving the sulphur indissolubly combined with the carbon. Such coke, when used in the furnace, is as bad for the iron as the sulphurus coal of which it was made. The sprinkling of water upon red-hot coke which has not lost all its sulphur, will prove its existence by the smell of rotten eggs, but will not rectify the coke."

Another product of coal is the common *gas,* used for lighting the streets and dwellings of our cities. It is a combination of carbon and hydrogen, producing what is technically known as *carbureted hydrogen gas,* and is sometimes generated spontaneously in the coal measure rocks, as well as in the bituminous shales of the older formations, and is frequently met with in shafts or wells that penetrate to a considerable depth below the surface in the coal and oil producing regions. It is manufactured from bituminous and cannel coals by distillation, and those coals most free from sulphur and rich in bituminous matters are the most desirable for the production of gas.

Coal oil, rock oil, naptha or petroleum are also the products of coal and carbonaceous shale, from which they are distilled in the great laboratory of nature by processes somewhat analogous to those adopted by the chemist. When they are distilled directly from the coal by artificial means, the cannel coals and the highly bituminous slates are used in preference to the common bituminous coal, because they are the richest in these liquid hydro-carbons. Since the discovery of the rich deposits of these substances in the oil regions of Ohio, Pennsylvania and Virginia, the manufacture of coal oil by artificial means has generally been abandoned, and these rich oil-bearing shales must remain comparatively valueless, until the great natural storehouse of these oleaginous products shall become exhausted.

Indications of the presence of these oils may frequently be seen where carbonaceous deposits abound, but it is only where the beds are of considerable thickness, and the conditions necessary for the distillation and retention of the oils were favorable, that they exist in paying quantities. There appears to be three principal horizons in the West from which oil is obtained in considerable quantities, one of which is in strata of Silurian age, another in the Devonian, and a third in the Conglomerate at the base of the Coal Measures. The oil region of Tennessee is in the former, that of Eastern Ohio, Western Pennsylvania and Canada West is reported to be in the

Devonian horizon, and that of Eastern Kentucky, according to the observations of Prof. J. P. Lesley, is in the Conglomerate; though, according to his report, the oil is not there confined to the sandstone, but is also obtained from wells sunk into the lower Carboniferous limestones below. These limestones separate the two upper oil horizons above named, and Prof. Lesley suggests that part of the oil afforded by the wells in the limestone may have come up from the lower or Devonian horizon. Petroleum is also found, in some parts of the world, in more modern formations, even to the Tertiary; but not yet, in the United States, east of the Rocky Mountains.

Petroleum varies greatly, in color and appearance, at different localities. It is sometimes a black viscid substance, resembling tar, and again appears as a transparent amber-colored fluid, almost as limpid as water. Where the volatile matters have evaporated, the residue is a hard, black, solid substance, called *Asphaltum.* Petroleum results from carbonaceous material, either animal or vegetable, and is simply a combination of hydrogen and carbon. It is in a gaseous form, when first distilled from the carbonaceous material from which it is derived, and as this gas ascends into a higher stratum, where the temperature is considerably lower than that necessary for its evaporation, it becomes condensed into the liquid condition. Much of this gas may escape to the surface and be lost in the atmosphere, and this will account, in part, for the absence of these oils at many localities in which they might be expected to exist. If there were no impervious strata between the carbonaceous beds from which the gas was first liberated and the surface, it would probably, in most cases, escape and leave no oil. The sandstones which overlie the oil-producing strata act as a sponge in absorbing the oil and preserving it, as in a natural reservoir, for the use of man; and if these are overlaid by impervious strata, we have the most favorable conditions for the accumulation of valuable oil deposits. The process of distillation is, no doubt, still going on in the bowels of the earth, and will only cease from the exhaustion of the carbonaceous deposits from which the oil is derived.

Although the productive oil wells in this country are confined to the Silurian, Devonian and Carboniferous systems, as we have already remarked, nevertheless petroleum is found in the rocks of all ages. The deposits of California and the West Indies are in the Tertiary formation, and the oil is probably derived from the *lignites,* from which they have been distilled by the internal heat of the earth, at a comparatively modern period. In the vicinity of Chicago the Niagara limestone is locally completely saturated with oil, but owing to the thinness of the bituminous portion of the rock, it is not probable the oil can be obtained from it in paying quantities, by boring.

Oil has been found in two or three counties in the southeastern portion of the State, in small quantities, and it is by no means improbable that paying wells may hereafter be obtained in that portion of the State. The counties of Gallatin and Saline, and those north of them and lying in the valley of the Wabash river, will, in my opinion, be most likely to afford productive oil wells. My reasons for this conclusion are the following: In this portion of the State the Coal Measures have their greatest development, and the conglomerate sandstone, which constitutes the best oil horizon in Kentucky, attains its maximum thickness of probably not less than three hundred feet. Again, the Devonian sandstones and shales, which are comparatively thin on the western borders of the coal field, thicken rapidly in an easterly direction, and come up from beneath the coal field in Indiana considerably thicker than they average in Western Illinois. Hence we find, in this portion of the State, conditions more nearly analogous to those which prevail in the oil-producing regions of Ohio and Kentucky, than in any other; and experiments carefully conducted may lead to valuable results in this portion of the State. It is especially desirable that wherever there are decided surface indications of oil, appearing as oil or gas springs, that the proper steps should be taken, in an economical way, to test, by a boring, the value of the oil deposits beneath the surface.

But at a time like the present, (1866,) when the people are laboring under an undue excitement in favor of speculations of this kind, it may not be out of place to say that very many of the experiments now undertaken are entirely unwarranted from any reliable surface indications, and can only end in disappointment and pecuniary loss to those who are reckless enough to embark in such wild speculations.

In determining the question whether certain beds that resemble the productive Coal Measures are really identical with them, the most reliable evidence is to be found in the study of the fossil animals and plants that are found embedded in the strata; and as every geological formation represents a distinct and definite period in the earth's history, it is necessarily characterized by a peculiar group of organic forms, quite unlike those of any preceding or subsequent period. The animal life of the coal period was represented by the Mollusca, the Radiata, the Articulata, (Crustacea, Insects and Myriopoda,) and the Vertebrata, the latter being only represented by its lowest forms, the fishes and batrachians. The most common and characteristic fossils of the coal era are marine shells, which abound in all the calcareous and many of the argillaceous beds of this formation. The species most widely distributed are the following: *Productus longispinus*, *P. costatus*, *P. Prattenianus*, *P. punctatus*, *Spirifer cameratus*, *S. lineatus* and *Athyris subtileta*, which appear in every part of the formation, from the base to the top. The Crustacea yet known are few, both in genera and species, but we find two or three species of Trilobites, the last of this interesting division known in a fossil state, one species of *Bellinurus*, an animal allied to the *King Crab* of the Atlantic coast, four species of smaller Crustacea, apparently not very nearly allied to any living genera, and two or three insects. The *iron nodules* from Mazon creek, in Grundy county, have afforded most of these Crustaceans, and, also, the bones of a *Salamander*, consisting of a nearly complete skeleton, which will be found described and figured in the second volume of the original reports.

The Carboniferous period was wonderfully prolific in land plants, presenting, in their fossilized remains, the evidence of a gorgeous flora, only equaled, at the present time, by the densest jungles of the tropical regions, but has afforded, as yet, no land animals more highly organized than the insect and the Salamander. No birds or mammals had yet sprung into being, and the silence of these ancient carboniferous forests was probably "unbroken, save by the chirping insect and the croaking frog." The era of mammalian life had not yet arrived, but the earth was gradually being prepared for the reception of the higher types of animal life that were subsequently to appear.

CHAPTER III.

LOWER CARBONIFEROUS LIMESTONE.

This division of the Carboniferous system may be properly separated into five divisions or groups, which are easily recognized from the specific characters of the fossils contained in each. It attains an aggregate thickness of about fifteen hundred feet in the southern portion of the State, but towards the north the different members thin out successively, and the whole division disappears entirely on the western borders of the coal field, before reaching Rock Island county. We have designated these divisions as the *Chester group*, the *St. Louis group*, the *Keokuk group*, the *Burlington limestone*, and the *Kinderhook group*.

CHESTER GROUP.

This group comprises three or more beds of limestone, with intercalated beds of arenaceous and argillaceous shales and sandstones, the whole attaining a maximum thickness, in Randolph county, of at least six hundred feet. The following section will illustrate the general characters of this group, as it appears in the county above named, where its peculiar features were first studied:

Hard gray siliceous limestone	25 to 30 feet
Shales and shaly sandstones, with fossil plants Sigillaria, Stigmaria, Lepidodendra, Knorrhia, etc., (partially hidden)	80 to 90 "
Shaly limestone (local)	15 to 18 "
Massive brown sandstone	40 "
Limestone, partly nodular and argillaceous	45 "
Green and blue argillaceous shales, with plates of limestone	45 to 70 "
Argillaceous and siliceous limestone (local)	20 to 30 "
Massive sandstone and sandy shale	15 to 20 "
Compact gray limestone, with intercalations of blue, green and purple clay shales	150 "
Brown sandstone	120 "

According to the observations of Mr. Henry Engelmann, the calcareous beds of this group are considerably increased in thickness, in the more southern counties examined by him. In a northerly direction the whole group thins out rapidly, and in the southern part of St. Clair county it probably does not exceed one hundred feet, and in the bluffs just above Alton, in Madison county, it is represented by less than twenty feet of grit and limestone. The divisions appear to thin out successively from the uppermost downward, and in Madison county, we find only a few feet of the two lower beds remaining. Towards the southeast it appears to become thinner in Kentucky, especially the calcareous beds, which, according to Mr. S. S. Lyon, only attain an aggregate thickness, though recognized in five divisions, of about one hundred and twenty feet.* The thickness of the whole group in Kentucky, from the top of the St. Louis limestone to the base of the conglomerate, appears to be about four hundred and twenty-five feet, according to Mr. Lyon's section.

The greater portion of the material constituting this group is an argillaceous or arenaceous sediment, more or less ferruginous, that gives rise to frequent and sudden changes in the lithological characters of the different members of the group. For example: in the section at the city of Chester,† where the middle portion is best exposed, we find seventy feet of green and blue argillaceous shales resting upon the lower limestone, but at the upper end of the city there is a massive sandstone, fifteen or twenty feet in thickness, intercalated between the lower limestone and the shale; and at Cole's Mill, one mile below, we find the same sandstone and a bed of shaly limestone, twenty to thirty feet thick, also intervening between the green shale and the lower limestone. It would probably be quite impossible to find two exposures of this group, at points a few miles apart, that would give exactly the same succession of strata.

The calcareous members of the group may be usually described as rather coarsely granulated gray limestone, sometimes argillaceous and ferruginous, and filled with the remains of Radiata and Mollusca, and more rarely containing the teeth and spines of fishes. The terms *Pentremital limestones* and *Archimedes limestones* have been applied by different authors to the calcareous beds of this group, in consequence of the great abundance of fossils belonging to these two genera found in them; but as these names were found to be equally applicable to other divisions of the lower Carboniferous series, the interests of science require that they should be discarded, and some other and less objectionable name substituted for the group.

---

* Transactions of the St. Louis Academy of Science, vol. 1, p. 614.

† See Report on Randolph County.

At some localities these limestones are quite evenly bedded, and constitute an excellent building material, and at others they become nodular and argillaceous, and will not stand exposure to atmospheric influences. The sandstones belonging to the group are finely but distinctly quartzose, and are filled with brown specks of oxyd of iron. They are usually quite evenly bedded, and form an excellent building stone and flagging material, where the layers are of suitable thickness.

The sandstones and shales of the middle and upper divisions of this group have afforded a few species of fossil plants belonging to the genera *Lepidodendron, Sigillaria, Knorrhia, Stigmaria* and *Megaphytum.* Casts of a few fossil shells, apparently belonging to the same species that are found in the associated limestone, were observed in the second sandstone at Chester.

Fossils are very abundant in some of the calcareous beds of this group, and the upper layers of the lower limestone, in some localities, seem to be composed mostly of plates of *Agassizocrinus* and other Crinoidea; nevertheless it is quite rare to find an individual specimen so well preserved as to enable the paleontologist to determine its specific character. The remains of fishes are quite abundant in the upper layers of the lower limestone, and in the calcareous plates that are intercalated in the green and blue shales. Sixteen species of this division of the Vertebrata are described and figured in the second volume of the original Report, from this horizon.

The most common forms of Crinoidea peculiar to this group are the following: *Pentremites godoni, P. sulcatus, P. pyriformis, P. cervinus, P. robustus* and *P. obesus; Zeacrinus maniformus* and *Z. Wortheni; Agassizocrinus conicus, A. constrictus* and *A. Gibbosus. Zaphrentis spinulosa* is also an abundant fossil in the shales above the limestone, where it is associated with several species of that peculiar form of Bryozoa to which the generic name of *Lyropora* has been given, and with it the *Archimedes Swallovana.*

The characteristic Brachiopoda of the Chester group are the following: *Spirifer bisulcatus,* Sowerby,* (*Spirifer incrassatus,* Hall), *S. Leidyi, S. lineatus,** Martin, (*S. setigerus,* Hall), *S. transversalis, S. contractus; Spiriferina octoplicata,** Sowerby, (*Spirifer spinosus,* N. and P.), *Athyris ambigua,** Sowerby, (*A. subquadrata,* Hall), *Athyris Royissii,** l'Eveille, (*A. sublamellosa,* Hall), *Productus elegans, P. parvus,*

* Authentic specimens of these species, from this State, were submitted to Mr. Thomas Davidson, of London, England, who pronounced them identical with the well known European species above named.

Retzia vera and *Rhynchonella explanata*. *Pinna Missouriensis* of Swallow (perhaps *P. flabelliformis* of Sowerby), is a common shell in the upper division of this group at Chester, and on Gravel creek, about four or five miles north of Chester, and is usually associated with *Allorisma clavata*, *Myalina angulata* and *Schizodus Chesterensis*.

But perhaps the most remarkable fossils which this group affords are the large Cephalopoda, from the upper limestone in the vicinity of Chester. The *Nautilus spectabilis* is by far the largest known nautiloid shell hitherto discovered in the lower Carboniferous limestones of America. Only two or three nearly perfect individuals have yet been seen, though fragments are of frequent occurrence. The first one found was on Gravel creek, and was said to be nearly two feet in diameter, but was broken into fragments by the quarryman who found it, *to see what was inside of it*. The second one was found by Mr. James M. Christian, of Chester, and is now in the State Cabinet. This specimen, which is nearly complete, measures twenty inches in diameter, and is four feet eight inches in circumference around the dorsum. It was obtained from the upper limestone, about half a mile east of the city of Chester. The *Orthoceras nobile*, from the same limestone, of which only a part of a single individual has been seen, must have been at least five or six feet in length and a foot or more in diameter at the larger extremity. The specimen found is a part of the septate portion of the shell, eighteen inches in length, and nearly nine inches in diameter at one end and seven inches at the other. It was presented to the State Cabinet by Mr. Alexander Dunn, of Chester. A half dozen species, or more, of chambered shells of smaller size have been found in Randolph county, from the upper limestone of this group, some of which are described in the second volume of the original Report. These chambered shells appear to have been more abundant, and to have attained a greater size, during the period in which these limestones were accumulating, than at any other of the lower Carboniferous era.

The fauna of this group, taken as a whole, is quite unlike that of any other sub-division of the Carboniferous system. There are not more than a half dozen species from the lower limestones that are known to extend up into this group, and only three or four that are known to extend from this into the Coal Measures. The fossil flora that abounds in the sandstones and shales of this division would seem to ally it more nearly to the Coal Measures, but the marine fauna of the calcareous divisions are of a decidedly lower Carboniferous character. Dr. D. D. Owen, in his Report on the

Geology of Kentucky, included these limestones in what he called the Millstone-grit series, which also included the conglomerate at the base of the Coal Measures; but as we have, for reasons already stated elsewhere, included the conglomerate with the Coal Measures, it seems proper to group these limestones, and the sandstones and shales associated with them, into a distinct division of the lower Carboniferous series.

The topographical features to which this group gives origin are those of a broken and hilly region, everywhere heavily timbered, the surface presenting sharp ridges, extending in the direction of the general drainage of the country, and separated by deep, narrow valleys. It forms, by decomposition, an excellent soil wherever the surface is sufficiently level to be easily cultivated, producing good crops of tobacco, wheat, barley, corn, and all the varieties of fruits adapted to the climate. Many of the finest peach orchards in Southern Illinois are located on soils derived from this group of rocks. The soil is mainly a buff or brown colored clay loam, and is far more productive than its appearance would indicate to the casual observer. Even the yellow clay sub-soil, thrown out from a depth of several feet below the surface, if left exposed for a few months to the influence of the atmosphere, becomes a good soil, and is productive in all the cereals adapted to the climate.

The lower sandstone of the Chester group, which is usually the most important of the arenaceous divisions, varies in thickness, where this group is well developed, from fifty to a hundred feet or more. In the Iowa Report it was described under the name of *Ferruginous Sandstone*, a name adopted, in the Missouri Report, for the conglomerate sandstone underlying the Coal Measures, with which the sandstone now under consideration appears to have been confounded. For reasons already stated, we have rejected the name Ferruginous Sandstone, and adopted that of Lower Sandstone of the Chester Group, for this subdivision.

This sandstone is generally found in thick beds, and sometimes presents a concretionary structure, and is usually composed of finer material than the conglomerate of the Coal Measures, is more homogeneous in texture, and contains no pebbles at any of the localities examined. The rock is usually permeated by the brown oxide of iron, which, when evenly disseminated, gives to the rock a soft brown color, but is sometimes disseminated through it in specks, giving it a mottled appearance. Sometimes it becomes thin-bedded, and affords good flagging stones. Where the ferruginous matter is evenly distributed through the mass, it forms one of the best freestones in the State, and becomes a very valuable material for building purposes. It is generally sufficiently massive to afford blocks of any desirable size, and is easily cut, and hardens slightly on exposure to the atmosphere. This rock has been extensively quarried in St. Clair county, and transported to St. Louis, where it has been used in the construction of one of the finest churches in the city. No fossils have yet been found in this sandstone. It thins out and disappears in Madison and Jersey counties, with the attenuated outliers of the lower limestone of the Chester group. Towards its base, at many localities, it becomes highly ferruginous, and affords bands of tolerably good iron ore.

ST. LOUIS GROUP.

Under this head we include the evenly bedded limestones of Alton and St. Louis, the concretionary and brecciated limestones of the former locality, and points farther north, the oolitic limestone which outcrops at the river's edge, three miles above Alton, and the equivalent beds at Bloomington and Spergen Hill, Indiana, and the blue calcareo-argillaceous shales and magnesian and arenaceous limestones at Warsaw, in Hancock county. These last named beds are characterized by a somewhat peculiar group of fossils, and have usually been regarded as forming a distinct division of the Mountain Limestone series, but on a careful examination of the beds at many localities, we are satisfied that such a division is entirely arbitrary, and not justified by paleontological evidence. Many of the species of fossil shells that occur in the beds above named, are also found in the upper division of this limestone at other localities, and the changes that occur in the fossil contents of the rock, at the various localities named, may be attributed to the local conditions under which the sediments were accumulated, rather than to any specific change in the character of the fauna of this period.

North of the junction of the Illinois and the Mississippi, where the Chester limestones are wanting, this formation forms the limestone floor on which the Coal Measures were deposited, and hence it becomes important as a well marked and reliable horizon for the guidance of those in search of this useful mineral.

In the vicinity of Alton and St. Louis, which may be considered as typical localities, this formation consists of regularly bedded light gray or bluish-gray limestone, sometimes massive, and again in thin beds suitable for flagstones, and, in their chemical constituents, a nearly pure carbonate of lime. Near the middle of the formation, between Alton and the mouth of the Piasa, we find a bed of concretionary and brecciated limestone from twenty to thirty feet in thickness, below which the limestones are darker colored, sometimes magnesian and oolitic, with bands of blue and yellow shales. The entire bluff, from the mouth of the Piasa to Alton, is composed of this limestone, which cannot be less than 200 to 250 feet thick in this vicinity. North of the Illinois river it thins out rapidly, the remaining portion in that region having a general resemblance to the middle and lower portions of the bed, as it appears in the vicinity of Alton.

In the southern portion of the State a marked change takes place in the lithological characters of the bed, and in Hardin county the upper portion is characterized by beds of light colored, massive, oolitic limestone, while the lower portion becomes thin-bedded and cherty; and in the vicinity of the Illinois Furnace some of the beds are of a brownish-black color, and being fine grained and compact n texture, take a fine polish and form a black marble. Without the aid of fossils, which everywhere characterize this formation, it would be utterly impossible to identify it at these various localities in consequence of the decided changes that take place in its lithological characters. Among the fossils most generally distributed wherever this limestone is found, from Northern Illinois to Alabama, and which can always be relied on for its identification, are two species of fossil corals belonging to the genus *Lithostrotion:* the *L. mamillare* and *L. proliferum*, which appear to abound over nearly the whole area occupied by this limestone.

The *Melonites multipora* and *Poteriocrinus Missouriensis* are also characteristic species of the evenly bedded gray limestones that constitute the upper part of this formation, in the vicinity of Alton and St. Louis, and there are also several species of shells which characterize this horizon, among which are *Productus ovatus, P. tenuicostus* (which is, perhaps, a variety of *P. semireticulatus*), *Athyris ambigua*, and a variety of *Spirifer Keokuk*, described by Swallow, in the Transactions of the St. Louis Academy of Science, under the name of *Spirifer Littoni*.

The fossil corals above named are almost always siliceous in their structure, the calcareous matter that originally formed the coral having been removed and subsequently replaced with silica; and, consequently, they weather out of the calcareous layers in which they were originally embedded, and are found lying in loose masses along the beds of the streams that intersect the limestone, as perfect in their condition as though they had just been detached from the coral reef where they originally grew. The *L. mamillare* is frequently found in masses of considerable size, composed of numerour calyces, having a polygonal structure, giving it some slight resemblance to a honey-comb in which the cells were enlarged to three or four times their natural diameter. North of Piasa creek the whole formation thins out to an average of from fifty to one hundred feet, and its characters are similar to those already described as peculiar to the middle and lower portions of the bed.

At Warsaw, in Hancock county, the upper portion of the bed comprises the concretionary and brecciated limestone, which varies from ten to thirty feet in thickness, and the lower portion is made up of a series of blue clay shales, alternating with bands of impure limestone, which contain great numbers of a remarkable Bryozoan, described and figured in the Iowa Report under the name of *Archimedes Wortheni* and *A. reversa*, the two being only varieties of the same fossil. Below this bed of shales and limestones there is a bed of magnesian limestone which, in that vicinity, averages from ten to twelve feet in thickness, and above the shales a bed of arenaceous limestone seldom more than ten feet thick, and affording, altogether, the following section:

Concretionary and brecciated limestone	30 feet
Arenaceous limestone	10 "
Blue Arg. shales and limestone	30 "
Magnesian limestone	12 "

In the river bluffs, three miles above Alton, these lower beds are represented by thin bedded magnesian and oolitic limestones, the latter containing *Pentremites conoideus* and several species of small fossil shells, identical with those found in a similar position at Bloomington and Spergen Hill, in Indiana, where the oolitic beds containing these fossils immediately overlie certain shaly beds containing geodes like those in the Keokuk limestone. This division of the lower Carboniferous limestone series affords a great amount of excellent building stone for foundation walls and other architectural purposes, and some varieties are susceptible of a fine polish, and may be used for ornamental purposes. The lead mines of Hardin county are in this limestone, the ore occurring in veins associated with calcite and fluor spar.

It affords a large amount of excellent building stone, and is the best limestone for the manufacture of quick-lime that is at present known in this State. Alton has long been noted for the amount and excellent quality of the lime manufactured at that point, and the limestone from which it is made is quarried from the upper beds of this formation. The statistics of the lime trade at Alton will be found in the report on Madison county. Just at the junction of this, with the Keokuk limestone that underlies it, there is a bed of hydraulic limestone in St. Clair, Monroe and Jersey counties, and the same bed may no doubt be found in Madison county, though its outcrop appears to be hidden at the localities examined along the river bluffs, where it should naturally be found.

Where this limestone constitutes the surface rock of the country, it gives origin to numerous *sink-holes* that originally formed the entrances to subterranean caverns; and hence this limestone has sometimes been called *cavernous limestone.* But many of these have been subsequently partially filled with sediment, that has been washed into them by the rain, which has closed the entrance to the caverns below, and formed numerous small ponds upon the surface, as may be seen in the vicinity of St. Louis. At some localities these sink-holes and ponds are so numerous as to seriously affect the value of the land for agricultural purposes. North of the Illinois river, where the lower portion of this division only is seen, its cavernous character is not observable, and the magnesian and arenaceous divisions, by their decomposition, contribute valuable materials to enrich the soils along the line of outcrop of this lower division of the group.

The remains of Vertebrata are not so numerous in this limestone as in some of the other divisions of the lower Carboniferous series, but a few localities have been discovered in this State where they are tolerably abundant, and nineteen species of *fishes* will be found described in the second volume of the original Report, from this horizon.

The lower division is also characterized by great numbers of Bryozoans, at certain localities, among which the screw-shaped axis known as Archimedes is conspicuous, and it attains a larger size here than anywhere else in the series. Crinoidea and Echinoidea are less numerous, both as species and individual specimens, in this than in the lower limestones. The following thirty species are already known to occur in this group: *Actinocrinus caliculus, A. caroli, A.* (*Batocrinus*) *irregularis, A.* (*Batocrinus*) *icosidactilus, Platycrinus plenus, P. Prattenianus, P. penicillus, P. pumilus, P. Georgii, Pentremites conoideus, P. Koninckana, P. cornutus, P. Grosvenouri, P. Kirkwoodensis; Taxocrinus semieovatus, T. Shumardianus, Zeacrinus intermedius; Scaphiocrinus dactyliformis, S. divaricatus; Dichocrinus constrictus, D. dichotomus, D. ovatus; Poteriocrinus Missouriensis; Graphiocrinus* *dactylus; Cyathocrinus Thomæ; Rhodocrinus Varsouviensis; Archæocidaris Wortheni, A. Shumardianus; Melonites multipora,* and *Schœnaster fimbriatus.* The genus *Actinocrinus* is not at present known above this horizon, and the *A. caroli,* which occurs in Hardin county, near the top of this group, may be regarded as the most modern form of this genus at present known.

Oolitic beds are quite characteristic of this division, and in Hardin county, massive beds of oolitic limestone form the upper portion of it at several localities, one of which is the river bluff just above Roseclare. This rock is very homogeneous in its texture, is susceptible of a fine polish, and makes a very pretty marble. About three miles above Alton there are some oolitic and semi-oolitic beds in the lower part of this group, which are characterized by great numbers of small shells, among which are *Rhynchonella Grosvenori, R. sub-cuneata, R. macra, R. Wortheni, Orthis dubia,* and *Terebratula formosa.* But these small Brachiopods are not entirely restricted to this horizon, but are also found at other localities in the upper division of the group. We hope, hereafter, to be able to give a complete catalogue of all the fossils hitherto described from the different members of the lower Carboniferous limestone series in this State.

KEOKUK GROUP.

Along the western borders of the State, from the north line of Hancock county to the mouth of the Illinois river, this formation may be separated into three divisions: first, the geode bed; second, the regular bedded gray limestones quarried at Keokuk and Nauvoo; and, third, the thin bedded cherty rock that forms the beds of passage from the limestone above named to the Burlington limestone below. The upper division consists of calcareo-argillaceous shales and shaly magnesian limestone, and is about forty feet in thickness. It is filled with siliceous geodes, varying in size from half an inch to a foot and a half, or more, in diameter, many of which are hollow spheres of quartz or chalcedony, with their interior cavity lined with beautiful crystals of quartz, calcite, dolomite, zinc blende, etc., and frequently with two or more of these minerals occupying the same cavity. There is no formation in the State that presents such attractive and interesting specimens of crystallized minerals as are to be found in this division of the Keokuk limestone, and tons of these beautiful geodes have been sent from the county of Hancock to adorn the cabinets of the mineralogists throughout the civilized world. A fine section of the geode bed is exposed just above the steamboat landing at Warsaw, where its whole thickness may be seen in the bluff above the railroad grade; and there is perhaps no locality known in the West where a few hours' labor of a good collector would be rewarded by so large a variety of finely crystallized specimens. At Niota, in the northern part of Hancock county, a few individual geodes have been found containing asphaltum. A small collection of these geodes was sent to Prof. Geo. J. Brush, the accomplished Professor of Mineralogy and Metallurgy in Yale College, with the request that he would note such interesting facts as they might present to the practiced eye of the mineralogist, and he has kindly transmitted the following interesting letter and report, which I am permitted to introduce here:

SHEFFIELD LABORATORY OF YALE COLLEGE,
New Haven, Conn., June 7, 1865.

A. H. Worthen,
State Geologist, Springfield, Ill.:

Sir—Herewith I send you a report on the character of the filling of the geodes from the Keokuk limestone, which you submitted to me for examination last November. You will observe that I have numbered each geode, and given a brief account of its mineralogical characters, with the order of deposition of the different species. To give an idea of the relative size of the geodes examined, I have stated their dimensions roughly, not attempting to give them accurately. To complete my report, it will be necessary for yourself, or some other person conversant with the facts, to make some general statements as to the great variety in the form of the geodes, their variations in size and the mode of their occurrence in the limestone. It is possible that an examination of a large number would add some further facts to the paragenesis of their mineral contents, and would furnish some generalizations which, as yet, are wanting.

You will observe that, in every case I have examined, the outer layer of the geode is siliceous, and is of that form of silica which is called *chalcedony*, although sometimes this outer siliceous rim is extremely thin. The next in the order of super-position is *crystalline quartz*. In every geode which contains crystalline quartz, this rests directly on the chalcedony. In some instances a second layer of chalcedony rests on the quartz crystals (Nos. 11, 14 and 22), and in one instance a second series of quartz crystals rests on the second layer of chalcedony. *Calcite* occurs in great beauty and variety of form, sometimes resting directly on chalcedonic crust, and sometimes resting on the lining of quartz. In no instance, where calcite and quartz occur in the same geode, have I found the quartz resting on calcite*; they all indicate that the calcite is subsequent in formation to the quartz. The calcite crystals are worthy of special crystallographic study.

The occurrence of *pyrites* shows that in some cases its formation was simultaneous with that of calcite, while in other instances it was apparently subsequent to it. The elongated crystals of tarnished pyrites are quite remarkable, and might easily be confounded with rutile; but they show a yellow color and a cross fracture, and a blow-pipe examination reveals their real character.

Blende seems to have been simultaneous in formation with the calcareous layer of the geodes in which it occurs, for in two instances I have observed it embedded in the calcareous layer, without resting on the chalcedonic base.

Gypsum, observed in minute crystals in only two instances, is subsequent in formation to the second layer of chalcedony in the geodes in which it occurs. *Pearl-spar, dolomite,*

---

* A single geode was found at Keokuk, Iowa, and is now in the cabinet of the writer, in which large crystals of calcite are partly covered with smaller crystals of quartz.—A. H. W

or brown-spar, as it might very appropriately be called, occurs in several geodes, and is almost always of subsequent formation to the calcite. In a few instances, however, calcite crystals appear resting on a dolomite base, and this leads me to call attention to the occurrence of calcite of at least two distinct periods of formation, as shown by the form and color of the crystals (Nos. 20 and 21). The dolomite in the geodes seems to be peculiarly liable to decomposition by the oxidation of the iron. An analysis of it shows it to contain a large percentage of carbonate of iron with the carbonates of lime and magnesia.

Aragonite was found but in one instance, and then resting on dolomite. Geode No. 32 contained a considerable amount of a loose white powder, which, on chemical examination, proved to be hydrous silicate of alumina; and it is exceedingly curious that the crystals of calcite, in what must have been the lower part of the cavity, contain, disseminated through them, this same silicate, as, upon solution in acid, they leave behind an insoluble white powder, similar in character to that found loose in the geode. Morever, the crystals differ in form from those lining the upper portion of the cavity.

Geode No. 4 is one of the most interesting of the suite, being almost filled with asphaltum, and having isolated quartz crystals embedded in the asphaltum. For other details I must refer to my report, and I repeat here, what I have already remarked, that the examination of other specimens may develop further generalizations as to the character of the minerals contained in them, and the manner and order in which they have been deposited. I have felt that it was best simply to put on record the facts I have observed, and leave to others more favorably situated to complete the study of these remarkable geodes.

Very respectfully,

Your obedient servant,

GEO. J. BRUSH.

Report on the Mineralogical Character of Geodes from the Keokuk Limestone, by* GEO. J. BRUSH, *Professor of Mineralogy and Metallurgy in Yale College.*

No. 1.—Dimensions of geode, 4½x4x2¼ inches. Crust, ½ to 1 inch thick; exteriorly siliceous and interiorly calcareous. Cavity lined with rhombohedral crystals of calcite 1/16 to ⅛ of an inch in diameter, and on these, filling about one-fourth of the cavity. rests a highly modified rhombohedron of colorless calcite. In one end of the cavity, and embedded in the crust, is a crystal of blende ¼ of an inch across. On the calcite are minute acicular crystals of a hair brown color, which have, on pyrognostic examination, proved to be tarnished pyrites. They are in the form of feathery spiculæ, and very much resemble the variety of rutile known as "*fleches d'amours*." A small amount of pulverulent siliceous substance is also contained in the cavity.

No. 2.—Dimensions, 7x5x4 inches. Crust, ¾ to 1 inch thick, entirely silicious: exteriorly chalcedonic and interiorly crystalline quartz. Cavity lined with quartz crystals, showing only the pyramidal terminations. Implanted on the quartz crystals is a scalenohedral crystal of calcite, with rhombohedral and other modifications. Minute crystals of iron-pyrites occur, inclosed in the calcite and resting on the quartz.

No. 3.—Dimensions, 4x4x2 inches. Crust, on the outer edge, chalcedonic, then calcareous, and about ⅜ of an inch from the exterior occurs a line of pyrites, and inside of this calcareous spar and blende. Dimensions of cavity, 1x1x1½ inches, lined with low hexagonal prisms of calcite, with rhombohedral summits. In one end of the cavity the calcite crystals are implanted on blende, and small cubic crystals of pyrites occur resting on the calcite. They are tarnished to a golden-yellow color.

No. 4. Dimensions, 4x3x3 inches. Crust, not over ½ an inch thick, siliceous and mostly chaledonic; lined with small quartz crystals, and the cavity apparently more than half filled with asphaltum, the latter breaking with a clear conchoidal fracture, having a high lustre and jet black color, and containing, embedded in it, detached crystals of quartz, sometimes ⅛ of an inch in length and half a line in diameter.

No. 5.—Dimensions, 3x2½x2 inches. Crust, siliceous, the exterior chalcedonic and interior crystalline quartz, on which are implanted hexagonal crystals of calcite, with

* Accompanying a letter to A. H. WORTHEN, State Geologist.

rhombohedral summits. The calcite crystals are ½ to 1 inch in length and ¼ to ¾ of an inch in diameter. A single isolated crystal shows both terminations. Minute crystals of pyrites also occur on the quartz.

No. 6.—Dimensions, 3½x3x1¾ inches. Specimen very much resembling No. 1, in general characters, but containing no blende.

No. 7. Dimensions, 3½x3x2 inches. Crust, from ⅛ to ⅜ of an inch thick, lined with small hexagonal crystals of calcite, with occasional points showing minute quartz crysals, and the cavity more than half filled with a single group of hexagonal crystals of calcite.

No. 8.—Dimensions, 4½x3½x2 inches. Crust, ¼ to ¾ of an inch thick, silicious, and interiorly lined with quartz crystals, showing the hexagonal form and pyramidal terminations, and having implanted on them hexagonal crystals of calcite, with rhombohedral terminations. Implanted on the quartz are minute crystals of iron pyrites.

No. 9.—Dimensions, 5½x5½x3½ inches. Crust, ½ to 1 inch thick; character of filling almost identical with No. 8, but containing quartz crystals with double terminations, and elongated crystals of tarnished pyrites.

No. 10.—Dimensions, 4¾x4x2½ inches. Crust, ½ inch thick, and quite uniform. Lined with quartz crystals, and containing a single partially developed crystal of calcite of the same form as in Nos. 8 and 9. The dimensions of this crystal are ½ an inch high and two inches across. Implanted on the quarts are minute crystals of tarnished pyrites.

No. 11.—Dimensions, 4½x4x3 inches. Crust, ½ to 1 inch thick; chalcedonic on the exterior, but consisting chiefly of crystalline quartz, having a bluish-white color and showing pyramidal planes. These crystals are coated with a layer of white chalcedony a line or more thick. Resting on this chalcedony are crystals of quartz, having a smoky tinge. A few of them have a thin scale of chalcedony covering them, and little specks of hydrated oxide of iron are also implanted on some of the crystals.

No. 12.—Dimensions, 4¼x3½x2¼ inches. Crust, ½ inch thick; entirely siliceous, and lined with quartz crystals. These are, for the most part, covered with a thin coating of white chalcedony, and this latter has implanted on it minute crystals of pyrites.

No. 13.—Dimensions, 4x3½x3 inches. Crust, ½ inch thick, and almost identical, in character, with No. 8.

No. 14.—Dimensions, 7x4½x3½ inches. Crust, varying in thickness from ⅛ to 1⅛ inches, and a portion of the exterior covered with calcite and dotted with minute crystals of pyrites and blende. The crust proper is mainly silicious; chalcedonic on the exterior, then crystalline—showing distinct crystallizations of quartz; and then, deposited on and covering these, a layer of bluish-white chalcedony, in some portions a line or more in thickness, but in other portions only sufficient to cover the quartz crystals, their form remaining perfectly distinct. Subsequent to the deposition of the chalcedony is calcite, which occurs in a group of low hexagonal crystals. Resting on the chalcedony in one end of the cavity, and deposited on the calcite, as well as on the chalcedony, are minute cubes of pyrites, sometimes mounted on delicate elongated prisms of the same species. The chalcedony has, also, resting on it minute crystals of pearl spar, and some extremely small and thin crystals of gypsum.

No. 15.—Dimensions, 3¾x3¾x2½ inches. Crust, from ¼ to ¾ of an inch thick. Characters resembling those of No. 1.

No. 16.—Dimensions, 2½x2¾x1½ inches. Crust, ¼ to ¾ of an inch thick. Characters like No. 1.

No. 17.—Dimensions, 3x2¾x2¼ inches. Crust, ¼ to ½ inch thick; exteriorly chalcedonic and interiorly calcareous; lined with translucent hexagonal crystals of calcite, with rhombohedral terminations. Crystals, ⅛ to ½ inch in diameter. Those in a portion of the geode were gray and opaque, from inclosed earthy matter.

No. 18.—Dimensions, 4x3¾x1¾ inches. Crust, ¼ to ⅜ inch thick; exteriorly chalcedonic and interiorly calcareous; lined with light brown rhombohedrons of calcite, and the cavity more than half filled with a solid mass of white calcite, the exposed surface of which is made up of low rhombohedrons, showing minute hexagonal planes. The other portions of the geode contain isolated transparent crystals of the same form, resting upon the small brown crystals which form the lining of the geode. Implanted on both varieties of calcite are minute crystals of pyrites.

No. 19.—Dimensions, 3x3½x1¾ inches. Crust, ¼ to ½ inch thick; exteriorly chalcedonic and interiorly calcareous; lined with brilliant translucent crystals of calcite ⅛ to ¼ of an inch long, and having a scalenohedral form, with rhombohedral terminations. Cavity. more than half filled with a group of calcite crystals, resting on the smaller crystals; and on both varieties of calcite occur minute hair-like crystals of pyrites.

No. 20.—Dimensions, 3¾x3½x2½ inches. Crust, ¼ to ¾ inch thick; exteriorly chalcedonic and interiorly calcareous; lined with yellowish-brown rhombohedrons of calcite, ⅛ to ½ an inch across; and resting on these are isolated crystals and groups of low rhombohedrons of colorless calcite.

No 21.—Dimensions, 2¼x1¾x1½ inches. Crust, ¼ to ½ inch thick; similar in character to No. 20, and also lined with brilliant brown rhombohedrons of calcite; and resting on these are modified rhombohedrons of colorless calcite.

No. 22.—Dimensions, 3½x3x2¾ inches. Crust, ½ an inch thick, silicious; the exterior chalcedonic, then crystalline quartz. On this is a second layer of chalcedony, showing botryoidal prominences, and dotted with spots of yellow oxide of iron, from decomposed pyrites; and the surface of the chalcedony is, for the most part, stained yellow. On the fracture it shows a delicate bluish-white color, with occasional minute black points. Deposited on some portions of the surface of the chalcedony are minute crystals of gypsum,

No. 23.—Dimensions, 3¾x2½x3 inches. Crust, ½ an inch thick; the exterior layer chalcedonic, then calcareous, and lined with yellowish-white scalenohedral crystals of calcite ¼ to ¾ of an inch in length, and the cavity divided into two portions by a group of scalenohedrons extending across it. Implanted on the crystals are minute elongated crystals of tarnished pyrites.

No. 24.—Dimensions, 2½x2x2 inches. Crust, ¼ to ½ inch thick, silicious; the exterior layer chalcedonic, the interior crystalline, and lined with crystals of quartz, tarnished on the surface by a thin film of oxide of iron. Resting on the quartz crystals is a nodule of crystalline calcite and crystals of hydrated oxide of iron, the latter evidently pseudomorphic of pearl spar.

No. 25.—Dimensions, 3½x3¼x2 inches. Crust, ⅛ to ⅜ of an inch thick; the exterior layer chalcedonic, the interior calcareous and lined with white, almost colorless rhombohedrons of calcite. Resting on one side, and probably embedded in the crust, is a large group of blende crystals, 1½ inches across, and filling perhaps one-third of the whole cavity. The blende is coated white, from a superficial conversion into zinc bloom. Resting on the calcite are small groups of rhombohedral crystals, with curved faces; and implanted on these, as well as on the calcite, are minute crystals of tarnished pyrites. Many of the dolomite crystals are stained yellow by oxide of iron.

No. 26.—Dimensions, 2¼x2x1¾ inches. Crust, ⅓ to ⅜ of an inch thick, silicious; exteriorly chalcedonic, interiorly crystalline, and lined with small hexagonal crystals of quartz, with the ordinary pyramidal termination. Resting on the quartz are groups of dolomite crystals having the same characters as those in No. 25.

No. 27.—Dimensions, 3½x2¾x2¼ inches. Crust, ¼ to ⅜ of an inch thick; resembling No. 26, but contains, also, rhombohedral calcite on the quartz, and dolomite resting on the calcite as well as on the quartz.

No. 28.—Dimensions, 3½x3½x2¼ inches. Cavity quite flat, and almost filled with the crystals. The lining is similar to No. 25, containing blende resting on the calcareous crust, calcite crystals with dolomite covering them, and again occasional isolated crystals with dolomite covering them, and again occasional isolated crystals of calcite, apparently resting on the dolomite. Minute crystals of pyrites occur, dotted over the surface of the dolomite and calcite crystals.

No. 29.—Dimensions, 4v3x3 inches. Crust, ½ an inch thick; the exterior layer chalcedonic and the interior calcareous. Lined with light-brown rhombohedral crystals of calcite, on which rest white modified rhombohedrons of the same species, and yellowish-brown crystals of dolomite. Inclosed in the calcite are minute hair-brown crystals of tarnished pyrites, as well as the ordinary form of the same species.

No. 30.—Dimensions, 4¼x3¼x5 inches. Crust, variable in thickness; the outside covered with yellowish-brown limestone, then a faint line of chalcedony, in some portions dolomite resting on calcite, then ferruginous dolomite resting on calcite, while in others calcite rests on dolomite.

No. 31.—Dimensions, 6x4½x4 inches. Crust, ¼ to ½ an inch thick; the outside partially covered with an earthy limestone, under which is a layer of chalcedony, lined with crystalline quartz. Resting on the quartz are dolomite, calcite and minute crystals of pyrites. The dolomite fills more than half of the cavity, and is almost entirely decomposed and converted into hydrated oxide of iron. The crystals are coated with a thin film of rhombohedral carbonate of lime, and implanted on the dolomite are beautiful acicular crystals of aragonite.

No. 32.—Dimensions, 3½x2½x1¾ inches. Crust, ¼ to ⅜ of an inch thick; exteriorly silicious and interiorly calcareous. Lined with crystals of calcite in two distinct forms—in one case, translucent hexagonal prisms, with rhombohedral summits; in the other, white (almost opaque) scalenohedrons. The cavity contains a white powder, which, on examination, proves to be a hydrous silicate of alumina. The white calcite, when treated with acid, gave an insoluble white residue, apparently identical with the powder found loose in the geode.

No. 33.—Dimensions, 3½x2½x2 inches. Crust, chalcedonic exteriorly, and lined with calcite in crystalline botryoidal or warty prominences, rarely in distinct crystals. The calcite has a yellowish-white color, and is stained with oxide of iron.

All the geodes sent to Prof. Brush for examination were of comparatively small size, but they represented all the varieties of crystallized minerals obtained from the *geode bed* up to the time they were sent; and it is hardly probable that a critical examination of the larger individuals would add very much to this interesting report, unless it might be to show some variety in the form of crystallization presented by the larger groups of crystals.

The geodes occur disseminated through the shale and shaly limestone, sometimes so thickly dispersed through it that the individuals press against each other, as they lie embedded in the matrix; and, again, are so sparsely disseminated that several cubic feet of the shale will afford not more than a single specimen. They are most abundant, at Warsaw, in the lower part of the bed, which also affords nearly all the large sized individuals. The general form of those filled with silicious minerals is globular, and many of them are solid spheres of quartz, the interior of which is generally crystalline, with a thin crust of chalcedony coating the exterior surface.

Through the middle of the geode bed there is a band of shale which, at Warsaw, is from eight to ten feet thick, in which nearly all the geodes are lined with calcareous minerals, and these present less regularity of form than those lined with quartz. Many of them are flat discs, nearly or quite solid, but always containing calcite, and frequently fine crystals of blende. Nos. 31 and 32 of the above report were obtained from a layer of shaly, brown magnesian limestone, exposed about four miles east of Warsaw. This limestone appears to occupy about the same horizon with the shales that afford the calcareous geodes at Warsaw, or at least we can assert that it overlies that portion of the bed which affords the silicious geodes in the greatest numbers. In the upper portion of the bed the geodes are also silicious, but much more sparsely disseminated than in the lower part.

The geode No. 4 was found in the vicinity of Niota, in the north part of Hancock county, with several others of similar character, one of which was filled with liquid bitumen. They belong to the lower part of the bed, and are associated with others exclusively siliceous. St. Francisville, in Missouri, is also a fine locality for large siliceous geodes, and many specimens from this locality contain splendid groups of calcite crystals implanted on the crystalline quartz. We have broken several specimens at this locality, the cavity of which was partially filled with clear water, and as they appeared impervious to water from the outside, it seems probable that the water was inclosed in the geode when the crust was formed.* A few individuals have been seen where a thin siliceous crust inclosed a globular mass of chaledonic quartz, covered with drusy quartz crystals. Sometimes this drusy mass is entirely separate from the crust and lies loose in the cavity of the geode, but usually it is attached on one side, at least, to the crust.

It is worthy of note, that although these geodes occur embedded in a matrix composed largely of alumina; indeed, at some localities it is a complete clay shale; yet there is no trace of any crystallized form of alumina known to occur in the geodes, and the only evidence of its presence, in any form, is the silicate of alumina, occurring as a white powder, in a few specimens.

Usually, the *geode bed* is destitute of fossils, but at some localities there are thin bands of limestone intercalated in it, which contain the same species which characterize the Keokuk limestone proper. The geodiferous character also pervades, to some extent, the whole formation, and pockets are frequently met with, in the limestone, lined with crystals of calcite.

The geode bed passes into, and is underlaid by, the gray limestone quarried at Keokuk, Iowa, and at Hamilton, Nauvoo and Niota, Hancock county, in Illinois. It is also found three miles northeast of Quincy, where quarries were opened to furnish material for the foundation walls of Gov. Wood's mansion, near Quincy. The

* The following note, in addition to the report of Prof. Brush, was received too late to be inserted in the proper place:

"Since the above was written, I have received from Mr. Worthen an unbroken geode containing water. A portion of this water, weighing 16.327 grammes, gave, on evaporation, a crystalline residue weighing .094 grammes, which, on analysis, proves to consist of sulphate of lime and sulphate of magnesia, with minute traces of silica. Another sample was examined for carbonic (acid) with a negative result."—G. J. B.

rock differs from the Burlington limestone, which is quarried in the river bluffs at Quincy, in its darker gray color, and in being more free from chert. Some of the beds are nearly of the color of common granite, and all are considerably darker than the Burlington stone. At Nauvoo, the lower beds, which were quarried for the construction of the "Mormon Temple," are lighter than the higher beds, but still are a few shades darker than the quarry rock at Quincy. The limestone beds vary in thickness from six inches to three feet, and are often separated by seams of blue or drab-colored marly clay. It is an excellent building stone, and is extensively used for foundation walls, for lime-burning, and for dressed stone for ornamental buildings. The Mormon Temple, which was entirely constructed of this stone, was the most imposing building ever erected in this part of the State, the outer walls being of cut stone, taken from the quarries at Nauvoo, and its destruction by the ruthless hand of the incendiary was an act of vandalism to be regretted by all.

The rock has, everywhere in Northern Illinois, a crinoidal structure, almost as marked as that of the Burlington limestone, from which it differs in color and in the specific character of its fossils. It has been transported by water to Galena and Dubuque for the construction of the United States Custom Houses at those points.

Mr. Pratten's analysis of a specimen of the Nauvoo limestone gave the following result:

Carbonate of lime	82.48
Alumina and iron	2.10
Insoluble matters	12.50
Water and loss	2.92
	100.00

Fossil shells, corals, encrinites and bryozoans of many beautiful and varied forms are abundant in the *debris* of the old quarries in this limestone; and of vertebrata, it has afforded nearly as many species, and three times the number of individuals, that have been obtained from all the other members of the Carboniferous system. Forty-eight species of fossil fishes have already been determined from this limestone, and will be found described in the second volume of the original Report, nearly all of which have been obtained in Hancock county, and several others yet remain undetermined.

Of Crinoidea, the most common and characteristic species of this formation are: *Agaricocrinus Americanus, A. Wortheni, Actinocrinus Mississippiensis, A. biturbinatus, A. Nashvillæ* and *Platycrinus Saffordi.* Among the most characteristic shells of the Keokuk limestone are the following: *Spirifer striatus, S. Keokuk, S. cuspidatus, S. lineatus, S. neglectus, Hemipronites crenistria, Productus punctatus, P. semireticulatus, Platyceras equilatera* and *P. infundibulum.* Of the Corals and Bryozoans, the most common are *Zaphrentis Dalii,* commonly known among local collectors as *petrified horns,* which are very abundant at some localities, and *Palæacis obtusum.* Of the Bryozoans, the *Archimedes Owenana* and *Semicoscinium Keyserlingi* are the most common. A familiar acquaintance with the specific characters of the above named fossils will enable the practical geologist to identify the Keokuk limestone wherever it may come under his observation, inasmuch as some of them occur in this formation wherever it has been found exposed, from Northern Illinois to Alabama.

The lowest division of this limestone consists of thin layers of light gray limestone, alternating with seams of chert and hornstone, the latter predominating in the lower part of the bed, forming a complete mass of cherty material. This division is usually about forty feet thick in Hancock county, and is well exposed on Hyde's creek, three miles above Warsaw, and from that point to Nauvoo it forms the lower portion of the bluffs, and also extends below the river bed, forming the serious impediment to the navigation of the Mississippi known as the *Lower Rapids.* Fossils are not as abundant in this division as in the one above, but present mainly the same specific forms.

These separate divisions are only observable along the northwestern outcrops of this formatiou, from the north line of Hancock county to the mouth of the Illinois river, and the adjacent region in Iowa and Missouri. Below the mouth of the Illinois the geode bed has not been recognized as a distinct division of the formation, and in its southern extension the cherty character predominates throughout the mass, so that the name of *Siliceous Group,* which it has received in Tennessee and Alabama, is quite appropriate to this formation in that region. It may be readily identified, however, by paleontological evidence, whatever changes may take place in the lithological character of the rock. The thickness of this formation in Hancock county probably does not much exceed 110 to 120 feet, but it increases in thickness towards the south, so that in Jersey county it is about 180 to 200 feet, and in Tennessee its maximum thickness is probably not less than 500 feet.

On the eastern side of the Illinois coal field, near Crawfordsville, in Indiana, this limestone is represented by about 60 to 80 feet of arenaceous and argillaceous beds, the former consisting of brown and buff-colored grit stones, which are underlaid by blue argillaceous shales with thin plates of limestone. The plates of limestone, as well as some portions of the clay shale and grit stones, are filled with the characteristic fossils of this formation, among which are the *Agaricocrinus Americanus, Forbesiocrinus Meekii?* with several other species of crinoidea peculiar to this locality, and these are associated with *Platyceras equilatera, P. infundibulum, Archimedes Owenana Spirifer cuspidatus* and *S. sub-orbicularis*, which clearly establish the true horizon of these shales and sandstones as the stratigraphical equivalents of the Keokuk limestone of Illinois and Iowa.

At Williamsport, on the Wabash, not more than forty or fifty miles northwest of Crawfordsville, the Keokuk limestone is represented by a band of coarse gray limestone, about two feet in thickness, intercalated in a bed of green sandy shale, which, at this locality, lies immediately under the conglomerate of the Coal Measures. The band of limestone is not more than 15 or 20 feet below the conglomerate. These shales pass downward into a shaly sandstone, which, in Northeastern Indiana and Northern Ohio, is known as the *Waverly sandstone.*

It seems evident, from the facts we have observed, that all the lower Carboniferous limestones become arenaceous on the northeastern border of the coal field, and that all the upper members above the Kinderhook group thin out in that direction, and are replaced by the grit stones forming the lowest member of the series; and in Ohio these grit stones occupy the entire horizon from the conglomerate to the "*Black slate.*"

The most southerly exposure of this rock in Illinois is in the vicinity of Elizabeth, in Hardin county, on the Ohio river. The lowest beds exposed here comprise from 60 to 80 feet of thin-bedded cherty-gray limestone, which is overlaid by about 70 feet of massive limestone, in tolerably regular beds, varying in thickness from one to three feet. It forms the center of a low arch along the river bluffs, and is overlaid a short distance above and below by the St. Louis limestone. The full thickness of the formation is not seen here, and therefore cannot be accurately determined; but it is probably not less than 300 feet. In Tennessee, it constitutes the *Siliceous Group* of the Tennessee reports, and probably attains a thickness of from four to five hundred feet, and directly overlies the Black Slate of the Devonian system in that region.

BURLINGTON LIMESTONE.

This formation lies immediately below the Keokuk limestone, from which it is separated by some cherty layers, which form beds of passage from one limestone formation to the other. The upper portion of the mass is the most calcareous, and consists of light-gray and brown crinoidal limestone, composed almost entirely of the remains of crinoids, cemented together by calcareous matter. The cleavage of the rock is generally through the joints and plates of the crinoidea, and this gives to the freshly broken surface a semi-crystalline appearance. The thickness of the mass varies, in different portions of the State, from twenty-five to about two hundred feet.

At Burlington, Iowa, the typical locality where this limestone was first studied, and its peculiar lithological characters determined, the mass is easily separated, either by its fossil contents or lithological characters, into two beds. The upper bed is a light gray or nearly white limestone, with some brown layers inter-stratified, and when free from chert, is a nearly pure carbonate of lime. Its most characteristic fossils are Crinoidea, of which the following are the most common species: *Actinocrinus rotundus, A. Verneuilianus, A. oblatus, A. Christyi, A. pyriformis*, and *Granatocrinus Norwoodi.* In addition to these, the following species of Brachiopoda are almost always present in this bed: *Spirifer plenus, S. Grimesi, Productus semi-reticulatus* var. *Burlingtonensis*, and *Chonetes Illinoiensis.*

The lower bed is usually a brown magnesian limestone, locally arenaceous—sometimes so much so as to become pulverulent, and this renders the rock worthless for building purposes. Chert and hornstone are abundant, both in this and the upper bed, and occur both in seams and nodules. The following species of Crinoidea and Brachiopoda are most abundant in the lower division of this limestone: *Actinocrinus unicornis, A. longirostris, Granatocrinus melo, Spirifer Forbesii, S. imbrex*, and *Strophomena analoga.*

The most northerly outcrop of this rock known in Illinois is at Bald Bluff, near the north line of Henderson county, where there is a partial exposure of from twenty to twenty-five feet of this limestone. The whole mass exposed here is a brown arenaceous limestone, thin-bedded and full of cherty nodules. Like all the other divisions of the lower Carboniferous series, it thins out to the northward, and this exposure probably exhibits the full thickness of the bed at this locality. North of this it probably will not be found, unless it may be in thin outliers, beneath the Coal Measures. From

Bald Bluff south it forms the main portion of the river bluffs to near the south line of the county, where it dips below the surface. It also outcrops on Henderson river and Honey creek, in this county, where it presents the same general characters as at the typical locality, and is extensively quarried at various points for building stone and for lime burning, for which it is well adapted. It is also well exposed on Cedar creek, in Warren county, forming the bluffs of that stream from a point about four miles northeast of Monmouth, where it is directly overlaid by the Coal Measures, to the Mississippi bluffs.

Everywhere along its northern line of outcrop this limestone is exceedingly rich in fossils, and especially so in Crinoidea; and it has afforded a greater number, both of species and individuals, than all the other palæozoic rocks of this continent combined. No spot of the same geographical extent has yet been discovered, on the surface of the earth, where these beautiful "*lily stars*" flourished in such numbers as along the northern shores of the lower Carboniferous ocean, during the deposit of this limestone; and nowhere else have their remains been found in such profusion, or in such a perfect state of preservation, as in this rock. Burlington, Iowa, and the adjacent region in Illinois, where this limestone is exposed, has become classic ground among all lovers of geological science throughout the civilized world. More than three hundred species have already been described from this region, and many new ones are still being discovered, from time to time, and yet probably not one individual in every hundred that lived during this period has been preserved in such a condition that their specific characters can now be determined.

The next appearance of this limestone in the river bluffs is in Adams county, a few miles north of Quincy, and from this point it forms the main portion of the bluff to the south line of the county. At Quincy the limestones quarried in the river bluffs are the equivalents of the upper beds at Burlington, and present similar lithological characters, and contain the same species of fossils. It is a light gray crinoidal limestone with some buff-colored layers, the beds varying in thickness from four inches to two feet, with considerable chert and hornstone in nodules and layers. Some of the white beds are a nearly pure carbonate of lime, and are quarried extensively both for building stones and lime burning. The lower beds are more calcareous in this county than they are in the vicinity of Burlington, and contain comparatively few fossils. On Mill creek, six miles below Quincy, the lower beds are well exposed, presenting a thickness of about forty feet, the lower twenty-five of which consist of alternate beds of gray and brown limestones, somewhat magnesian in their composition, and forming an excellent building stone. The massive character and firm texture of the rock at this locality renders it admirably adapted to the purposes of heavy masonry, where dimension stone of considerable size and of great firmness are required. Some portions of the mass here are susceptible of a fine polish, and might be used as an ornamental stone.

Through the counties of Pike and Calhoun this limestone forms the upper portion of the river bluffs, as far south as Hamburg, below which point it is replaced by the Devonian and Silurian groups down to the lower end of the *Cape au Gris* bluff, where it again appears by the dislocation and downthrow of the strata. Just below this bluff, the Burlington limestone appears, tilted up to a nearly vertical position, but the exposure is scarcely more than a hundred yards in length, when it disappears, dipping beneath the higher beds of the series.

On the eastern side of the Illinois river this rock makes its first appearance in the river bluffs near Glasgow, in Scott county, and from that point down to where the *Cap au Gres* axis crosses the Illinois, five miles above Mason's Landing, in Jersey county, it is found continuously. It also caps the bluffs in the vicinity of Mason's Landing, and Grafton, at the mouth of the Illinois; and at Jersey Landing, about five miles below, it forms the entire bluff, about two hundred feet in height, and probably attains here its maximum thickness in this State. Below this point the easterly dip of the strata carries the bed rapidly below the surface, and in a distance of about three miles it disappears entirely, and is replaced by the overlying formations. Although the rock still preserves its crinoidal character here, and seems to be almost entirely composed of the joints and plates of crinoids, it is rare to find a single specimen so well preserved that its specific character can be determined. Shells are far more abundant, and *Productus semi-reticulatus, Spirifer Grimesi S. striatus, S. plenus,* and *Euomphalus latus* are quite common.

Its next appearance in the river bluffs is in Monroe county, where it forms the upper portion of the bluff at Salt Lick Point, and presents the same lithological characters noticed in Jersey county. On the south side of the axis at this point it dips rapidly below the surface, and is not known to appear again in this county. Its last outcrop in Southern Illinois is at Walker's Hill, in Jackson county, where it appears overlying the Devonian strata at the lower end of

—6

the hill, with a hidden slope of considerable thickness between them. The rock is here a massive, brown, impure limestone, the lowest bed exposed being a compact redish-gray crystalline limestone, the upper beds being of a yellowish-brown color, closely resembling some of the brown layers in the lower bed at the typical locality. It dips rapidly to the northeast, and is soon lost beneath the overlying limestones which form the middle and upper end of the hill. Below this point it has not yet been recognized in this State; and although the horizon at which it should appear is exposed in Union and Hardin counties, it has not yet been identified in that region, and its true place in the sequence of the strata appears to be occupied by the Keokuk division of the lower Carboniferous series. We have also examined some points in Tennessee, Kentucky and Southern Indiana, where the proper horizon of this limestone was exposed, but found nothing that could properly be referred to it, and it probably thins out in a southerly direction before reaching the Ohio river. At White's Creek Springs in Tennessee, where the junction of the lower Carboniferous limestone with the black slate of the Devonian series is plainly seen, the silicious shales which rest directly upon the black slate are evidently of the same age with the Keokuk limestone, and show the entire absence in that region of both the Burlington limestone and the Kinderhook group.

This limestone formation is a very important one, both for the amount of excellent building stone which it affords, as well as an inexhaustible supply of limestone suitable for the manufacture of quicklime, and in these respects its value is not excelled by any member of the lower Carboniferous limestone series of equal thickness. It also gives origin to a great number of excellent and never-failing springs of fine limestone water, which percolate through the fissures and caverns in the strata, and find their outlet along the river bluffs, especially along the line of junction between the limestone and the shales of the Kinderhook group which underlie it.

But it is to the naturalist who is searching into the hidden mysteries of a bygone creation that this formation is of peculiar interest. Its limestone strata are made up of the remains of the millions of extinct organic beings that lived and flourished during its formation, and hundreds of species, the representatives of an extinct creation, may be disentombed from their limestone sepulchres, where they have been inclosed for untold ages, in a condition so perfect that their form and structure may be as accurately determined by the skillful paleontologist, as though they had perished but yesterday. It thus presents for our investigation one of the most interesting and important links in the grand chain of organic creation, which, if we commence with the present existing races, and with man, as the highest type of all, goes simultaneously backward in the scale of time, and downward in the scale of organic development, until it finally ends in the metamorphic strata of the Laurentian series, with, so far as known, a single species, and that belonging to the lowest known type of animal life.

Mr. Pratten's analyses of two specimens of this limestone, from Quincy, gave the following results:

1.—*White Limestone.*

Carbonate of lime	94.68
Carbonate of magnesia	4.31
Alumina and iron	0.20
Insoluble matters	0.05
Water and loss	0.76
	100.00

This it will be seen is a nearly pure carbonate of lime, and is an excellent material for the manufacture of quicklime.

2.—*Brown Limestone.*

Carbonate of lime	71.00
Carbonate of magnesia	24.00
Iron and alumina	4.00
Insoluble matters	1.00
	100.00

This specimen approaches nearer to a hydraulic limestone, but has lime in excess, and is too deficient in alumina and iron to constitute a good hydraulic rock.

The Burlington limestone has not yet been recognized beyond the States of Iowa, Illinois and Missouri; and on the eastern and southern borders of the Illinois coal field, no calcareous beds have yet been found occupying the horizon to which this limestone properly belongs. Its decomposition upon the surface forms a reddish brown marl, that constitutes a soil of unsurpassed fertility, admirably adapted to the growth of every variety of fruit suited to the climate.

KINDERHOOK GROUP.

This name was proposed by Mr. Meek and the writer, in a paper communicated to the American Journal of Science, and published in Vol. XXXII, No. 95, for Sept., 1861, and was designed to include all the beds from the base of the Burlington limestone to the top of the *Black Slate*. These beds comprise a thickness varying, in different localities, from one to two hundred feet, and consist of grit stones, sandy and argillaceous shales, with thin beds of fine grained and oolitic limestones, and constitute what we regard as the lowest division of the lower Carboniferous series.

This group includes the Choteau limestone, the Lithographic limestone, and the Vermicular sandstone and shales of the Missouri Report, the so-called Chemung rocks of the Iowa report, that part of the Waverly sandstone of Ohio which overlies the Black slate of that region, and the Goniatite limestone of Rockford, Indiana. The reference of these beds to the horizon of the Chemung group, of New York, was made purely on lithological grounds, none of those advocating their synchronism contending that any of the fossils found in these beds could be specially identified beyond doubt, as common to the two formations, but on the contrary they all admitted their general dissimilarity in specific characters, and the strongly marked carboniferous aspect of those obtained from this group at western localities.

All the early Western geologists, including Dr. D. D. Owen, Dr. Norwood, and Mr Pratten, regarded these beds as lower Carboniferous, and Mr. Verneuil, who examined a collection of fossils from this horizon, while exploring the geological formations of the Mississippi valley, during his visit some years since to the United States, expressed unhesitatingly the same opinion; and until the examination of these beds by Prof. Hall, on his first visit to the West, their lower Carboniferous age had scarcely been called in question. As already remarked, the supposed equivalency of these beds with the upper Devonian or Chemung beds of New York, was placed entirely on stratigraphical and lithological grounds, while not a single species of fossil remains was positively identified as common to the New York and Western localities.

The Goniatite limestone of Rockford, Indiana, consists of a thin bed of limestone overlaid by two or three feet of calcareo-argillaceous shales resting upon the Black slate, and underlying the heavy beds of grit stones and shale which are well exposed a few miles to the westward of that locality. This Goniatite bed, with the underlying Black slate, was referred by Prof. Hall, about December, 1860, in the 13th No. of the New York Regent's Report, to the horizon of the Marcellus shale, at the base of the Hamilton group (a still lower member of the Devonian series) mainly from the fact of its containing Goniatites in considerable numbers. Upon the publication of our paper, however, of September, 1861, showing that it could not be of the age of the Hamilton group, as it holds a position above the Black slate, which latter rests upon the Hamilton group in Illinois, Prof. HALL issued a supplementary note to the 15th Regent's report, referring this bed to the horizon of the Chemung, as he had equivalent strata in Iowa. Two species of the Goniatite found at this locality were pronounced by Mr. VERNEUIL as identical with well known European carboniferous species, while the fossils associated with them were more closely allied to carboniferous than to any known Devonian forms. With these facts before us, we could not hesitate to consider this Goniatite bed and its equivalent, the Choteau limestone of Missouri, as distinct from any recognized member of the Devonian series, and the whole group as being of lower Carboniferous, instead of Devonian age.

A good detailed section of the several members of this group may be seen in the vicinity of Burlington, Iowa, where the following section in the descending order from the base of the Burlington limestone is seen:

Oolitic limestone	3 to 5 feet	
Gritstone	4 to 6 "	
Compact thin bedded limestone	8 to 10 "	
Oolitic limestone	0 to 0 "	6 in.
Gritstones and shales	25 to 30 "	

The shales at the base of this section extend below the level of the river, and are said to have been penetrated in a boring at Oquawka junction, in Henderson county, Illinois, to the depth of more than a hundred feet, making the entire thickness of the group in this region not less than one hundred and fifty feet. These beds outcrop for some distance along the bluffs in Henderson county, but are more or less hidden by the *talus* of the sloping hills. They rapidly disintegrate on exposure to the atmosphere, and are therefore of little value for building purposes. The oolitic bed has been extensively used in the city of Burlington as a curbing stone for the construction of sidewalks, but it invariably splits into thin plates when exposed to the action of frost and water, and has to be sooner or later replaced by some more durable material.

At Kinderhook, in Pike county, where this group was first examined in the prosecution of the Geological Survey of Illinois, the oolitic bands are wanting, and the upper member of the group is a fine-grained limestone, from five to ten feet thick, underlaid by shales and grit stones from sixty to eighty feet in thickness, extending below the level of the Mississippi bottoms.

In the vicinity of Hamburg, in Calhoun county, the lower part of the river bluff is formed by this group, affording the following section:

Green arenaceous and argillaceous shales	60 to 70 feet
Shelly oolitic limestone	8 to 10 "
Compact fine-grained limestone	15 to 20 "

At Grafton, in Jersey county, this group is represented by fifty feet or more of ashen-gray impure limestones, sometimes magnesian, in part, with marly partings between the beds. Five miles below Grafton these beds measure eighty-five feet in thickness, and at the base of the limestones are shelly and argillaceous. The beds in this and some of the adjoining counties contain nodules of crystallized carbonate of lime, with a more or less siliceous crust, resembling geodes in their external appearance, but contain no cavity within. A few fossils were obtained from these beds in Jersey county, but they are not abundant. Among them we identify *Productus semi-reticulatus*, *Spirifer Grimesi*, *S. Vernonense*, *Athyris Prouti*, and an undetermined Gomphoceras and a Goniatite.

At Salt Lick Point, in Monroe county, this group is again seen in the river bluffs, affording the following section:

Ash-colored shaly limestone	20 feet
Brick-red and variegated shales	24 "
Slope, with outcrops of argillaceous shale	84 "

No fossils were found in the lower part of the above section, but the upper divisions afforded *Actinocrinus pistilliformis*, *Spirifer Grimesi*, *S. Vernonense*, *Athyris Hannibalensis*, *Productus semi-reticulatus* and *Palæacis enorme*.

In Union county we find this group represented, about two miles west of Jonesboro, by a hundred feet or more in thickness of variegated shales. These shales are siliceous, and contain nodules and seams of chert in considerable quantities. These beds also appear in Hardin county, two miles north of Martha Furnace, presenting similar characters; and at both these localities they rest directly upon the black slate, and are overlaid by the more calcareous divisions of the lower Carboniferous series.

The addition of this group to the Carboniferous system of the West gives to it the same general features which characterize this system in Europe, and which it holds in common with the other great divisions of the Palæozoic series. We have, at the base, a fragmentary series composed of sandstones and shales, the *debris* of pre-existing formations; in the middle, calcareous and highly fossiliferous beds, representing the higher divisions of the lower Carboniferous series; and ending, in the ascending scale, with another fragmentary series comprising the sandstones and shales of the Coal Measures. Prof. DAWSON aptly remarks, in his annual address as President of the Natural History Society of Montreal, in speaking of the Laurentian system of Canada, "that the grand order of succession, in the older member of the Laurentian system of rocks, seems to be the same with that so often represented in other parts of the geological scale. First, a coarse fragmentary series, represented by conglomerate and gneiss; next, a calcareous division represented by the eozoon limestones; next, a finer earthy series, represented by dioritic rocks. This brings the Laurentian into a cycle somewhat similar to that of Potsdam sandstone, the Chazy and Trenton limestones and the Utica slate, and the Hudson river, in the lower Silurian; or to that of the Medina sandstone, the Niagara limestone and lower Helderberg, in the upper Silurian; or to that of the lower Carboniferous conglomerates and sandstones, the Carboniferous limestones, and the Coal Measures of the Carboniferous period." "This recurrence of cycles," continues Prof. D., "of deposit cannot be accidental. It is more or less to be seen throughout the geological scale and in all countries; and, as I have elsewhere pointed out, it includes numerous subordinate cycles within the same formation, as in the Coal Measures. EATON, HUNT and DANA have called attention to it, but it deserves a more careful study as a means of settling the sequence of oscillations of land and water in connection with the succession of life. It will also be important in giving fixity to our geological classifications, and may eventually aid in establishing more precise views of the dynamics of geology and the lapse of geological time. The progress of the earth has, like most other kinds of progress, been not by a continuous evolution, but by a series of cycles, of great summers and winters, or days and nights of physical and vital change, in each of which all things seem to revolve back to the place of beginning, only to begin a new cycle, or a new turn of the spiral, similar to the last in its general course, though altogether different in its details, accompaniments and results."

Fossils are quite abundant in this group at some localities, and exceedingly rare at others. In the arenaceous beds they are generally found in the form of casts, the substance of the organism having been dissolved and removed by the leaching of the beds, or the action of the acids with which they are impregnated. In the calcareous beds they are often in a good state of preservation. In the compact bluish-drab limestone, called Lithographic limestone, in the Missouri Report, the fossils are frequently found in pockets in the limestone, which are partly filled with a red marly clay, the residue of the decomposed limestone. The oolitic beds are also highly fossiliferous, and afford many species in a well preserved condition. The Lithographic limestone was so named in Missouri, from its general resemblance to the celebrated German stone used in lithography; but as the name was already appropriated to designate a rock holding an entirely different geological position in Europe, it seems proper to discard it for some other not already in use. It is usually of a light bluish-gray or dove color, weathering to a drab, and is thinly bedded, the layers varying from two to eight inches in thickness. It is intersected by seams or crevices at right angles to the line of stratification, and large slabs are rarely obtained. It appears to be a durable stone for foundation walls, and will probably make a good quicklime, as it affords, on analysis, about 90 per cent. of carbonate of lime, with about 8 per cent. of silica and magnesia. It breaks with a smooth conchoidal fracture, and contains fine crystals of Iceland spar, with small quantities of crystallized zinc blende.

The grit stones of this group are often perforated with small cylindrical holes, like the borings of a Teredo in wood, giving a worm-eaten appearance to the weathered portions of the rock.

These probably resulted from the decomposition of the cylindrical stems of marine plants with which the rock was filled. A fucoides, like the so-called *F. cauda galli* of the Devonian rocks, is quite abundant at some localities in this bed. Some of the beds have the aspect of a hydraulic limestone, but, on analysis, prove to be deficient in lime.

This group has its greatest development along the western borders of the State, in the counties of Henderson, Pike, Calhoun and Jersey, where its general thickness is from one hundred and fifty to two hundred feet. To the north it has not been met with beyond the north line of Henderson county, and it no doubt thins out in that vicinity with the other members of the lower Carboniferous series. In the southern portion of the State it is represented by a single bed of silicious shale, and in the more southerly extension of the lower Carboniferous formation in Tennessee and Alabama it is merged in the Siliceous group of Prof. Safford, which includes all the lower Carboniferous divisions from the St. Louis limestone to the base of the series.

Before closing our remarks on this group, we may say that three species of fossil fish have been described from this horizen: *Helodus* *biformis*, *H. placenta* and *Orodus multicarinatus*, *all of which are of strongly marked carboniferous types. The two first-named species were obtained from the grit stones at Burlington, Iowa, and the last from the Goniatite limestone at Rockford, Indiana.

Crystals of calcite and dolomite are frequently met with, filling pockets in the Burlington and St. Louis limestones, and the former also occurs in fine crystallizations in the calcareous beds of the Kinderhook group.

The curious forms known as *stylolites* are frequently met in the Burlington limestone, sometimes penetrating the strata to the depth of several inches, and always at right angles to the line of bedding. They consist of a series of parallel columns or flutings in the strata, the opposite surfaces fitting into each other along a zigzag line like the sutures of the human skull, which has suggested to Prof. SWALLOW the name *suture joints*. Sir WILLIAM LOGAN, in the Canada Report, suggests that they may have resulted from the crystallization of soda, which crystals were subsequently dissolved, and the moulds filled by the sediment that formed the succeeding layer; but it seems quite as probable that they were formed by the slipping or pressing together of the material, under great pressure, while in a plastic state. Similar markings may be seen in the blue plastic clay under Lake Michigan, through which the tunnel at Chicago is now being constructed. These so-called *stylolites* sometimes occur in the St. Louis limestone, though rarely. In the Burlington limestone they are quite common.

The entire group of lower Carboniferous limestones, with the argillaceous and arenaceous shales and sandstones that are associated with them and form a part of the series, attain a thickness of not less than twelve to fifteen hundred feet on the southwestern borders of the Illinois coal field, where they are fully developed; but they thin out rapidly towards the north, and entirely disappear before reaching Rock Island county, leaving the Coal Measures resting directly upon the Devonian limestone. On the southeastern borders of the coal field we find that the only calcareous division developed in Floyd county, Indiana, is the St. Louis limestone, which is exposed about three miles west of New Providence. It consists of about fifty feet or more of gray limestones and calcareous shales, the upper part being a massive gray limestone, similar to

*Since this was written, 26 new species of fish teeth and spines have been figured and described in Vol. 6 of the original Reports, from this group, and a number more will be described and figured in Vol. 7, now in preparation.

that at Bedford.* These limestones are underlaid by brown shales, containing geodes and nodules of hornstone, which undoubtedly represent the horizon of the geodiferous shales that constitute the upper division of the Keokuk group.

These geodiferous shales are underlaid by the grit stones that constitute what has heretofore been known as the Knob formation of Southern Indiana, and they contain, at this locality, numerous fossils, among which are *Spirifer cuspidatus, Hemipronites crenistria, Productus semi-reticulatus, Orthis Michelini,* and various other forms characteristic of the Keokuk limestone at other localities. These grit stones probably attain a thickness of one hundred and fifty feet or more, and rest directly on the *Black slate* of the Devonian series.

From New Providence northward, along the line of the railroad from New Albany to Lafayette, continued alternations of the St. Louis limestone with these grit stones may be seen, and the road passes successively from the outcrop of one formation to the other, to Crawfordsville, where the Keokuk group is represented by about thirty feet of blue argillaceous shales, overlaid by from thirty to forty feet of thin-bedded brown sandstone, filled with the characteristic fossils of this group.

The next point north of Crawfordsville, where we have been able to examine the beds underlying the conglomerate, is along the line of the Toledo, Wabash and Great Western Railroad, near Williamsport, Indiana. The conglomerate that forms the base of the Coal Measures is from fifty to sixty feet thick at this point, and is underlaid first by about thirty feet of greenish-colored shale and shaly sandstone; second, by a band of coarse-grained greenish-gray limestone, containing *Productus semi-reticulatus, P. punctatus, Hemipronites crenistria,* and *Spirifer lineatus,* with joints of crinoidea in abundance, and presenting the general aspect of the crinoidal beds of the Keokuk limestone. This band of limestone is underlaid by thin-bedded sandstones exactly resembling the Waverly sandstone of northern Ohio, and these constitute the only rocks exposed on this route from the Wabash river to the Devonian slates east of Lafayette. These grit stones are, no doubt, the equivalents of our Kinderhook group, the only division of the lower Carboniferous series that extends into Northern Ohio and Northwestern Indiana, and constitute all of the so-called *Waverly sandstone* above the Black slate of the Devonian series.

* The lower layers of this limestone contain several species of the small fossils that are found so abundant at Spergen Hill, among which are *Orthis dubia* and *Pentremites conoideus.*

Whether or not there is a bed of sandstone in Northern Ohio which may represent the Chemung group of New York, is a question that we leave for the decision of those who are especially interested in working out the geological structure of that State; but so far as relates to the formations that underlie the Illinois coal field, we feel fully justified in the assertion that there are no beds, either in Western Indiana or Illinois, that can, with any degree of propriety, be considered equivalent to the Chemung group of New York, and that those that have been so referred in the geological reports of Missouri, Iowa and Michigan, really belong to the Carboniferous and not to the Devonian system.

CHAPTER IV.

DEVONIAN AND SILURIAN SYSTEMS.

DEVONIAN.

BLACK SLATE.

Immediately underlying the *Kinderhook group*, we find, in Southern Illinois, a series of dark blue, green or chocolate-colored shales, passing locally into a black bituminous shale, to which the above name was applied by the early investigators in Western Geology. It rests directly upon the Hamilton limestone, and is probably the stratigraphical equivalent of the Erie shale of Ohio. It has afforded but a single species of fossil shells, a *Lingula* described in Vol. 3 of the Geological Survey of Illinois, page 437, under the specific name of *Lingula subspatulata*, and illustrated on plate 13, fig. 1, of the same volume.

Its thickness varies, in different localities, from sixty to seventy feet, and where highly bituminous it resembles so closely the black shales of the Coal Measures, that search has been made in it for coal at almost every locality in the State where its outcrop occurs. By referring to the general section, however, it may be seen that it lies more than a thousand feet below the Coal Measures, where the lower Carboniferous limestones are in full force, and must consequently always underlie all the true coal-bearing strata, even where the above named limestones are not developed. It outcrops in Jackson, Union and Hardin counties, and attains its maximum thickness only in the Southern part of the State. Nodules of sulphuret of iron are common in the argillaceous portions of this bed, at some localities.

This formation occupies the horizon of one of the great oil producing zones of Ohio and Pennsylvania, but the bituminous beds are too thin in this State to promise any considerable yield of oil, and it has, so far as we have observed, afforded no oil springs or other surface indications of oil where it outcrops in Illinois. The highly bituminous portions of the bed, however, will no doubt yield a large amount of oil by distillation, and it may also answer for the manufacture of patent roofing, in the place of common roofing slate. No fossils, except the Lingula above-named, have yet been obtained from it in Illinois. In Hardin county, this slate forms the nucleus of an anticlinal axis, and appears to have been partially altered by metamorphic action.

DEVONIAN LIMESTONE.

Immediately below the *Black Slate* we find in Illinois a series of limestones and calcareous shales, varying in thickness from ten to one hundred and twenty feet, that appears, from paleontological evidence, to represent the Hamilton group of New York, though containing some fossils which in that State are characteristic of the Corniferous limestone as well; and it seems quite probable that they are really the Western representatives of both these formations.

In the northern part of the State this group is first met with in Rock Island county, where it outcrops, both on the Mississippi and Rock rivers, from a point about 1½ miles below Hampton, where it first appears on the Mississippi, to the south line of the county; and on Rock river it extends from a point about equally far north to the mouth of that stream. It is here overlaid unconformably by the Coal Measures, both the Black slate and the lower Carboniferous limestone series being absent. Where fully developed, it may be sub-divided into three distinct beds, as is the case in this county. The upper bed is a light-gray limestone, filled with fossil corals, among which are *Acervularia Davidsoni*, *Phillipsastrea Verneuili*, and an *Alveolites*, perhaps *A. Goldfussii* of BILLINGS. Below this limestone there is a bed of brown calcareous shale, filled to repletion with fossil shells at some localities, as in the quarries between Rock Island and Moline, among which the *Orthis Iowensis*, *Strophodonta demissa* and *Spirifer pinnatus* are the most common.

This shale is underlaid in this vicinity by a light bluish-gray or dove-colored limestone, irregularly bedded and concretionary in structure, and quite destitute of fossils, except in the upper layers, near its junction with the shales, where it contains *Phillipsastrea Verneuili*, *Alveolites* and *Atrypa reticularis*. This bed is a nearly pure carbonate of lime, and is extensively quarried in the vicinity of

Rock Island, for the manufacture of quick-lime. Its thickness above the low water level of the river is about twenty-five feet. The outcrop of these limestones in this country is confined to the bluffs and valleys of the streams in the southern part of the county, and on the highlands they are hidden by the overlying Coal Measures and Quaternary deposits.

In addition to the fossils above named, the following are also to be found in the vicinity of Rock Island: *Atrypa aspera, Orthis suborbicularis, O. Vanuxemi, Strophomena lepida, S. fragilis, Productus subalatus, Spirifer subattenuatus, S. inutilis, S. fimbriatus, S. bimesialis, S. aspera, S. Parryanus, Cyrtina umbonata, Cyrtina triquetra, Calymene bufo,* an undetermined *Chonetes,* and several undetermined species of *Cyathophylloid* corals.

South of this county this formation next appears in Calhoun and Jersey counties, where it is only from 8 to 12 feet in thickness. In the vicinity of Grafton, at the mouth of the Illinois, the rock is a brownish-gray limestone, rather thin bedded, and presents the appearance of a hydraulic rock. It contains, at this locality, *Strophomena fragilis* and *Atrypa reticularis,* with joints of *Crinoidea.* In Calhoun county it is a coarse granular-gray limestone, from 8 to 12 feet thick, and forms a good building stone, and may also be used at some localities for manufacturing quicklime. In Monroe county, where the proper horizon of this limestone is exposed, no representative of it has been seen. It appears again, however, in Jackson county, and at the *Bake Oven,* opposite the *Grand Tower,* it is represented by a series of dark-gray fetid limestones, very hard and somewhat siliceous in texture, and from 90 to 100 feet or more in thickness. About the middle of the bed there are some drab-colored shaly layers that are full of fossils, as are also some of the dark colored limestones above. Among the species most common here are *Calymene bufo, Strophomena demissa, Orthis Iowensis, Chonetes pusillus, C. Martini* and *Tropidoleptus carinatus.* The lower portion of the bed is comparatively poor in fossils, but contains a few species, among which are a large *Strophomena, Chonetes Littoni,* a shell resembling *Lucina,* and one or more species of *Gomphoceras.* The beds at this locality have never been quarried for building stone, though the upper portion appears to contain some valuable material for that purpose. The exposure here is restricted to an outcrop of about half a mile along the river bluff, where the beds have been thrown up, and dip to the northeast at an angle of about 25°. The overlying beds are not exposed here, but at Walker's Hill, about half a mile east of the river bluffs, there is a covered slope above the upper beds of this limestone which forms the lower end of the hill, indicating the presence of soft shaly beds, which probably belong to the Black slate and Kinderhook group.

In Union county this limestone is well exposed on the road leading from Jonesboro to Willard's Landing, and about two miles west of the first named point. There are here two beds of limestone, separated by about 20 feet of brown shale, passing locally into shaly limestone, the whole attaining a thickness of 100 to 120 feet. The lower bed of limestone is quite massive, dark colored and emits a fetid odor under a blow of the hammer. It contains considerable siliceous matter disseminated through the rock in cherty nodules, and in nearly all cases the calcareous material that formed the corals and shells that are embedded in it has been removed and replaced with silica. The fossils obtained from this bed were the following: *Strophomena fragilis, S. rhomboidalis,* two or more species of *Platyceras, Calymene bufo,* and several undetermined corals. The shaly limestone forming the middle division contains a small *Aviculopecten* and a crushed shell like a *Rhynchonella.* The upper limestone is lighter colored, contains less cherty matter and is more evenly bedded. Some of the layers are charged with *Tropidoleptus carinatus* and *Strophomena rhomboidalis,* which appear to be the most common fossils it contains. South of Union county we have not met with this formation within the limits of the State. The only material of economical value that it contains is good building stone, and limestone suitable for manufacturing lime. Near Grafton this limestone has the appearance of hydraulic rock, but no experiments have yet been made to determine its probable value as a hydraulic limestone. In this portion of the State it forms the base of the Devonian system, and rests directly upon the Niagara limestone.

ORISKANY SANDSTONE.

This interesting division of the Devonian system was identified in Southern Illinois in the spring of 1858, while making a section across the Silurian and Devonian strata of that region from the *Grand Chain,* in Alexander county, to Jonesboro', in Union county. It appears as a massive quartzose sandstone or siliceous shale, passing locally into an arenaceous limestone, and is sometimes exceedingly hard, resembling quartzite in texture, being partially metamorphosed; and at other localities it is a soft, friable sandstone, which crumbles so easily under a blow of the hammer that a good specimen is difficult to obtain. Its color is usually white, passing into a reddish-brown where the oxide of iron is present in any considerable quantity.

Three and a half miles southwest of Jonesboro', in Union county, where it was first observed, it consists of a massive quartzose sandstone about thirty feet in thickness, underlaid by about ten feet of striped siliceous shales. About two miles west of Jonesboro' the shale is replaced by a band of cherty limestone, which, at another locality, becomes a tolerably pure light gray limestone, from four to six feet in thickness. Fossils are rare in the sandstone, and occur only as casts, and are consequently difficult of determination. Fragments of Trilobites and casts of two or three species of Brachiopoda, with a curious form of Bryozoa resembling *Pleurodictyum problematicum*, are the common forms of this sandstone. Where the beds become calcareous, the fossils are more abundant, and may be obtained in a better condition.

At the *Bake Oven*, in Jackson county, the rocks forming the base of the bluff belong to this division of the Devonian system, and consist of about sixty feet in thickness of sandstone and arenaceous limestone. At the base it is a nearly pure quartzose sandstone, and in the middle of the bed it consists of alternations of sandstone and limestone, and at the top it becomes a nearly white crinoidal limestone. These beds are well exposed at the lower end of the ridge known as the *Back-bone*, and also on the south side of Big Muddy, where they form the hill known as *Bald Bluff*. At these last named localities the beds are more or less calcareous, and contain a variety of fossil shells belonging to the genera Platyceras, Euomphalus, Rhynchonella, etc., which have not yet been specifically determined.

In Alexander county this sandstone caps the river bluffs in the vicinity of Clear creek, overlying the cherty limestones of that region.

North of Jackson county, no representative of this sandstone has been seen, except, perhaps, at a single locality in Calhoun county, just below Gilead, where a single stratum of quartzose sandstone is found, about one foot in thickness, overlying the Niagara limestone. This sandstone, at many localities, is pure enough to be used in the manufacture of glass, when not too much discolored by the presence of oxide of iron. Unless the rock is partly metamorphic, it is too friable to be of any value as a building stone; and when metamorphism has taken place, it is too hard to be quarried with facility. The upper portion of the bed in Jackson county, where it is calcareous, and forms a massive gray limestone, will afford an excellent building stone. The average thickness of this formation in Southern Illinois may be estimated at from forty to sixty feet.

The Oriskany sandstone is supposed to form the base of the Devonian system in New York and Pennsylvania, but in Southern Illinois it is underlaid by a group of siliceous limestones, next to be described, that in their upper beds contain well marked Devonian fossils, and below, those that seem to be characteristic upper Silurian forms; thus forming beds of passage from the upper Silurian to the Devonian systems. This group seems to hold about the same relation to these two systems that the Anticosti group of Canada holds between the upper and lower Silurian of that country. We have, therefore, drawn the dividing line between the Devonian and upper Silurian, in our general section, through this limestone group underlying the Oriskany sandstone.

DEVONIAN AND UPPER SILURIAN.

CLEAR CREEK LIMESTONE.

We use this term to designate a group of strata, that are limited in their outcrop to the counties of Jackson, Union and Alexander, first making their appearance in the bluffs of the Mississippi, at the lower end of the ridge known as the *Devil's Backbone,* in Jackson county, and continuing along the river bluffs to Clear creek, in Union county, where they are fully developed, and where they probably attain their maximum thickness of from two hundred and fifty to three hundred and fifty feet. From the lower axis which crosses the Mississippi at Thebes, in Alexander county, it trends off to the southeast, and soon dips below the superincumbent Devonian beds. Its outcrop is nearly forty miles in extent from north to south, with an average width of from five to ten miles. It occupies exactly the same stratigraphical horizon in Southern Illinois that the Niagara limestone occupies in the northern portion of the State, and as it afforded but few fossils at the principal localities examined, and those in such a condition of preservation as to render their determination somewhat difficult, we were at first inclined to refer the group to the same age as the Niagara limestone; but more complete collections of the fossil forms peculiar to this group having been obtained by Mr. Engelmann, in his detailed examination of the counties of Jackson, Union and Alexander, they were found, upon critical examination by Mr. Meek, to present a mingling of Devonian with some upper Silurian forms, and it became necessary to give to the group a distinctive name.

It may be proper to state here, that the Niagara limestone, as it is traced south from the mouth of the Illinois river, soon disappears with an easterly dip below the surface; and in Monroe county, where it should again appear at *Salt Lick Point*, where the lower Silurian limestones are again elevated to the surface, no trace of it can be seen, and the Trenton limestone is directly overlaid by argillaceous shales, and the calcareous beds of the Kinderhook group.

From this it would appear probable that no beds of undoubted Niagara age were ever deposited in Southern Illinois, but in their place these siliceous limestones, representing in part the age of the Lower Helderberg limestones, and in part the Oriskany sandstone of the New York series, were deposited in its place, resting directly upon the Cincinnati group of the lower Silurian. The upper division of the Cincinnati group, in this portion of the State, is a fine grained, thin-bedded blue limestone, "Cape Girardeau" limestone of the Missouri Report. About two miles above Thebes, in Alexander county, we find the Clear Creek limestone succeeding this in the following order: First, a coarse texture dark bluish-gray limestone, about four feet in thickness, that contains numerous fossils, among which the fine Trilobite, recently described by Mr. Meek and the writer in the Proceedings of the Philadelphia Academy of Sciences, under the name of *Dalmania Danæ*, is quite abundant, associated with a *Strophomena*, that appears to be identical with *S. radiata* of the lower Helderberg limestones, a *Meristella* like *M. bella*, and an undetermined *Heliolites*.

This band of dark-gray limestone appears to be a local deposit, and has not yet been met with at any other locality. It is succeeded by a mottled limestone in regular beds, sometimes of a dark reddish-brown color, but more commonly mottled with red and gray. It occurs in beds from one to three feet in thickness, takes a fine polish, and makes a very handsome variegated marble. A few Orthoceratites were observed in it at one locality about five miles north of Thebes, but it appears to be usually without fossils, and is not separated from the thin-bedded siliceous limestones above by any distinct line, but seems rather to merge gradually into them. The thickness of this mottled limestone varies from ten to twenty-five feet.

Above this comes the great mass of the Clear Creek limestones, with an aggregate thickness of three hundred feet or more, consisting of thin-bedded siliceous limestones of a yellowish-gray color, weathering to a light buff, and forming on the hill-sides a steep *talus* of loose chert. This limestone forms the bluffs of the Mississippi from Thebes, in Alexander county, to the lower end of the "*Backbone,*" in Jackson county, and the belt of country which it underlies east of the river bluffs is very broken and hilly, and of but little value as an agricultural region. Nearly all the farms that have been opened over that portion of this limestone belt, which we have examined, are in the valleys of the small streams. The tops of the ridges are usually covered with timber, but the slopes of the hills are generally naked masses of loose chert.

At the exposure of this limestone, just below Bailey's Landing, in Missouri, we found a variety of fossils in the lower portion of it; but on the Illinois shore we were not able to find any, except in the upper divisions of this formation. The species obtained near Bailey's Landing are *Strophomena rhomboidalis*, *S. radiata*, *Cyrtia Dalmani*, *Leptocelia imbricata*, *Calymena rugosa*, *Dalmania tridentifera*, *Orthis planoconvexa*, and several undetermined species of *Platyceras*. In the upper portion of this limestone, west of Jonesboro', in Union county, we obtained the pygidium of a Trilobite closely allied to, if not identical with, *Dalmania micrurus*, an undetermined species of *Stricklandia*, two or three species of *Spirifer*, apparently of Devonian forms, one of which has a very extended hinge line like *S. pinnatus*, but as these fossils are all casts and in a fragmentary condition, their specific characters are not readily determined. On looking over the collection made by Mr. ENGELMANN from this limestone it seemed necessary to separate it from the Niagara group, and to place it in a higher position in the geological series, ranging from the Niagara limestone to the base of the Oriskany sandstone. Dr. SHUMARD has suggested that these limestones may be the equivalents of the upper Silurian beds that form the cedar glades in Decatur and Perry counties, in Tennessee, but there seems to be no such mingling of characteristic Niagara forms with those of more recent age, in these limestones in Southern Illinois, as characterize the upper Silurian limestones of Tennessee. For a more detailed description of the peculiar features of this group of rocks, the reader is referred to the detailed surveys of Union and Alexander counties.

UPPER SILURIAN.

NIAGARA LIMESTONE.

This important formation occupies a large area of surface in Northern Illinois, and along the northern line of the State west of Rockford it caps the "*Mounds*," which form a marked feature in the topography of that region; and in the northeastern portion of the State it becomes the fundamental rock over a wide extent of surface beyond the northern boundary of the Illinois coal field. In the counties of Cook, Will, DuPage, Kendall and Kane, in the northeast, and in JoDaviess, Stephenson, Carroll, Whiteside, Lee and Rock Island, in the northwestern portion of the State, this formation generally appears as a regularly bedded brown dolomite, with occasional intercalations of beds of massive gray limestone. It forms continuous bluffs on the east bank of the Mississippi, from the north line of Carroll county nearly to Hampton, in Rock Island county, and, except near the lower end of the outcrop in the last named county, it is everywhere a regularly bedded brown or buff dolomitic limestone, sometimes cherty and thin-bedded, and at other localities massive and quite free from siliceous matter.

In the vicinity of Port Byron, where only the upper portion of this limestone is to be seen, it appears as a yellowish-gray concretionary mass of limestone, presenting no regular lines of bedding or stratification, but showing lines of false bedding or cleavage at every conceivable angle to the horizon. It has also a porous or vesicular structure, and some portions of the mass are a true *breccia*. It is much harder than the brown dolomite of this formation, and breaks with an irregular, splintery fracture. Some portions of the mass present an amygdaloidal or vesicular structure, from the solution of the fossils with which it was originally filled. This limestone first makes its appearance in the river bluffs at the lime kilns, about one mile above Port Byron, and continues down the bluffs nearly to the town of Hampton, where it dips below the level of the Mississippi river and is seen no more. The entire thickness of this portion of the bed exposed in this vicinity is about fifty feet. It affords an excellent material for the manufacture of quick lime, and is extensively quarried for this purpose in the vicinity of Port Byron.

In the Report on the Geology of Iowa, published in 1858, Prof. Hall separated the limestones of Leclare, in Iowa, and Port Byron, in Illinois, from the Niagara group, and expressed the opinion that they were the equivalents of the limestones of Galt, in Canada, and in part, also, of the Onondaga salt group of the New York series. He also mistook the lines of false bedding for the true stratification of the rock, and announced the thickness of the beds exposed at this locality as over *six hundred feet*, by actual measurement, and at the same time expressed the opinion that it was probably much more. The regularly bedded buff-colored dolomites which occur at Leclare he considered to be the equivalents of the Onondaga salt group and as overlying the Galt limestone.

While constructing the river section along the east bank of the Mississippi, in the autumn of 1858, we carefully examined the limestones on both sides of the river in this vicinity, and in the course of these examinations we thought there were good reasons for doubting the correctness of the conclusions announced by Prof. Hall, in the Iowa Report. We made a large collection of fossils at these localities, intending to study them carefully after the completion of the field labor for the season, to see what light they might throw on this question; but unfortunately the whole collection was lost, by the burning of the freight depot of the St. Louis, Alton and Chicago Railroad, in Springfield, where they were temporarily stored. Nevertheless, our examinations in the field developed the fact that the limestone at LeClare and Port Byron was a concretionary or amorphous mass, without any true lines of bedding, and that its supposed thickness, as determined by the author of the above named report, was vastly overestimated. We also discovered that the evenly-bedded dolomitic limestone, about thirty feet in thickness, on the Iowa side of the river, which he referred to the age of the Onondaga salt group, and placed above the concretionary limestone, was really intercalated in and formed a part of that limestone. These evenly-bedded layers scarcely appear at all on the Illinois shore, but on the Iowa side they are seen at two localities, and at both are overlaid by the concretionary limestone of which they form a part.

In the summer of 1861 we revisited this locality for the purpose of replacing, as far as possible, the collection of fossils which had been so unfortunately lost; and on comparing the fossils collected at this time with those from a limestone, presenting similar lithological characters at Bridgport, near Chicago, the age of which was generally admitted to be the same as the Niagara limestone of New York, we were unable to resist the conviction that the beds at Leclare and Port Byron were of the same age, and consequently that they represented the upper division of the Niagara limestone, as it appears in the western development of that formation.

These conclusions we announced in a paper dated November, 1861, and published in the American Journal of Science, Vol. XXXIII, p. 46, May, 1862; and subsequently Prof. HALL, in an advanced sheet of the New York Regent's Report, dated December, 1864, published the same conclusions in regard to the age of the concretionary limestone of Leclare, but, perhaps inadvertently, forgot to mention the fact that the announcement had been made nearly three years before in the American Journal of Science. He also reiterates his conclusions, in the last named paper, in regard to the position of the evenly-bedded limestones of Leclare, but brings forward no additional facts in confirmation of their correctness, nor does he attempt to answer the objections urged against them. So far as the geology of Iowa is concerned, the disputed point may be safely left to the able geologist recently appointed to complete the geological survey of that State; but for Illinois we will say just here that there are no beds yet known in the northern portion of the State, of upper Silurian age, overlying the Niagara limestone; but, on the contrary, we find this limestone directly overlaid by the Devonian limestones where they are developed, and, in their absence, by the Coal Measures, which, in some portions of the State, is the next succeeding formation.

At Bridgeport, near Chicago, the rock presents the same general characters as at Port Byoon and Leclare, and is extensively used for the manufacture of lime. West and northwest of Chicago, and just outside the city limits, it is highly charged with petroleum, which oozes from the face of the limestone, filling all the cavities which it contains, and gathers in pools in the bottoms of the old quarries, or covers the surface of the water with which they are partially filled. Notwithstanding the rock is completely saturated with oil, it seems that the conditions are such, owing to its concretionary structure, that it cannot be made available as an oil producing deposit. This bituminous portion of the limestone is from thirty-five to forty feet thick, and at the artesian well was found to be underlaid by about eighty feet of regularly bedded limestone which no doubt includes the *Athens marble* and the *Joliet limestone*, and below this one hundred and twenty feet of what is called by those who kept a record of the well, "arenaceous beds with flint nodules," which probably represents the lower part of the Niagara limestone. This gives a thickness of about two hundred and forty feet to the formation at Chicago, and through Northern Illinois it probably ranges from two hundred to two hundred and fifty feet in thickness.

At Athens this formation affords a beautiful compact gray limestone that takes a fine polish, and is extensively used in Chicago as an ornamental stone for outside walls, and has also found a market in varions portions of the State where an extra-fine quality of rock was required, and it has come to be generally known as the *Athens marble.* At Joliet there is about forty feet in thickness of regularly bedded buff and gray limestones exposed above the level of the canal. The beds vary in thickness from two inches to three feet, and for all the ordinary purposes of building and for flags, these quarries will afford an inexhaustible supply of material of the very best quality. This stone is now shipped to almost every part of the State that is accessible by railroad to this locality, and is more or less used in nearly every city and town in the northern and central portions of the State. It affords a beautiful flagstone, that from its even bedding may be obtained of any required size, and the heavier beds dress easily, are free from chert, and afford a building stone that, for its excellence, cannot be surpassed, and is destined to subserve the architectural requirements of the Northwest as completely as the brown freestone of the Connecticut valley does that of New England and New York. The following is the result of Mr. PRATTEN's analysis of this rock:

Moisture and loss	1.07
Insoluble matter	14.73
Per oxyd of iron	1.77
Carbonate of lime	41.92
Carbonate of magnesia	40.51
	100.00

An analysis of the concretionary rock at Leclare, in Iowa, by Dr. C. F. CHANDLER, as published in the Iowa Report, yielded the following result:

Insoluble silicates or sand	0.42
Oxide of iron and alumina	0.53
Carbonate of lime	57.54
Carbonate of magnesia (by loss)	41.51
Total	100.00

This may be taken as an average of the concretionary limestone at Port Byron and Bridgeport, where it is almost identical in character with the beds at Leclare.

At Sterling, in Whiteside county, and Oswego, in Kendall county, the lower part of this formation is exposed, and its junction with the lower Silurian beds may be clearly seen. At Sterling there is about forty-five feet in thickness of the Niagara limestone exposed, consisting of thin-bedded buff colored dolomite, the layers varying from two to three inches to a foot in thickness. Thin seams of chert are interspersed through the mass. Fossil corals are quite abundant here, and are all siliceous. *Halysites catenulatus, Fovosites Gothlandica, Stromatopora rugosa,* and an undetermined species of *Syringopora,* are the most common. At Oswego, there is from twenty to thirty feet of rock exposed of similar character, and containing the same species of fossils. At both localities these beds rest directly upon the Cincinnati group. At Joliet the quarries afford comparatively few fossils, but *Calymene Blumenbachii, Lituites capax, Orthoceras crebristriatum, O. Sub-baculum, O. Jolietense,* and *O. undulatum,* and a single specimen of *Favosites Gothlandica,* have been obtained there. Along the northern borders of the coal field this limestone passes directly beneath the Coal Measures which overlie it unconformably, but in Rock Island county it passes underneath the Hamilton limestone with a gentle dip to the southwest.

Along the southwestern border of the State this formation comes to the surface again in Pike county, and where it first makes its appearance it is a rough gray heavy-bedded limestone, which rises abruptly from the river bottoms, and with a dip to the N. 20° W. at an angle of 7°, rises in a distance of about one hundred yards to form a cliff from forty to fifty feet in height. Two or three miles below this point this rock is again seen with a reversed dip to the S. 20° E. of about 6°. At this locality the upper ten feet of the bed is a brown dolomite, underlaid by a gray limestone, similar to that mentioned above. The entire thickness of the formation was not seen, and probably the lower beds do not come to the surface in this county. Mr. Pratten's analysis of a specimen of the brown dolomite from Wells' quarry, near the mouth of Six Mile creek, gave the following results:

Water and loss	.31
Carbonate of lime	61.60
Carbonate of magnesia	33.14
Insoluble material	3.35
Iron and alumina	1.60

Through the southern part of Pike and the northern part of Calhoun county this formation is frequently met with, presenting outcrops from ten to sixty feet in thickness, along the river bluffs. It has afforded no well marked or characteristic fossils in these counties, but only some fragments, sufficient, however, to determine, in connection with the lithological characters of the rock, its true horizon.

In Jersey county it is again met with in full force, forming perpendicular cliffs from fifty to more than a hundred feet in height along the bluffs of the Illinois and Mississippi rivers. At Grafton this bed forms a perpendicular cliff, immediately below the town, from eighty to ninety feet above the low water level of the river. Here it is a regular-bedded buff colored dolomite, the strata varying from three inches to three feet in thickness, is even-textured, and may be easily obtained in blocks of any desirable size. These quarries have afforded the material for the old Lindell Hotel, in St. Louis, and for heavy buildings it is fully equal to the Joliet stone. Its entire thickness in this county is about one hundred and fifty feet. It affords some fossils, generally of the same species obtained at Joliet. About a mile below Grafton the dip of the strata carries this limestone below the river bed, and it has not been met with anywhere south of this point presenting similar lithological characters to those which distinguished it in Northern Illinois.

Mr. Pratten's analysis of a specimen of this rock from the Grafton quarries gave the following results:

Insoluble matters	5.60
Carbonate of lime	47.79
Iron and alumina	1.40
Carbonate of magnesia	42.86
Water and loss	2 35
	100.00

At *Salt Lick Point*, in Monroe county, where the proper horizon of this formation is exposed, it is not represented, but we find the lower Silurian strata directly overlaid by shales that appear to belong to the Carboniferous system. At points still further south in this State, the Niagara limestone is replaced by the thin-bedded silicious limestones already described in these pages under the name of Clear Creek limestones.

LOWER SILURIAN.

CINCINNATI GROUP.

This name was proposed by Mr. Meek and the writer in a paper published in the proceedings of the Philadelphia Academy of Science, for August, 1865, to include the upper group of lower Silurian strata, as developed in the West, the sub-divisions of which have hitherto been known under various names, such as Utica Slate, Lorraine Shales, Cape Girardeau Limestone, etc., while the whole was often included under the general name of "Hudson River Group," now known to belong, as developed at the typical localities on the Hudson river, to a very different horizon from our Western rocks under consideration.* It consists, in this State, of argillaceous and sandy shales, brown sandstone and compact blue limestone, the whole of variable thickness, ranging from forty to one hundred and fifty feet.

In the *lead region* of the Northwest it consists of argillaceous, bituminous and sandy shales, with intercalations of thin bands of calcareous shales and limestones. From the soft and yielding nature of the strata, good exposures of the rocks are rarely seen in this portion of the State, and its outcrop is usually covered by a sloping *talus*, extending from the dolomitic limestones of the Niagara group that overlie it to the Galena limestone below. For a detailed description of this group, as it appears in this portion of the State, the reader is referred to the report on the *lead region*, by Prof. WHITNEY, in a subsequent chapter. At Savanna, in Carroll county, the lower part of the bed is more calcareous, and consists of thin-bedded buff and brown limestone, some layers of which are remarkable for their cleavage into regular diamond-shaped blocks. These layers are from two to four inches thick, and contain fragments of Trilobites. The upper portion of the bed at this locality is an ash colored argillaceous shale, with thin plates of limestone thickly covered with fossil shells, among which are *Orthis lynx*, *O. occidentalis*, *O. testudinaria*, *O. bella-rugosa*, *Chætetes petropolitanus*, and fragments of Trilobites.

---

* As it is now acknowledged that the rocks along the Hudson river valley, to which the name "Hudson River Group" had been applied, belong, as long ago maintained by Prof. EMMONS, to a different horizon from the so-called Hudson River Rocks of Western New York and the States further westward, it seems to be an awkward misnomer to continue to apply the name "Hudson River Group" to these western deposits. Hence it is certainly desirable that this group should receive some appropriate and generally applicable name. Its sub-divisions, it is true, had already received various lithological names, such as "Utica Slate," "Frankfort Slate," "Lorraine Shale," etc.; but as each of these names will probably always be directly associated, in the minds of geologists, with the particular sub-division to which it was originally applied, while neither of them is applicable to the lithological characters of the whole series, we cannot, without creating confusion, so extend its signification. It has recently been proposed to designate this as the "*Green and Blue Shales and Limestones*." This, however, is not a name, but a descriptive phrase, and has the disadvantage of being based on lithological characters not everwhere characteristic of these beds. In view of all the facts, we concluded to propose the name "Cincinnati Group" for this series, as this name possesses the advantage of being equally applicable to rocks of any color or composition, while it carries the mind to a well known locality where the formation referred to is extensively developed and its fossils so abundant that they have been thence widely distributed, both in this country and Europe. Consequently geologists will everywhere at once understand to what particular horizon of the lower Silurian this name refers.

At Oswego, in Kendall county, the junction of this group with the overlying Niagara limestone is well exposed, and also from eighteen to twenty feet in thickness of the upper part of this group. The upper six feet of the latter, at this locality, is a regularly bedded gray limestone, in layers from six to twelve inches thick. Below this the rock is an irregularly bedded limestone, with intercalations of green shale extending below the bed of Fox river. It affords the following species of fossils: *Strophomena alternata, Orthis lynx, O. bella-rugosa, Chætetes petropolitanus, Heterocrinus crassus,* two species of *Nautilus* (one of which appears to be identical with *N. Hercules* of BILLINGS), and *Tentaculites Oswegoensis.* The line of demarcation between the upper and lower Silurian strata is well defined at this locality, the upper rock being a brown dolomite, presenting the same general characters which distinguish it everywhere in the Northwest. At Wilmington, in Will county, there is from fifteen to twenty feet of this group exposed in the bluffs of the Kankakee. The lower part is an irregularly bedded argillaceous limestone, which passes upward into green shales, with thin bands of limestone. *Rhynchonella capax* is very abundant here, in addition to most of the species observed at Oswego.

In the southern portion of the State this group presents a very different aspect, lithologically, from that observed at the localities noticed in the northern division. Here it consists of about one hundred feet in thickness of brown sandy shales and sandstone, which form the lower portion of the group, overlaid by about forty feet of thin-bedded compact blue limestone. This limestone was described in the Missouri Report under the name of Cape Girardeau limestone, and was included in the upper Silurian system, while the shales are not mentioned and appear not to have been observed in their explorations in Missouri. The sandstone is mentioned as occurring near Cape Girardeau, and overlying the Trenton limestone. This sandstone is well exposed in the bluffs at the town of Thebes, and has received locally the name of *Thebes sandstone.* It is a regularly bedded brown sandstone, sometimes massive, and affording excellent dimension stone for heavy masonry, as well as some thin beds suitable for flags. It withstands the action of atmospheric agencies, and appears to be in every way reliable as a building stone. It has been quarried at this point and transported to Cairo, for the construction of foundation walls, and is perhaps the most durable sandstone for this kind of work to be found in the southern portion of the State. Neither the sandstone nor the shale above has afforded any fossils, except a single species of *Lingula,* which was found in the upper part of the shale between Thebes and Santa Fé, where it becomes quite argillaceous. Below the sandstone there is a bed of yellowish-brown shale, about five feet thick, containing fragments of Trilobites (mostly *Asaphus canalis*) in abundance. This shale rests directly upon the Trenton limestone.

The blue limestone which forms the upper division of the group, in this portion of the State, is a thin-bedded dark bluish-gray fine grained limestone, with shaly partings between the layers, and breaking usually with a smooth conchoidal fracture, it somewhat resembles, in lithological characters, that portion of the Trenton limestone known in the mining region of the Northwest as the *glass rock.* The beds vary in thickness from two to six inches, and are intersected by numerous vertical joints, so that it is difficult to obtain blocks of this limestone of any considerable size. It is well exposed on Orchard creek, one mile and a half below Thebes, and also at the river's edge, at low water, about one mile and a half above the town. The rock is quite fossiliferous at these localities, and has afforded a number of interesting species, among which are *Glyptocrinus decadactylus, G. fimbriatus, Chætetes petropolitanus, Asaphus canalis, Orthis Missouriensis, Strophomena tenuistriata,* and undetermined species of *Conularia, Cyclonema, Cyrtolites,* with *Tentaculites tenuistriatus* and *T. incurvus.* This limestone is no doubt a durable building stone, but in consequence of the thinness of the beds, and its numerous vertical joints, it can only be obtained in small blocks. Its outcrop in this county is confined, so far as is known, to the two localities above named, and one or two others on Sexton's creek, a short distance east of Thebes. The outcrop of the whole group is restricted to a very limited area in this county, its exposure here being due to the elevation of the axis which forms the *Grand Chain* just below Thebes, and with a reversed dip it passes rapidly below the surface on both sides of the axis, as may be seen by referring to the section of the Mississippi bluffs from Dunleith to Cairo in the first Vol. of the original Reports. It has not yet been found at any other locality in Southern Illinois.

Some of the argillaceous beds of Western and Northern Illinois may afford good potter's clay, while the bituminous shales of the northwest may be made available for the production of oil or illuminating gas. A specimen of this shale, from one mile east of Savanna, in Carroll county, analyzed by Dr. C. F. CHANDLER,* afforded the following result:

---

*See Iowa Report, Part I, Vol. I, page 359.

Moisture		.75
Volatile combustible matter	14.12	
Fixed carbon	6.84	
Total combustible substances		20.96
Incombustible residuum		78.29
		100.00

These materials, together with building stone and flags, are the only products of economical importance which this group will be likely to afford.

TRENTON GROUP.

Under this general head we include the *Galena*, or lead-bearing limestone of the Northwest, together with the *Blue* and *Buff* limestone which underlie the lead bearing limestones, thus including all the calcareus and dolomitic beds from the St. Peters sandstone to the Cincinnati group. In all that portion of the State examined north of the *coal field*, the sub-divisions and general lithological characters of this group of strata are similar to those presented by it in the lead region, where it consists of the following divisions:

Galena or lead bearing limestone	250 to 300 feet
Thin-bedded bluish-gray limestone (glass rock in part)	50 to 75 "
Buff and brown magnesian limestone	20 to 30 "

The *Galena* limestone is by far the most interesting and important mineral-bearing deposit in the State, being the principal repository of the ores of lead and zinc, the former of which has been successfully mined in the vicinity of Galena ever since the first settlement of the country by the French. These mines are said to have been discovered by M. Le Seuer, who made an exploring trip up the Mississippi in the year 1700, but no attempt was made to work the mines until nearly a century later, when Julien Dubuque, a half-breed of French and Indian descent, obtained a grant of land from the Fox Indians, on the west side of the Mississippi, including the present site of the city of Dubuque, and commenced the business of lead mining in 1788, which he prosecuted successfully until his death, in 1810. From that time the business was gradually extended, and in 1823 the tide of emigration began to flow rapidly from Kentucky and some of the eastern States towards this Eldorado of the Northwest, and in the next succeeding decade "*diggings*" had extended over nearly the whole extent of the lead-bearing rocks of this region, including also that portion of the mineral region embraced in the present area of the States of Illinois and Wisconsin.

The village of Galena was laid off in 1827, and *permits* were granted to individuals to occupy and improve lots on condition that they were to be surrendered to the United States Agent upon thirty days' notice. These *permits* were the only titles the citizens had to their lots or improvements up to 1838, when the town was re-surveyed under an act of Congress, and the settlers allowed a pre-emption right to their lots and improvements. The mining region in Illinois is mostly confined to the area included in the county of JoDaviess, though small amounts of lead ore have been raised in the adjoining counties of Carroll and Stephenson. For further details in regard to the lithological characters of the lead-bearing limestones, as well as the mode of occurrence of the metallic ores which they contain, the reader is referred to the report of Prof. J. D. Whitney, in a subsequent chapter. Since his report was written, however, valuable deposits of *galena* have been found below the mouth of the Galena river, in a region south of that represented on the *crevice map*. These mines are known as the *California diggings*, and the lead-bearing crevices were first discovered where they intersect the river bluffs in a general east and west direction.

Although a great amount of labor has been expended in the lead region in prospecting for the ore, there is a large extent of surface still unexplored, and from the crude manner in which these examinations have been conducted, it seems quite probable that some of the richest deposits of ore still remain hidden in the rock. New diggings are still being discovered and opened every year, and when the operations of the explorer are guided to some extent by known facts and laws in regard to the mode of occurrence of the ore, instead of being entirely controlled by the caprice of the miner, as has generally been the case, the results can not fail to be far more satisfactory than they have been heretofore.

The usual method of prospecting for lead ore in this region has been to sink a hole down to the rock at such points as the caprice of the miner might dictate, in search of a crevice, and if none was found at the place first selected, the hole was abandoned and a new one commenced at some other point. Of course no more ground was proved by this kind of exploration than the hole actually covered. Probably not more than one foot in a hundred of the entire surface of the lead region has been proved even in this way, while the remaining portion is still unexplored.

The principal lead-bearing crevices have a general east and west direction, and consequently an adit or level driven into a hillside at right angles to the general course of the lead-bearing crevices, would intersect all the crevices that the hill might contain at a certain level, and would consequently prove a considerable extent of surface. These levels would also serve to drain the mines, and thereby greatly add to the economy with which the mines might be worked. As the productive crevices are for the most part confined to certain levels or "openings" in the Galena limestone, which are generally well known to the practical miners, the adit should be started at about the same horizon or a little below that of the productive "opening" it was intended to strike. This system of proving mining ground by horizontal drifts, instead of perpendicular shafts, was first suggested by Prof. Whitney, in the Iowa Geological Report, and so far as it has been tried the result has been quite satisfactory, and it will, no doubt, eventually supercede entirely the superficial system heretofore practiced in the lead region of the Northwest.

The *galena* of Northern Illinois contains but a very small per cent. of silver, the average product of seven analyses* by Dr. A. Hayes, of Boston, for the Geological Survey of Wisconsin, being only about one ounce and a quarter of silver to the ton of ore. As these assays were made from the ores produced by different mines in this region, the result may be taken as a general average of the amount of silver contained in the lead ores of the northwestern mines in this and the adjoining States.

Although the Galena limestone is found to extend over a considerable portion of Stephenson, Winnebago, Carroll, Ogle and Lee counties, presenting the same lithological features which distinguish it in the vicinity of Galena, it has not been found to contain any valuable deposits of metallic wealth beyond the limits of JoDaviess and adjoining portions of Stephenson and Carroll counties.

At Rockford the Galena limestone is well exposed, forming ridges in the vicinity of the city from fifty to more than a hundred feet in height, above Rock river. At Foster's quarry, and at Corey's Bluff, about a mile below the city, and on opposite sides of the river, the rock has been extensively quarried, the quarries showing a perpendicular face of limestone from twenty to forty feet in thickness. At Benj. Kilbourne's quarries, one mile north of the city, this limestone is exposed from seventy to eighty feet in thickness. The upper portion of the mass is thin-bedded, in layers from one to six inches thick, while towards the bottom the beds are quite massive, and afford strata from three to five feet thick. Fossils are

---

* For the result of the analyses mentioned above, I am indebted to the kindness of Capt. E. H. Beebe, of Galena.

tolerably abundant at the old quarries in this vicinity, especially a large species of *Receptaculites*, or "*Sun-flower coral*." Two or three species of *Pleurotomaria*, among which we recognize *P. lenticularis* and *P. subconica*, and one or more species of *Orthoceratites*, are among the most common forms met with.

At Savanna the Galena limestone, which passes below the river level near the mouth of Apple river, again appears, forming the plateau on which the town is built, and rising to a height of about twenty-five feet above the river level. Some lead ore has been found here in excavations in the upper beds of this limestone. Partial outcrops of this rock are also seen on Plum river, in the northern part of this county.

In Lee and Ogle counties it forms the bluffs of Rock river for some distance, and also underlies a considerable portion of both counties. In the vicinity of Dixon, the exposures of this limestone are from sixty to eighty feet in thickness, above the level of the river, the upper portion of which is generally thin-bedded, with more massive beds below. It forms the main portion of the bluff from Dixon to Sterling. About two miles above Dixon the bluffs are composed of the lower members of the Trenton group, consisting of from sixty to eighty feet of thin-bedded bluish-gray limestone, weathering to a drab color, presenting characters very similar to the *blue* limestone of the lead region, of which it is undoubtedly the equivalent. It abounds in fossils, among which are *Strophomena alternata, S. deltoidea, Asaphis canalis, Illenus ovatus, Leperdita Canadensis? Maclurea* of undetermined species, and *Orthoceratites*. Below these thin beds there are fifteen to twenty feet of massive brown dolomitic, limestone, representing the base of the Trenton series, and resting upon the St. Peters sandstone.

In LaSalle county these beds are frequently overlaid directly by the *Coal Measures*, and they appear to have been subjected to erosion before the deposit of the coal-bearing strata, which greatly reduced the thickness of the group. No locality was observed by me in this county where the Trenton beds attain a thickness of more than forty or fifty feet. At Homer, on the Little Vermilion, there is an exposure of about twenty feet of brown dolomitic limestone, in rather thin beds, with numerous nodules of white chert. These quarries have afforded some fine fossils, among which are, *Gonioceras anceps, Favistella stellata*, a large *Lituites* like *L. undatus*, and two or three undetermined species of *Orthoceratites*. These beds rest directly upon the St. Peters sandstone at this locality. These dolomitic beds lie at the base of the Trenton series of Northern Illinois, and appear to be the equivalent of the first Magnesian limestone of the Missouri Report, and hold apparently about the same stratigraphical position as the Black river limestone of the New York series. It thickens evidently towards the southwest, and is said by Dr. SHUMARD to be one hundred and fifty feet thick in Cape Girardeau county, in Missouri, but we have not seen it in Illinois more than from sixty to eighty feet in thickness.

South of the northern boundary of the coal field, the Trenton limestone appears at four localities on the western borders of the State. In Calhoun county it forms the main part of the bluff from a point four miles below Gilead to *Cap au Gris*, and first appears at the base of the bluff, forming a low bench but little above the level of the river bottoms. It rises rapidly, however, towards the south, and forms a mural bluff, more than a hundred feet in height, about three miles below its first point of outcrop. The upper part consists of a coarse, granular, yellowish-gray limestone, in tolerably regular beds, from six inches to two feet thick. It is rather unevenly textured, from which cause it weathers with a very irregular surface. Below this coarse-grained limestone we find about twenty feet in thickness of fine-grained chocolate colored limestone, in thin beds from two to six inches thick. Below the chocolate colored limestone there is from sixty to eighty feet or more of thin-bedded, compact gray limestone, the lower part of which is thickly charged with fucoids, among which the peculiar species described in the New York Reports under the name of *Phytopsis tubulosum* is conspicuous, and which gives to the polished specimens of the rock that peculiar appearance which has suggested the name of "Birdseye Limestone" for some of the lower beds of this series in New York.

Below these fucoidal beds are a series of buff and brown magnesian limestones, in regular beds from six to eighteen or twenty inches in thickness. This portion of the group has not been accurately measured, but has been estimated approximately at from sixty to seventy feet. These beds afford an excellent building stone, and may be readily quarried, at the *Cap au Gres* bluff, and lowered into lighters or barges lying at the shore, and cheaply transported to any point on the river where material of this kind is required. No fossils have, as yet, been collected from these magnesian beds, and but few from the gray limestones above. *Favistella stellata* and *Illenus ovatus*, together with *Strophomena alternata* and *S. deltoidea*, are the principal forms identified. On the lower side of the *Cap au Gres* axis these beds are thrown entirely below the surface and do not appear again in this county. In Jersey county, where this axis crosses the Illinois, there is about forty feet of the upper part of the Trenton limestone elevated above the surface, presenting a series of thin-bedded bluish-gray limestone strata, with shaly partings, which, with a strong easterly dip, soon pass below the level of the river, and are only to be seen at a single point of outcrop, about five miles above Mason's Landing.

In Monroe county, the Trenton limestone again appears, forming the base of the bluff known as *Salt Lick Point.* It outcrops here in remarkably heavy beds, some of which are from four to seven feet thick, and consist of a coarse-grained even-textured limestone, of a light gray color. It forms the centre of an anticlinal axis here, rising about a hundred feet above the river bottom at the point of greatest elevation, and rapidly disappears with a reversed dip on the south side of the axis. These massive beds afforded the huge blocks of limestone for the columns of the Court House in St. Louis, which were obtained on the Missouri side of the river, at the Sulphur Spring.

The last appearance of the Trenton limestone in Southern Illinois is in Alexander county, where another axis brings this formation above the surface, forming the reef of rocks known as the "Grand Chain," which crosses the Mississippi just below Thebes, and forms, at low water, a difficult and dangerous impediment to the navigation of the river. This limestone is elevated, on the Illinois shore, to the height of about seventy feet. and is composed of massive beds of light-gray semi-crystalline even-textured limestone, some beds of which take a fine polish and form an elegant and durable building material. It has been extensively quarried at Cape Girardeau, on the Missouri shore, for many years, and has obtained considerable celebrity under the name of *Cape Girardeau Marble.* It dresses easily and is an excellent material for columns, caps and sills, and all other uses for which a dressed stone is required. The exposure on the Illinois shore embraces only the upper part of this formation, but it includes all of that portion which affords the finest building material. An analysis of this limestone, by Mr. Pratten, gave the following result:

Moisture	1.07
Insoluble matter	.06
Carbonate of lime	97.08
Alumina, with a trace of iron	.20
Carbonate of magnesia	1.59
	100.00

The Trenton group everywhere affords excellent building stone throughout its whole extent of outcrop. In the vicinity of Dixon and Rockford the Galena limestone is extensively used, both for foundation and outer walls, and some of the most compact beds dress very well and are entirely reliable for outside walls. Some of the layers of blue limestone, two miles north of Dixon, take a fine polish, and make a very handsome appearance as an ornamental stone. Nearly the whole thickness of this formation in Calhoun county, which is not less than three hundred feet, is of economical value for building purposes and the manufacture of lime.

The fossils collected from this formation have not yet been critically examined, and some of the most important localities have not yet been thoroughly explored for the purpose of collecting, and hence we shall not attempt to give an extended catalogue of the characteristic species at this time; but among those collected in Alexander county, we recognize *Strophomena alternata, Orthis testudinaria, O. lynx, Rhynchonella capax, Receptaculites Oweni,* and *Illænus Trentonensis.* These were all obtained from the upper part of the bed, in the white limestone.

ST. PETERS SANDSTONE.

This formation has been recognized at several localities in this State, forming the upper part of what may be considered as the Western equivalent of the Calciferous sandstone series in New York. Its most northern outcrop in this State is on Rock river, in the vicinity of Grand de Tour, where it forms the arch of an anticlinal axis, and outcrops along the river bluffs for several miles, in the vicinity of Oregon City and Grand de Tour. A short distance below the last named point, it dips below the Trenton limestone and is seen no more on Rock river. It also outcrops along the bluffs of the Illinois river, between LaSalle and Ottawa, forming an anticlinal axis with the lower Magnesian limestone as a nucleus. It outcrops over a part of several townships in the central part of LaSalle county, and is sometimes surmounted by from twenty to forty feet of Trenton limestone, and at other localities is directly overlaid by the Coal Measures, as may be observed in the vicinity of Ottawa.

The island-like plateau known as the "*Starved Rock,*" on the south side of the Illinois river, between LaSalle and Ottawa, is formed entirely of this sandstone. It is about one hundred and twenty-five feet above the river level, and the base of the sandstone is still hidden below the river bed. Its entire thickness here is probably not less than one hundred and fifty feet. Its general character at all the localities observed in the northern portion of the State, is that of a white soft incoherent sandstone, composed almost entirely of grains of crystalline quartz, with scarcely any cementing material, and crumbles so easily under a blow of the hammer that it is often very difficult to obtain a hand specimen. There are, however, some beds in the vicinity of Oregon City, which are finer grained and quite coherent in texture, probably from the presence of calcareous matter as a cement, and these afford a very good building stone.

Its great value, however, consists in its adaptation to the manufacture of glass; being composed almost entirely of pure silica, often quite free from coloring matter, it is one of the very best materials yet discovered in the West for this purpose. It is exactly the same sandstone that is known in Missouri under the name of *Saccharoidal* sandstone, and which has been transported to Pittsburgh by the quantity, for the use of the glass manufacturers. In LaSalle county we have this sandstone in inexhaustible quantities, in the near proximity to an adequate supply of coal, and with every desired facility of water and railroad transportation to all the principal markets of the country. No good reason can be assigned why Illinois should not manufacture not only all the glass required for home consumption, but also enough for the supply of the whole Mississippi valley.

On the western border of the State we find this sandstone outcropping in Calhoun county, forming the lower part of what is known as the *Cap au Gres* bluff. It appears here a soft friable brown sandstone, considerably stained with oxide of iron, which renders it less adapted to the economical uses above named than it is at its more northern points of outcrop. It presents here a concretionary structure, with but slight traces of a true stratification. Only the upper part of the bed is exposed here about a hundred feet in thickness. No trace of any organic form, either of animal or vegetable origin, has as yet been found in this sandstone in Illinois. South of this point it has not been met with in Southern Illinois, though its outcrops are numerous on the Missouri side of the river. At Bailey's Landing, Mo., where the "*Bake Oven*" axis strikes the Mississippi, this rock becomes quite metamorphic, and some portion of it is a pure white quartzite. There is also a bed of massive quartzite exposed on the river bank, just above the town of Commerce, in Missouri, which probably belongs to the same formation.

LOWER MAGNESIAN LIMESTONE.

This formation, which is the oldest rock yet discovered in this State, has only been observed at a single locality in LaSalle county, between LaSalle and Utica, where it forms the arch of an anticlinal axis, which crosses the Illinois river at this point. Only a part of the bed appears above the surface, including about a hundred feet in thickness of thin-bedded buff colored dolomitic limestone, in beds which vary in thickness from one inch to a foot or more. Some of the layers are covered with septaria-like markings on the surface, which do not penetrate far into the strata. This formation affords an excellent bed of hydraulic limestone* about eight feet in thickness, which supplies the extensive cement mills of Messrs. Clark & Co., of Utica. The beds quarried for hydraulic cement consist of thin layers of buff and bluish-gray limestone, and belong to the upper part of the formation. The quarries are opened in the valley of the Illinois river, about half a mile from the town, where the overlying beds have been removed by the denuding forces that excavated the valley, leaving the hydraulic limestone near the surface, where it can be readily and cheaply quarried. This is the best hydraulic rock yet found in this State, and the cheapness with which it can be quarried, its proximity to the coal beds that furnish the required fuel, and the facilities for transportation to market, both by canal and railroad, will enable the owners of these quarries to bid defiance to other localities in the manufacture of hydraulic cement. As a building stone, this rock is not equal to the Magnesian limestone of the Trenton and Niagara series, and at Utica the more compact layers of the St. Peters sandstone, some of which harden on exposure to the atmosphere, are preferred. A single species of a spiral univalve shell, probably a *Murchisonia*, is the only fossil we have found in this rock. Some of the hydraulic beds are covered with short cylindrical forms that may be due to fucoids.

---

*Messrs. BLANEY & MARINER's analysis of this hydraulic limestone gave the following results, in per cent.:

Carbonate of lime	43.50
Carbonate of magnesia	30.07
Clay	20.00
Free silica	1.00
Carbonate of iron	2.00
Potash	.18
Water	3.00
	99.75

CHAPTER V.

GEOLOGY OF THE LEAD REGION.

By Prof. J. D. Whitney.

To A. H. Worthen, State Geologist of Illinois:

Sir:—In accordance with your instructions, I herewith submit a "*Report on the Lead Region of Northwestern Illinois.*" Having been employed for a considerable portion of the time since 1865 in examining the lead region of the Upper Mississippi, while engaged in the service of the States of Iowa and Wisconsin, I have had the opportunity of making myself pretty well acquainted with the geology of the adjacent corner of Illinois, and have personally examined many of the most important and interesting points. The small amount of money furnished by you for the purpose of collecting additional information has been mainly devoted to having the lead-bearing crevices surveyed and located, in order that a map of them could be furnished, and to some additional geological explorations in the eastern portion of the lead region of Illinois, so that the different rock formations might be laid down with an approach to accuracy.

I have endeavored to give, in my report herewith furnished you, a concise account of that portion of the lead region which lies within the State of Illinois, and at the same time would refer you, for more detailed information, to my "Report to the Commissioners of the Geological Survey of Wisconsin," just completed, and which will be printed during the coming winter. Accompanying the Wisconsin Report are two maps, one of which is a geological one of the whole lead region of the Upper Mississippi, on a scale of half an inch to the mile; the other, a crevice map of the region between Dubuque, Galena and Shullsburg, on the same scale as the one furnished with this report. I have also, in my report to Wisconsin, gone at some length into the theory of the formation of the lead deposits, the prospects of deep mining, and other points of interest which the limits of this partial report would not permit me to discuss in it. As whatever is published by the State of Wisconsin will undoubtedly be accessible to those in Illinois who are especially interested in lead mining, the present report need only be considered as giving a general idea of the region to those in other parts of the State who have no special motive for making themselves thoroughly acquainted with the whole subject.

The surveys of the crevices were made, under my direction, by Mr. U. G. Scheller, of Galena; and in a portion of the field and office work connected with this report I have had the assistance of Dr. J. P. Kimball.

My thanks are due to several gentlemen residing in the lead region for assistance and advice, given at different times during the past five years, while I have been engaged in investigating the geology of the Upper Mississippi valley. To Messrs. E. H Beebe and Augustus Estey, of Galena, I am under especial obligations for many favors; also, to J. W. Foster, Land Commissioner of the Illinois Central Railroad, for various facilities afforded by the company.

Very respectfully,

Your obedient servant,

J. D. Whitney.

Northamton, Mass., Oct. 1, 1860.

REPORT.

INTRODUCTORY.

The lead bearing district of Illinois, in the northwestern corner of the State, forms a portion of the Upper Mississippi lead region, which occupies an extensive area in the three States of Wisconsin, Illinois and Iowa, where they corner with each other. The whole area over which lead has been raised in sufficient quantity to be worthy of notice, is about 4,000 square miles, of which nearly two-thirds is in the State of Wisconsin, and the other third about equally divided between Illinois and Iowa. The most productive portion of the region, however, is that which lies between Dubuque, Galena and Shullsburg, so that both Iowa and Illinois raise more lead, in proportion to the area over which mining operations have been extended, than Wisconsin does. It is quite impossible to give the exact amount for each State, as the imaginary line which separates Illinois from Wisconsin has no influence in the division of property or the supplies of ore furnished to smelting works. Some of the heaviest deposits of ore in Wisconsin are owned or managed by citizens of Illinois.

The lead bearing district in Illinois is entirely comprised within the limits of JoDaviess and Stephenson counties, and by far the larger portion is in the first named county. Indeed, although ore has been found and mined, to some extent, in Stephenson, and although the proper lead bearing rock covers a large area in that county, as will be noticed further on, yet we are not aware of any digging now in operation outside of JoDaviess county. In fact, a circle of four miles radius, with its center situated a little northeast of Galena, would include nearly all the productive diggins, with the exception of those at Apple river and in the vicinity of Elizabeth; and certainly nine-tenths of the ore raised in Illinois come from the area included within that circle of only eight miles in diameter.

For a long time, a large share, indeed almost the whole of the business of the lead region of the Upper Mississippi was done at Galena; which, before the building of railroads, was the natural outlet of Southwestern Wisconsin. From this point the lead smelted was shipped down the Mississippi river to St. Louis, and there found its way all over the south and west, and for a time, even to the Atlantic States and Europe. The present prosperity and solid standing of Galena among western cities, are chiefly due to the fortunes accumulated during the palmy days of the lead business, when from 20,000 to 25,000 tons of the metal were shipped down the river, an amount equal at that time to from one-fifth to one-fourth of the produce of the world. The city took its name from the ore of lead to whose existence in the surrounding rocks it owed its rise and prosperity; this name was given to the town in 1827, by a Scotchman named Muir, as I have been informed by some of the old citizens. The first settlers found their way to this remote corner of the United States about the year 1821, chiefly from the southwestern and middle States. Mining was in actual progress by 1827, and the whole lead region was actively explored from one end to the other in a very short time, so that in a few years not a single district of importance remained undiscovered. The period of greatest production was from 1840 to 1850, and the maximum was reached about 1845. Since that time there has been a gradual decline in the quantity of ore raised, until within the last two years,† when the general financial distress of the West and the failure of crops caused the attention of many to be turned towards mining again, for want of other and more remunerative employment; and the consequence is, that the production of lead has undoubtedly greatly increased since the year 1858. The records of the shipments from Galena, Dubuque and other points on the river, were faithfully kept by E. H. Beebe, Esq., of Galena, as long as the produce of the smelting furnaces went to market exclusively by the river route. On the completion of the Illinois Central Railroad, the lead soon began to find its way to Chicago, in part by rail, and since 1853 we have no exact returns of the annual production. As by far the larger portion of the lead smelted goes either to St. Louis or Chicago for reshipment or manufacture, by combining the receipts at those two cities we shall have a pretty near approximation to the amount actually produced. There are no manufacturing establishments in the lead region which use up any considerable amount of the metal, those near Dubuque not having been put in successful operation. From the returns of the Chicago Board of Trade, and the St. Louis Chamber of Commerce, we have compiled the following table:

TONS* OF LEAD RECEIVED.	1853.	1854.	1855.	1856.	1857.	1858.	1859.
At Chicago	1,452	1,895	4,449	2,919	1,900	3,870	......
At St. Louis	14,248	10,123	9,757	6,076	6,347	9,496	8,262
	15,700	12,018	14,206	8,995	8,247	13,366	8,226

* The ton equals 2,240.

† This report was made in 1860.

The amount received at St. Louis was rapidly falling off up to 1857, but the discovery of new mines in Southwestern Missouri began to add sensibly to the receipts at that city. Before 1858, the receipts at St. Louis from Missouri mines were almost insignificant; but since that time they have been growing in importance, as will be seen by the annexed table of receipts by river and railroad:

PIGS OF LEAD RECEIVED AT ST. LOUIS.	1856.	1857.	1858.	1859.
By river	214,656	162,555	228,897	157,265
By railroad	14,628	37,847	75,000	107,115

What portion of the whole amount of lead raised in the lead region comes from diggins situated within the limits of Illinois, we find ourselves unable to state, but think it probable that it may be about one-sixth.

Having thus given some idea of the relative importance of the mining region, we will proceed to some of the more interesting facts connected with its geology, and in this we shall preserve the following order:

1st. The principal topographical features of the Illinois lead egion will be briefly sketched, and a few words added in regard to the surface geology.

2d. The different rocks which occur there will be described in their geological order.

3d. The mode of occurrence of the lead ore will be noticed; and

4th. Some account of the different diggins, their positions, peculiarities of form, extent of the workings, amount of ore produced, etc., will be given, so far as the dates are accessible, or the facts have been collected.

SECTION I.

Topography of the Lead Region of Illinois.

The district under consideration, although not one which in most parts of the world would be called mountainous, or even hilly, is, in comparison with this portion of Illinois, quite a broken and picturesque region. It includes the most elevated region of the State.

The Mississippi river bounds it on the west, having a southeast course, while its principal tributaries have a nearly south direction. JoDaviess county is chiefly drained by Fever and Apple rivers; the smaller streams are the Menomonee, Sinsinnewa, Plum and Rush creeks. These are all valuable as furnishing water power at various points along their courses. All the above named streams are directly tributary to the Mississippi. Stephenson county is drained by the Peccatonica and its branches, of which the Yellow river is the most important; the Peccatonica flows into the Illinois river, after pursuing a tortuous course through the county, having collected with its numerous branches a large part of the surface waters of the lead region in Wisconsin.

In Northwestern Illinois the streams are usually bordered by high and precipitous bluffs, which decrease in altitude as we go from the northwest towards the southeast. In the corner of the State west of Apple river, the smallest creeks are hemmed in by almost vertical walls of rock, inclosing a narrow strip of bottom land, in which the streams meander from side to side with a very crooked course. The height of these bluffs is usually from one hundred to two hundred feet. The ridges between the smaller branches of the streams are frequently narrow, and precipitous on both sides.

The principal feature of the topography of the northwestern corner of Illinois is formed by the outcrop of the Niagara limestone, and the Mounds, which are outliers capped with this formation. As it will be more convenient to describe these under the head of the Niagara limestone, in the next section, the further consideration of this division will be postponed to that place.

SURFACE GEOLOGY.

The surface geology of the northwestern corner of Illinois is of a very simple character. As has been very fully set forth in the Wisconsin Report, before referred to, the larger portion of the lead region has never been invaded by the drift, and is, therefore, entirely free from all accumulations of gravel, pebbles or boulders. The topographical features of the country have been produced by the quiet but ceaseless agency of water, not sweeping over the surface in the mighty currents of the diluvial epoch, bearing the detritus of northern crystallized rocks and grinding down and bearing away the softer strata, but falling as rain, percolating through the calcareous and magnesian deposits, and gradually carrying them off in solution, leaving the insoluble portion behind in the form in which we now see it covering the solid rock, as an intimate mixture of the finest argillaceous and siliceous particles. There can be no doubt that the denudition of the region in question has been effected in this way. The facts that there are no boulders or beds of gravel, pebbles or other water-worn materials in this region; that the superficial deposits are not stratified; that there is no evidence that they have been moved from their original position; these, and other considerations of the same kind, go to show that the surface has never been covered by water since the earlier geological periods, and certainly not during the quaternary period, or that of the drift, alluvium, etc.

The extent of the region thus elevated above the oceanic waters during the drift epoch, is nearly coincident with that of the productive lead region in Northwestern Illinois, Iowa, and Southwestern Wisconsin. How far it extends north of the Wisconsin river I am unable to state from my own observation, but I am informed by Mr. Lapham that there is a considerable area in that direction which has not been invaded by boulders.

On the Iowa side of the Mississippi we find small pebble stones in the superficial detritus, a little west of Dubuque; and a few miles farther, in that direction, we have large boulders on the surface—the line between the region of boulders and that in which none are found, running nearly parallel with the river and four to ten miles distant from it. On the east, in Wisconsin, the line indicating the outline of the boulderless district runs between the Peccatonica and Sugar rivers, bending to the south as it enters Illinois, and crossing the former river a little below Winslow. Large boulders are seen in Waddam's Grove, both at a high and low level; but in a direct line to the west of this no evidences of boulders or drift were observed as far as the Mississippi. Two large boulders of hornblende rock, two or three feet in diameter, were noticed about six miles south of Warren, on section 24, township 28, range 4 east, as near as could be made out. These were quite isolated, no others having been seen anywhere in the neighborhood. The southern limit of the boulderless region I have not been able to lay down, but the drift certainly sets in a few miles south of Freeport.

As additional evidence of the truth of the statement that this part of the country has not been under water since the deposition of the upper Silurian rocks, it may be noticed that only the remains of land animals and plants are found in the superficial detritus. The bones and teeth of a great variety of species are frequently obtained, at various depths, in the lead crevices, mixed with clay and decomposing rock, having been washed in from the surface and carried down, in some instances, fifty or sixty feet before finding a lodgment. The most abundant among the remains of animals thus found are those of the Mastodon, whose teeth and bones have been procured from a great number of crevices, over the whole area of the lead region, showing that the species must have lived and flourished in

Plate IV.—Section of the Rocks of the Lead Region of Upper Mississippi.
The bracketed portion of the Section is that which comes to the surface in N. W. Illinois.

UPPER SILURIAN.	*NIAGARA LIMESTONE.* *(Mound Limestone of Percival.)* *Coralline and Pentamerus beds of Upper Magnesian Limestone of Owen.*	300	Dolomite: closely resembles the Galena Limestone in Lithological character.
LOWFR SILURIAN.	*Cincinnati Group.*	60	Siliceous Shale: some portions very bituminous.
	GALENA LIMESTONE. *(Upper Magnesian of Percival.)* *Lead-bearing beds of Upper Magnesian of Owen.*	275	Dolomite: the chief depository of the Lead ore.
	Blue Limestone.	50	Alternations of pure with magnesian and argillaceous limestone.
	Buff Limestone.	25	Argillaceous Dolomite.
	Upper Sandstone. St. Peters Sandstone of Owen.	80	A pure Siliceous Sandstone: not recognized east of Wisconsin.
	LOWER MAGNESIAN LIMESTONE. *Calciferous Sandstone of New York Report*	250	Dolomite: frequently brecciated and concretionary; contains small deposits ot Lead ore.
	LOWER SANDSTONE. *Potsdam Sandstone of New York Report.*	300 to 500	A Siliceous Sandstone, often ferruginous. Its thickness is variable, but is not less than 300 feet.

immense numbers and through a long period of time, since the chances of the preservation of the remains of any one individual by being washed into a crevice must have been exceedingly small. The remains of both living and extinct species are found in the crevices in such positions, in reference to each other, as to indicate pretty clearly that they were living together. From a crevice near the Blue Mounds I obtained bones and teeth of the Mastodon, Peccary, Buffalo and Wolf—the two former extinct, the two latter supposed to be identical with animals now living. In a crevice near Dubuque, I obtained, with the teeth and bones of the Megalonyx (an extinct animal of the Sloth family), teeth of a Peccary, pronounced by WYMAN to be those of a species now living. This animal was once very abundantly distributed over this region, since its remains are found in many of the crevices, as well as in the superficial detritus in Illinois and the adjacent States. The Elephant was also once an inhabitant of this region, although apparently much less abundant than the Mastodon. A few teeth found near the surface at Galena, and now preserved in a collection in that city, are all the remains of this animal that I have met with in the lead region.

SECTION II.

Character of the Rocks Exposed in the Illinois Lead Region.

The range of geological formations or groups exposed in JoDaviess and Stephenson counties is very limited. There is nothing seen lower than the Blue limestone, or higher than the Niagara.

The annexed table, plate 4, shows the different members of the series which appear in the Upper Mississippi lead region, and which underlie the rocks occupying the surface in Northwestern Illinois. A reference to the geological map will show how these formations are distributed in JoDaviess and Stephenson counties. That part of the series which is included within the brackets includes the rocks exposed at the surface. From the section it will be seen that the three lowest members of the series do not come to the surface in the lead region of Illinois, although they will all be passed through successively in sinking a shaft to a sufficient depth below the surface.

The stratified fossiliferous rocks which are exhibited in the section rest on a floor of crystalline slaty quartzose and granitic rocks, forming what has been designated as the Azoic* system, since, as

*These rocks are probably the equivalents of the Huronian system of Canada, and are metamorphic sedimentary strata, and not true Azoic. A. H. W.

far as the evidence goes, it was deposited previous to the introduction of organic life upon the globe. To reach this series, it will be necessary to sink probably about a thousand feet at Galena. It is the same series of rocks which is exposed in the iron region of Lake Superior.

Above the Azoic lies the Potsdam or Lower sandstone, a formation which covers a vast extent of surface in Northern and Central Wisconsin, but which does not emerge anywhere in Illinois, so far as I know. This, as recently developed, is made up of a series of beds of almost pure siliceous sandstone, and is probably from 300 to 500 feet thick. It is quite destitute of valuable minerals, except in the Lake Superior region, where it is associated with trappean rocks, and has been mineralized by them.

Above this sandstone, and passing into it by alternating beds of siliceous and dolomitic materials, and of the two intermixed, is the lower Magnesian limestone, as it is commonly called in the lead region, and which occupies the place of the Calciferous sandstone of the New York geological survey. It is a heavy body of almost pure dolomite or carbonate of lime and magnesia, in the proportion of one atom of each. It is from 250 to 300 feet thick as exposed in Northeastern Iowa and along the Wisconsin river. Like the sandstone which lies below it, it is very rarely found to contain fossils. In respect to its metalliferous character much discussion has been had. It is a favorite idea with some that it is to be mined in to a great extent at some future time, and that it will prove to be a highly valuable formation. After a complete investigation of the matter, while engaged on the survey of Wisconsin, I have come to the conclusion that there is hardly a possibility of this being the case. It is indeed true that the lower Magnesian contains, at a number of points, more or less galena; but I have failed to find any evidence of workings having been profitably carried on in that rock for any length of time. In the Wisconsin Report I have gone fully into the reasons why I have been unable to advise sinking to this rock for the purpose of developing or proving its metalliferous character; and as there is no reason to suppose that any such attempts will be made in Illinois, or that the State will be called upon to furnish the money for a work of this kind, it will not be necessary to do more than refer to the subject as having been discussed in the report mentioned above.

The lower Magnesian just comes to the surface in the arch or undulation of the strata which brings up the lower Silurian groups near LaSalle. To the north of that point, in Illinois, I believe it does not make its appearance.

In the ascending order, we have next above the lower Magnesian a stratum of sandstone, commonly called the Upper, or St. Peters sandstone; it is a purely siliceous rock, made up of very minute grains of quartz of quite uniform size, not held together by any perceptible cement, except here and there, and doubtless destitute of all traces of any fossils, or fragments of foreign rock, so that it is difficult to account for its formation by any theory which recognizes it as of a detrital origin. It is well exposed on the bluffs of many of the streams in the Wisconsin portion of the lead region, but no where appears in Illinois north of the axis of elevation near LaSalle, spoken of above, where its whole thickness is brought up in a low arch. The nearest points to this lead region at which it makes its appearance on the Wisconsin side of the line, are at Buzzard's Roost, north of Benton, and on the Peccatonica river, north of Winslow. Its thickness is from 80 to 100 feet, and its persistency over so large an area, its freedom from intercalated beds of magnesian or calcareous matter, as well as the entire absence of fossils and ores in it, make it a matter of no little difficulty to account for the altered condition under which it was deposited as compared with those prevailing while the great masses of dolomite and limestone above and below it were thrown down.

The rocks enumerated above, although underlying the lead region everywhere, are not brought to the surface in Northwestern Illinois, and it is not until we reach the Buff and Blue limestone, the next members of the series above the Upper sandstone, that we have groups which are exposed within the limits of the district under consideration.

That portion of the series included between the Upper sandstone and the Galena limestone, as seen in the section, is usually recognized in the Northwest by the designation of the *Blue Limestone*, but it should, from its lithological and paleontological characters, be separated into two groups, as was originally done by Dr. D. D. Owen, in his report on the Lead Region, published in 1840 and 1844. Of these the Lower or the *Buff Limestone*, as it has been generally called, is made up of a series of dolomitic beds, varying in different parts of Wisconsin and Iowa from 15 to 25 feet in thickness. This group of strata is especially well exposed on the various branches of the Peccatonica, and especially in the vicinity of Mineral Point, where it is extensively quarried for building purposes. The rock of which it is made up is a dolomite, but containing a larger percentage of insoluble matter than either the lower Magnesian or Galena limestone; the various analyses show from 10 to 25 per cent. of clay and sand in this portion of the series. In general, and especially in the western part of the lead region and in Iowa, the Buff limestone is very unfossiliferous; but in the Peccatonica valley it is quite well supplied with organic remains. These seem to indicate that this rock is closely allied to the Birdseye and Black river limestone of the New York Reports. The most conspicuous fossil is a large *Lituites*, probably *L. Undatus*, of Hall, a Black river fossil. I have never observed it in any other than the Buff. Large orthocerata are also very abundant in this part of the series; also gasteropods, among which *Murchisonia* and *Pleurotomaria* are most abundant.

The Buff limestone is the lowest member of the series which may properly be considered to belong to the lead bearing rocks, and it is very rare that the crevices or openings are worked down as low as this. Only in one or two instances near Mineral Point, at the Crow Branch diggings, and perhaps a few other localities, have any productive openings been met with as low down as this. As this rock hardly crops out at all in the Illinois portion of the lead region, it of course has not been worked in. The only locality where it has been observed is at Winslow, on the Peccatonica, where about thirty feet of a thin-bedded yellowish dolomite were exposed, which was referred to the Buff limestone. It contains numerous fossils in some of the layers, all casts. A species of *Pleurotomaria*, probably *P. sub-conica*, is quite abundant here; also, *Streptelasma*, identical with a species which is very abundant in the lower beds of the Galena limestone.

The Blue limestone proper, or the Trenton limestone, lies between the Buff and the Galena limestone. It is the first group of strata in the series, as developed in the Northwest, in which there are any purely calcareous beds. Above and below, all the rocks other than sandstones or shales are dolomitic, or at least contain a large proportion of the carbonate of magnesia. Here, also, we have, for the first time in the series, an abundant development of organic life, many of the beds of the Blue being replete with fossils.

There is no section of this rock, exposing more than a few feet in thickness, to be seen within the limit of Illinois, although it occupies the valley of Fever river from the forks north to the State line, and is also seen on the Mississippi at Dunleith and above. In its full development it is about fifty feet in thickness, made up

—9

of the following divisions, as measured at Quimby's Mill, near Benton, in Wisconsin:

A Very fossiliferous, thin-bedded and sometimes rather shaly and argillaceous layers of bluish-gray color, bleaching of a dirty white on exposure—12 to 15 feet.

B. Gray and light yellowish-gray layers, with a finely crystalline texture, containing a considerable proportion of magnesia, but not enough to form dolomite, and remarkably free from insoluble substances—thickness, 5 feet.

C a. Pure limestone: very compact, brittle; breaking with a conchoidal fracture; color dark gray and very uniform, both in texture and color; rather heavy-bedded, but not so much so as the division next below (*C b.*); in layers from 6 to 8 inches thick, but not very regular; fossils few in number, and chiefly in the shaly partings between the beds.

C b. Very heavy-bedded and regularly stratified layers, of nearly the same color and texture as the division next above; layers 18 to 24 inches thick; great numbers of *Strophomena alternata* between them: the lower portion more shaly and passing gradually into the Buff limestone below—5 feet. Total thickness exposed of the Blue limestone—27 to 30 feet.

D. Buff limestone—17 feet.

Division C, as above designated, is the glass rock proper, as generally designated in the lead region, by which term reference is made to its hardness and its clear, sharp fracture resembling that of glass. It is a very pure limestone, containing only about one per cent. of insoluble matter and a trace of magnesia.

The Blue limestone varies considerably in character and thickness in different parts of the lead region. To the west of the Mississippi it becomes thicker and less easily to be separated from the Galena limestone above. To the northeast it grows thinner, and the whole of the series from the Buff upwards is commonly called the glass rock.

As exposed at Dunleith, and above on the banks of the Mississippi, a thickness of about 20 feet of the upper beds of the Blue limestone, or of beds of passage from the Blue into the Galena limestone, is seen. These layers, which are from six to eight inches thick, are of a light bluish-gray color, pretty regularly bedded and separated by shaly partings, crowded with fossils, which weather out in some of the strata in a quite perfect manner. The most abundant of these are *Strophomena alternata*, everywhere a characteristic species of the Blue, *Leptæna sericea*, *Orthis*, n. sp., *Ceraurus* (*Cheirurus*) *pleurexanthemus*, *Isotelus gigas* (*Asaphus canalis*), and many Crinoidal fragments.

The fact that this rock splits in layers of a suitable size for building purposes, and that it dresses well, being quite free from cherty masses, renders it a desirable building stone, and it has been much quarried for use at Dubuque, especially for caps and sills.

The only other exposures of the Blue limestone in Northwestern Illinois are along Fever river, from the forks of that stream northward. At Tuttle's Mill considerable quarrying has been done, and this is the only point where a good section could be obtained of this part of the series. The following measurements were made here:

Beds of limestone, passing into dolomite, in rather thin layers, with shaly partings—6 feet.

Thin-bedded limestone, weathering in layers about two or three inches thick, with the usual fossils of the Blue limestone—8 feet.

"Glass-rock," one pretty solid layer—17 inches.

Blue shaly mass, representing the "Pipe-clay opening," but not showing any galena—6 inches.

Gray brittle glass-rock, dividing into irregular layers on weathering—2 feet, 6 inches.

Gray limestone, breaking with a conchoidal and slightly shaly fracture when weathered; a few fossils between the layers—3 feet, 2 inches.

Layers not exposed in the quarry, but cut through in the wheel pits of the mill—4 feet.

The last two divisions are good building stone; the others are too shaly to be worth quarrying.

The upper fossiliferous layers of the Blue limestone are also exposed in a cut on the railroad, just at the forks of Fever river, and have about the same character as at Tuttle's Mill. Fine specimens of *Asaphus* and *Ceraurus* have been collected at these exposures.

With the exception of those above cited, there appear to be no localities in Northwestern Illinois exposing any rocks lower than the Galena limestone. The Menomonee and Sinsinnewa rivers do not cut down through this formation, and in going east and north from Galena we soon rise into higher groups.

The Blue limestone is a metalliferous formation in some parts of the lead region, as at Mineral Point, Linden and vicinity; but no workings have been carried as low as this in Illinois or Iowa. Farther on, under the head of "Mining," some remarks will be made on the probability of successful mining below the Galena limestone.

We come next to the formation which covers the larger portion of the region to which this report refers, and the only one which has, up to this time, been found to contain valuable ores; it is the group of strata to which the name of *Galena Limestone* has been applied. The term "Upper Magnesian" is that by which the rock in question is most generally described in the lead region, but as it originated in a misapprehension of the geological structure of the district, and is really not the upper Magnesian limestone, a change of name has been deemed advisable in order to avoid confusion, as will be fully explained under the head of the Niagara limestone, further on.

The *Galena limestone*, as usually developed, is a rather thick-bedded, light gray, or light yellowish-gray dolomite, distinctly crystalline in its texture, and usually rather granular, although occasionally quite compact. The coarse-grained portions frequently contain small cavities of irregular shape, which are often lined with minute crystals of brown spar. In its chemical composition this rock is quite homogeneous; it is almost a pure dolomite, since the various analyses which have been made show it to contain only from two to five per cent. of substances insoluble in acid (clay and sand), while the remainder is a mixture of the carbonate of lime and magnesia, in the proportion necessary to form dolomite, (carbonate of lime, 54.35, and carbonate of magnesia, 45.65 per cent.) with one or twc per cent. of the carbonate of the protoxide of iron, which becomes gradually peroxidized on exposure to the air, and traces of the alkalies, chlorine and sulphuric acid. The grayish tinge which it has in the interior of the thicker layers, passes into a very light straw-yellow after a time, in consequence of the oxidation of the iron.

The unequal mixture of the crystalline granular and the more compact portion of this rock causes it to weather very unequally in some places, so as to give to its outcrop a variety of picturesque forms. As the streams in Northwestern Illinois and the adjacent territory of Iowa have cut deeply down into the Galena limestone, they are bordered by precipitous bluffs of this rock, which are generally crowned by perpendicular ledges, having frequently a castellated appearance, like the walls of some half-ruined city, while isolated masses of rock sometimes rise abruptly from the valleys, resembling lofty watch-towers. Nowhere is this disposition of the strata better seen than in the vicinity of Dubuque and Galena, and the latter city is remarkable for its picturesque situation between lofty bluffs of the Galena limestone, the rock having received this name from the fact of its being so well exposed at the city of that name, as well as for its being the principal repository of the ore of lead, called "galena" by mineralogists.

The upper layers of the Galena limestone are usually more regularly and thinly bedded than the middle and lower, and hence are chiefly quarried for building materials when a choice can be had. Near Dubuque the upper fifty feet are in layers from seven to eight inches thick, and furnish a pretty good stone for most purposes. At the very summit of the formation the rock is quite shaly and argillaceous, indicating a passage into the Cincinnati group above. These thin layers are called "shingle rock" by the miners. In this portion of the series there are but few of the siliceous nodules or flints; hence the greater value of the upper layers for building purposes. The middle portion of the Galena limestone is usually very heavy bedded, crystalline, and marked by an abundance of flints, arranged in parallel layers. The lower portion of this rock is more variable in its lithological character than either the middle or upper. It is sometimes regularly bedded; in other places it is intersected by seams and flaws of crystallized calcareous spar, and, in connection with the mineral openings, contains a large amount of flints.

The maximum thickness of the Galena limestone, where none of it has been removed by denudition, is from 250 to 275 feet; from 150 to 200 is usually exposed in the bluffs about Galena, where the river cuts down almost to the bottom of this rock.

As the sole depository of the ore of lead in Northwestern Illinois, the Galena limestone is of the greatest economical importance, and in the section specially devoted to the mining interests, this relation of the mineral deposits to the rock will be discussed in full.

As a fossiliferous formation the Galena limestone offers quite a contrast to the underlying Blue limestone. All the shells it contains are preserved as casts, with the exception of those which consisted originally of phosphate of lime, such as *Lingula quadrata*, which is so common in the upper beds and characteristic of this rock. There are occasional layers which are quite well filled with casts of gasteropods, *Murchisonia* being by far the most abundant genus, and *M. major* the most marked species. The Brachiopods, with the exception of *Lingula*, are more sparsely represented, although two or three species of Strophomena are not unfrequent. The most noticeable fossil, however, of this series, is the *Receptaculites*, generally known at the West as *Coscinopora*, popularly called "Sun-flower Coral," or the "lead fossil," from its sun-flower-like form and its abundance in the lead diggings. Although formerly considered a coral, this curious fossil has been referred by Dr. Owen, in his last report, to the *Foraminifera*, and more recently the same opinion has been advanced by Mr. Salter. Another closely allied form is that described by Dr. Owen as *Selenoides*, which is equally characteristic of the Galena limestone, but more rare than the *Receptaculites*. Both the upper and lower portions of the rock show immense numbers of branching forms in which few traces of structure can be detected, but which appear beyond a doubt to be the remains of marine plants and sponges, which must have flourished most luxuriantly, and may have furnished, by their growth and decay, a large part of the material of which this part of the series is made up. The paleontological affinities of the Blue and Galena limestone ally these groups of strata closely to the Trenton limestone, and with each other, although they are so different in their lithological characters. A more thorough investigation of the fossils of the lower Silurian rocks of the Northwest will probably form one of the objects of the paleontological portion of the Report on the Geology of Wisconsin.

Next above the Galena limestone we find the *Cincinnati Group*, formerly referred to the position of the rocks called "Hudson River Group," in the New York Geological Reports.* This group of strata is composed chiefly of argillaceous and silico-argillaceous shales, with a small and varying amount of calcareous and magnesian carbonates intermixed. This is the first set of beds deposited in this region which consisted chiefly of detrital materials—that is to say, such as originated from the wearing away and disintegration of previously existing strata, and which were brought from a distance in the form of a fine mud, and quietly deposited at the bottom of the ocean.

The predominating color of this portion of the series is a light-blue, weathering, on exposure, to a light ash-gray; hence the name of Blue shale, given to it by Dr. PERCIVAL, in his Wisconsin Reports. Intercalated with the shales are occasional bands of argillaceous magnesian limestone, and the upper portion of the series becomes more and more calcareo-magnesian, passing gradually into a regular dolomite.

Owing to the rapidity with which these shaly beds disintegrate on exposure, it was a long time before their existence and position in the lead region was fully understood, since natural sections exhibiting these rocks are extraordinarily rare. When the miners in Iowa and Wisconsin had to sink through a few feet of these shales overlying the lead bearing rock, as was frequently the case near Fairplay and Dubuque, the fragments of that rock thrown out would, of course, soon be covered up, as the working descended into the underlying Galena limestone, so that their presence would very naturally escape the notice of the casual visitor, unless he happened to be present at the first opening of a shaft. Hence it was for a long time supposed that the Niagara limestone, which forms the tops of the mounds, and the Galena limestone, or the lead bearing rock, were not separated by any intervening strata of a different lithological character, although known to be paleontologically quite distinct. In all Northwestern Illinois not a single foot of these

---

*Now known to occupy a very different horizon at the typical localities on the Hudson river, New York. A. H. W.

shales has been found exposed in any natural section, although one good section has been found on the Iowa side, where twenty-five feet may be seen. The cuttings of the Illinois Central Railroad, however, between Scales' Mound and Apple River stations, supplied this deficiency, in a measure, and have given us a good idea of at least the lower portion of the series.

The section a little west of the station at Scales' Mound, as measured by Prof. HALL and myself, in 1855, was as follows:

Alternating bands of impure argillaceous and siliceous shales, with calcareous layers of a few inches in thickness—8 feet.

Bluish-gray siliceous and silico-calcareous shales—11 feet, 6 inches.

Limestone, magnesian, somewhat argillaceous, and containing a little carbonaceous matter—3 inches.

Shales, similar to those above—12 feet.

Calcareo-magnesian band—2 inches.

Shales, as above—6 feet.

Layer filled with minute fossils, of which *Tellinomya (Nucula)* is the most abundant, hence the st atum has been called by Mr. DANIELS, in his Report to the State of Wisconsin, he "Nucula bed," and the whole series the "Nucula shales;" at the bottom is a thin layer ontaining two species of *Lingula*—6 to 12 inches.

Dark olive shales, finely laminated and destitute of fossils—3 feet.

Nucula bed, similar to the one above—4 to 6 inches.

Whole thickness exposed, belonging to the Cincinnati group, about 42 feet.

In the western end of the cut, the upper beds of the Galena limestone are well exposed. They are made up of alternating beds of dolomite and yellow shaly layers, which, however, are also chiefly dolomitic in composition, with a little more clay than the harder beds. The shaly portions are a few inches in thickness, and contain a considerable number of fossils, among which *Murchisonia belicincta* and *Pleurotomaria lenticularis* were recognized. Above these alternations of dolomite and shales we find about ten feet of a rather compact bluish dolomite, with numerous geodes, usually of from two to three inches in diameter, the sides of which are lined with very pretty crystallizations of pyrites, heavy spar and bitter spar, forming quite handsome cabinet specimens. This geode bed has an irregular surface, on which is deposited the lower Nucula bed. This fossiliferous layer, which is at the bottom of the Cincinnati group, is from four to six inches in thickness. It is strongly impregnated with iron pyrites, which soon decomposes, on exposure to the air, so that the blocks which were quarried at the time the railroad was constructed are now entirely disintegrated. This stratum is almost entirely made up of fragments of fossils, chiefly *Tellinomya (Nucula)*, small *Orthoceratites*, *Pleurotomaria*, *Murchisonia*, etc., together with a great number of small pebble-like concretions of a dark slaty material, and nodules of pyrites. The upper Nucula bed is similar in character to the lower one, being equally crowded with fossils, although not quite as pyritiferous.

Three miles east of Scales' Mound station, on the railroad, is another deep cut through these rocks, exposing twenty-five or thirty feet of shales; and about a mile farther on still another, in which nearly fifty feet are displayed. The details have not been measured. The road runs along between Scales' Mound and Apple river all the way nearly on the top of the Galena limestone, and the cuts expose the lower beds of the shales; but we have failed to discover any section, natural or artificial, which exhibits the passage of the Cincinnati group into the Niagara above. The whole thickness of rock intermediate between the Galena and the Niagara limestone is, of course, preserved under the mounds, but not a foot of this portion of the series is exposed about any of them, except when wells are dug or other artificial excavations made.

The very interesting section of the Cincinnati group near Channingsville, Iowa, on the Little Makoqueta river, first pointed out by C. Childs, Esq., of Dubuque, exhibits about twenty-five feet of alternating beds of soft shales and layers, crowded with *Orthoceratites*, as well as *Tellinomya* (*Nucula*). Layers made up exclusively of *Orthoceratites*, packed as closely as possible, are seen on the small streams a few miles west of Dubuque, but in no two localities has precisely the same sequence of beds been remarked.

The whole thickness of the Cincinnati group in Northwestern Illinois is probably nowhere less than sixty feet, and may be in some cases as much as one hundred. As its junction with the Niagara limestone above has never been seen, the thickness of the series can only be approximately arrived at by measuring the gentle slope which it gives rise to at the base of all the mounds.

An interesting fact in connection with this rock, and one which contrasts it strongly with all the other members of the geological series in this region, is the large quantity of bituminous matter which it contains, but not uniformly distributed through it, since some portions of the series are much richer than others, and the amount of carbon present varies greatly at different localities. A specimen from Savanna, Illinois, examined by Messrs. Chandler and Kimball, was found to have the following composition:

Insoluble in Chlorohydric Acid:

Clay and sand		73.57
Carbon	15.03	
Hydrogen	1.65	
Oxygen	5.39	
		22.07

Soluble in Acid:

Carbon of lime	1.29
Carbonate of magnesia	.76
Alumina and protoxide of iron	2.79
	100.48

Other specimens of shale from various other localities were found to contain from five to fifteen per cent. of organic matter, and the larger portion of those examined take fire and burn with a brilliant flame when heated in the crucible.

The shales of the Cincinnati group in the lead region are entirely destitute of any accidental minerals so far as known; no instances have ever been observed of the lead-bearing crevices extending up into this rock, and the causes which produced the deposition of the ores so abundant in the group immediately below must have ceased to operate before the shales were formed.

The paleontological affinities of this group of strata are with the rocks occupying the same position in New York, but how far the species are identical, remains to be investigated. The lithological characters and the minute details of organic forms are subject to many changes over so extensive an area as that embraced between the east and the west; but the general order of sequence remains the same, and the principal groups are traced in an unbroken series from New York into Canada, and thence along the shores of Lakes Huron, Superior and Michigan into the Valley of the Mississippi, presenting one of the finest fields for the study of the Silurian groups which the world affords to the geologist. There is a rich material here for years of elaborate investigation.

Above the Cincinnati group we find next in order, everywhere in the lead region and its vicinity, a heavy mass of dolomite, the third in order, which, from its thickness and persistency of lithological and paleontological characters over a wide area in the Northwest, deserves especial notice. It is the rock to which, prior to the recognition of the Cincinnati group in this region, the name of "Coralline and Pentamerus beds of the Upper Magnesian" was given. As the general appearance and chemical composition of the rock forming this series of beds is almost identical with that of the Galena limestone, and as the group of strata separating them in so marked a manner was not noticed, it was natural that the whole series from the bottom of the Galena limestone to the top of the rocks in question, should be grouped together; and the name of "Cliff limestone" was that first given, in reference to the peculiar denudation which has taken place in the district occupied by these rocks, which exposes them in abrupt and picturesque bluffs or cliffs along the principal streams. In the same way the term "Upper Magnesian" was applied, in contradistinction to the Lower Magnesian, and these terms are still in general use among the miners, the former being, however, limited to the lead-bearing beds. As the palæontological differences between the Galena limestone and the upper beds of the "Cliff limestone" were too evident to escape recognition, the former rock was called the "lead-bearing beds," and the other the "Coralline and Pantamerus beds" of the Upper Magnesian. Dr. PERCIVAL, in his reports, to escape confusion, has retained the term Upper Magnesian for the lead-bearing dolomite beds, and has applied that of "Mound Limestone" to the rock above the Cincinnati group, since it is found everywhere in the lead region capping the mounds. As, however, the rock in question is continuous with that described by the geologists of the New York Survey as the Niagara limestone, and as a large number of identical and closely allied fossils occur through the whole range of the formation from New York to the Mississippi, it is in every respect proper to apply the same name to the same rock in its eastern and western extension, and hence we shall follow Prof. HALL in calling it the Niagara limestone.

Although occupying but a very small area in the lead region proper, this formation is one which covers a vast area in the Northwest. It is largely developed in Eastern Wisconsin, forming a belt from thirty to fifty miles wide along the west shore of Lake Michigan, and extending down into Northern Illinois, where it covers an extensive area. It stretches across the Mississippi into Iowa, and trending to the northwest passes into Minnesota, where it has not yet been traced out with accuracy; but it probably covers an immense expanse in the far Northwest, and is the most important group developed in that far-off region.

In its lithological character the Niagara limestone, as developed in the Mississippi valley, is quite homogeneous; indeed, there is little difference in its chemical composition from the bottom to the top of the series anywhere between the St. Mary's river and Minnesota. It is essentially a pure dolomite, generally containing the carbonates of lime and magnesia in almost exactly the proportion required by one atom of each, although occasionally showing a small excess of lime. The amount of insoluble clay and sand which it contains is generally very small; it is sometimes less than one per cent., and rarely exceeds three or four.

As developed in the vicinity of the lead region this rock is of a light yellowish-gray color, varying in shade somewhat, according as it has been more or less exposed to the atmosphere, and the amount of iron which it contains, which, however, is quite small, even in the most ferruginous varieties. Its texture is more uniform and less crystalline than either the Lower Magnesian or the Galena limestones, and it is more regularly and thinly bedded. Still, in hand specimens it would be impossible to distinguish these three great dolomitic rocks from each other. The Niagara limestone, being of a more uniform texture, does not weather so unequally, or form such fantastic and picturesque ridges and outliers, when deeply cut into by streams. Like the other Magnesian rocks in the lead region, it is abundantly supplied, especially in its middle and lower portion, with siliceous nodules or flints, which are usually arranged in layers parallel with the stratification. These flinty beds are particularly abundant in the middle portion of the series; where they are absent the rock is well adapted for building purposes, as it splits and dresses well, and is of a fine color, as well as very durable; it is extensively quarried on the mounds, especially on Waddell's, near Galena, although not free from flints in the beds exposed here. This tendency to silicification exhibits itself through the whole of the series, in the fact that the numerous corals which it contains have all been converted into silica. In the West Blue Mound a thickness of over 150 feet has been entirely converted into flint of a brownish-red color from stains of iron. The exceeding hardness and durability of this material seems to have been the principal cause why this outlier of the Niagara has been left so far to the north, while such extensive denudation has gone on all around, leaving it elevated nearly five hundred feet above the general level of the surrounding country.

The whole thickness of the Niagara limestone in the Mississippi valley I am unable to give, as it is nowhere left entire in the lead region, or exposed in its vicinity, in its whole thickness, so as to be capable of being measured. In Iowa the greatest thickness observed in one section was about 250 feet, and probably 350 feet may be taken as an approximation. On the mounds there is usually about 150 feet of the rock remaining, but as its junction with the shale below is never exposed, it is difficult to give any exact figures. On the West Blue Mound the thickness of the Niagara limestone appears to be nearly 200 feet. On the Sinsinnewa there is a little over 125 feet of this rock.

The outcrop of the Niagara limestone in and around the lead region forms the most marked feature in its topography, as already remarked; and taken in connection with the curious outliers of this rock, known as the Mounds, shows what an extensive denudation has been going on over this part of the country.

Coming into the lead region from the east or north, we find the first evidence of the existence of the Niagara limestone in the two Blue Mounds, the west one of which is elevated 486 feet above the village of Pokerville, at its base, and 1151 feet, nearly, above Lake Michigan, being the highest ground in Southern Wisconsin. It is about 30 miles, in a southwest direction, before we come to the next outliers of the Niagara—the Platte Mounds, as they are called—three isolated eminences, two of which are about 150 feet above their bases and 700 feet above Lake Michigan. Sinsinnewa Mound, in the southwest corner of Wisconsin, is the only other isolated knob of the Niagara in that State. It is 591 feet above the lake, and not far from 200 feet above the general level of the region at its base. Crossing the Mississippi into Iowa, we find a single outlier of this rock a few miles in advance of the main line of outcrop, and called Sherald's Mound. The Galena limestone rises above the river, as we ascend the Mississippi, near Bellevue, and forms bluffs directly on the river, which rapidly increase in height, attaining their maximum at Dubuque, where the whole thickness of the rock is exposed, about 250 feet. Above the bluffs of the Galena limestone is a gently sloping plain, extending back from the river for a short distance and underlaid by the Cincinnati group. Rising above this, in a steep and frequently precipitous escarpment, is the outcrop of the Niagara, which, with many irregularities and deeply cut into by the streams coming into the Mississippi, extends along close to that river as far as the mouth of the Catfish. From this point, owing to the bend of the river, the line of the bluffs marking this rock is thrown back from six to eight miles into the interior, but gradually approaches the river again near the *Buena Vista;* then bends round and keeps to the south of Turkey river, and stretches itself towards the far Northwest. This outcrop is everywhere a marked feature in the topography of the district, as it causes a sudden, almost precipitous rise of from 250 to 300 feet, with the gentle slope of the Cincinnati group at its base, and with its irregularities of outline caused by unequal denudation. Beyond this to the northwest there is little to break the monotony of the surface, and the lines of junction of the different geological groups, instead of being thus boldly marked, are very obscure, and only to be approximately made out.

The principal body of the rock lies between Small Pox creek and Apple river, although deeply cut into by the streams which run across this part of the district to the south southeast. The surface covered by this rock is quite broken, intersected by numerous ravines, and is pretty well timbered with a variety of oaks and other forest trees. It is, as yet, but sparsely settled. In the valleys of Apple river and Rush creek, and in all the region drained by their head waters, the larger part of the surface is covered by the Galena limestone, while occasional mounds capped with the Niagara diversify the surface, and the higher grounds between the streams have some remains of the Cincinnati group upon them, the exact extent of which can only be conjectured, as this rock is never exposed except in artificial excavations. The main body of the Niagara lies to the south of Rush and Yellow creeks.

The most northeasterly outcrop of the Niagara in this region is at Waddam's Grove, between Nora and Lena stations, on the Illinois Central Railroad. The larger part of the upper strata on the elevated ground at the Grove, which forms a low, flat, but narrow ridge, extending along for two miles in a northwest and southeast direction, belong to the upper portion of the Cincinnati group, namely: the yellow argillaceous dolomite, which is characterized by an abundance of *Chætetes petropolitanus;* also, *Orthis occidentalis* and *Asaphus canalis*, (*Isotelus gigas.*) The *Chætetes* occur in hemispherical flattened, discoidal and branching forms, and are very numerous. Below these yellow argillaceous dolomitic strata the blue shales have been sunk into in several places, in digging wells, so that the relation of the two can be made out, although the whole thickness of the formation was not ascertained. There are two points on the mound a little higher than the rest of the ridge, where the beds of passage into the Niagara are seen in place in the form of heavy-bedded yellow dolomitic strata, with shaly partings without fossils. The northwestern summit is the higher of the two, and about this are seen several large fragments of characteristic cherty Niagara dolomite, containing large masses of flints. The flints are also seen scattered over the surface on both the higher points of the ridge.

Proceeding southwest from Waddam's Grove, we find indications of a low axis of upheaval, or an undulation of the strata, trending southeast and northwest, in a line of elevated ground running from the head waters of yellow river towards Scales' Mound. The most southeasterly of these elevations is Simmons' Mound, which is a little south of the corner of townships twenty-seven and twenty-eight, ranges four and five east. This is a narrow ridge, running east and west, and capped by about fifty feet of the Niagara limestone, in which a vain search has been made for lead.

About one mile and a half to the northwest of Simmons' is Rice's, and still further, Benton's Mound, where there is a thickness of perhaps 126 feet of the Niagara. There are some cave-like openings of small dimensions on this mound, which have been fruitlessly explored for ore. The rock, at the summit, is a yellowish-gray crystalline dolomite.

Power's Mound is on the line between sections five and six, township twenty-eight, range four east. It was not particularly examined.

Paige's Mound is chiefly in the southeast quarter of section thirty-six, township twenty-nine north, range four east. There is a lime kiln and quarry near the summit, where the upper trilobitiferous layers of the Cincinnati group are exposed. Specimens obtained here of an argillaceous dolomite and are filled with fragments of *Asaphus*. The blue shales are not exposed, but were said to have been struck in a well near the base of the mound.

Bean's Mound, near Apple river, about one mile southeast of the railroad station, exhibits the lower beds of the Niagara.

Wood's Mound, on the line between sections thirty-four and thirty-five, township twenty-nine, range three east, is a small circular outlier, capped by the Niagara.

Hudson's Mound is on section twenty-eight of the same town.

To the north of Scales' Mound station, and near the State line, is Charles' Mound, a long, narrow ridge, running east and west, and capped with a considerable thickness of the Niagara. Handsome specimens of *Heliolites* were obtained here in a grayish thin-bedded dolomite. This mound is supposed to be the highest point in the State of Illinois. By my barometrical measurement, it was found to be 295 feet above the railroad track at the station, which is 656 feet above low-water mark in the Ohio river, at Cairo, which is given as 275 feet above high tide in the Gulf of Mexico. This would make the elevation of Charles' Mound 1,226 feet above tide-water.

Scales' Mound, which also exposes a thickness of over 100 feet of the Niagara, in the form of a thin-bedded gray dolomite, is 211 feet above the railroad track, and consequently 1,142 feet above tide-water. The summit level of the road between Apple river and Scales' Mound is 805 feet above the Ohio river, at Cairo, and 1,080 above the sea level.

Passing from Scales' Mound toward Galena, the main outcrop of the Niagara keeps to the south of Small-Pox creek, forming a precipitous bluff of from 150 to 250 feet in height, but exceedingly broken and irregular in its outline. Where intersected by streams, it is deeply cut into and left in the forks between them in narrow, rocky ridges, affording many picturesque landscapes when combined with the undulating and richly fertile slope of the Cincinnati group below. The outliers of the Niagara assume a great variety of forms, but are always graceful in their outlines, and as they are usually crowned with fine forest trees, they contrast most charmingly with the rocky bluffs of the Galena limestone.

There is a broken ridge with occasional mounds, running along parallel with the Small Pox creek, and from one to two miles to the northwest of it. These mounds are very conspicuous objects as seen from the city of Galena. Waddell's Mound is a semi-circular ridge, with the concave side turned towards the city; it is chiefly on the southwest quarter of section twenty-two, about a mile east of Galena, and is capped by over a hundred feet in thickness of the Niagara limestone, in which a few corals are found, of which *Halysites catenulatus* is the most striking. A small brachiopod, resembling *Leptocœlia planoconvexa*, was found here; also a number of fragments of crinoids in a very imperfect condition. The elevation of Waddell's Mound was found to be 484 feet above Fever river at its usual summer stage of water, and four feet higher than the lowest water-mark, as was said.

Pilot Knob is another conspicuous land-mark in this vicinity, and is an object familiar to those navigating the river as a guide to the mouth of Fever river; it is a conical eminence, quite conspicuous from its isolated condition near the Mississippi, and affording from its summit a most beautiful and extensive view of the Mississippi river from Dubuque to Bellevue, with the region to the north and northeast as far as the Platte and Blue Mounds. The Pilot Knob was found to be 429 feet above Fever river, by barometrical measurements. Although the Niagara limestone has been repeatedly explored and dug into for lead ore, an instance has never come under my observation where any has been found; and I have no authentic accounts of any such occurrence in this rock. Although this dolomite is so closely allied in its lithological character to the proper lead-bearing rock, yet it is entirely destitute of the useful ores which that contains. Further west in Iowa, on the Makoqueta river, the occurrence of numerous nodules of brown iron ore, altered from pyrites, has given rise to the idea that the Niagara limestone might contain workable beds of that ore; but nothing has been discovered as yet to justify that opinion.

As a quarry rock, this dolomitic mass is of considerable value, especially when not injured by the presence of flinty nodules. It is also extensively burned for lime, at localities where fuel is abundant, as is almost always the case on and around the mounds.

We have thus passed in review all the groups of strata which are found in the lead region of Illinois and its vicinity. There is no rock higher in the series than the Niagara limestone, coming to the surface on the Mississippi river, until we reach the vicinity of the Upper Rapids, where Devonian rocks make their appearance.

The general dip of the rocks in this region is to the southwest, but there are many undulations and irregularities. From Galena to Scales' Mound there is a rapid rise of the strata, which continues on to Apple river, where the top of the Galena limestone is from 200 to 250 feet higher than it is at Galena. These flexures of the formations do not appear to have been accompanied by faults or actual ruptures of the strata; at least no evidence of anything of the kind has been detected.

Mode of Occurrence of the Lead Ore.

By the "mode of occurrence" is meant the peculiarities of form and arrangement of any deposit of ore, and its relations to the rocks in which it is embedded or inclosed; in short, it should comprehend all that is required to be known in order to enable one to form a correct idea of the probable extent and value and the best method of working the deposits in question. We propose, then, to set forth briefly in this section the most important facts in regard to the occurrence of the ores of lead in Northwestern Illinois, referring at the same time, for fuller information in regard to the whole lead region, to a more voluminous report furnished to the State of Wisconsin in 1860, and published in 1862.

The only metal which has yet been the object of mining enterprise, in the mineral region of the Upper Mississippi, is *Lead*. Considerable quantities of Zinc ore do indeed occur in some parts of that district, but they have never been raised, except accidentally in mining for Lead; and it is only within the last year or two that any portion of the large amount of Zinc ore accumulated on the surface has been attempted to be utilized. Zinc smelting works have been erected at LaSalle, and Mineral Point, Wisconsin, and some of the metal actually smelted at the latter place, although the operation has not been, on the whole, a successful one, and is now for a time suspended. In regard to the LaSalle works, I have not been informed whether the furnaces have ever been completed, and the manufacture of the metal actually commenced.* In the Wisconsin Report above mentioned, I have given the reasons somewhat at length why I believed the smelting of the zinc ores could not be carried on profitably, at present, in the lead region, and I need here only repeat that, although zinc can be made at the West, yet the facilities are not sufficient in the way of the cost of the ore and fuel, abundance of capital and nearness to a market, to enable the work to be carried on profitably in competition with the establishments of Belgium and Silesia, or even with those of New Jersey and Pennsylvania. The ores of zinc are very abundantly distributed over the world, but it is only under very favorable circumstances that they can be smelted with profit; and a few regions, where abundance of the ore, of coal and other advantages are combined, have a monopoly of the business.

But as the quantity of zinc ore associated with that of lead in the Illinois portion of the lead region is comparatively trifling, the matter is of very little importance to this State, except as affording a market for our coal. The occurrence of zinc ores in the lead region in considerable quantity is almost exclusively confined to deposits in the lower beds of the Galena limestone, and especially in the Blue, at a lower horizon, geologically, than has been worked, or than is believed to be workable, in Northwestern Illinois. There is, therefore, no reason to suppose that the metal will ever become of importance in that section, and our inquiries need not be farther directed to its occurrence, except as incidentally in connection with that of the lead.

The only ore of lead which occurs in any noticeable quantity anywhere in the lead region is the *sulphuret*, the galena of the mineralogists, universally called "mineral" by the miners of that district. When perfectly pure and free from rock, it contains 86.6 parts of lead and 13.4 parts of sulphur, in the hundred. According to the size of the masses of ore, and their arrangement in crystalline groups, the different varieties are distinguished by miners, and called by names which explain themselves, such as "chunk," "dice," "cog" and "sheet" mineral. The galena of the Upper Mississippi region

* The Zinc works at LaSalle are in successful operation at this time, 1866 A. H. W.

is always crystallized when it has had a vacant space in which to develope its crystalline planes, and never occurs in granular or fibrous forms. Ores from the lead mines of Southern Illinois, in Hardin and Massac counties, and which occur in the Mountain limestone, on the other hand, have a granular and fibrous structure, quite unlike any specimens ever obtained from the northern part of the State.

As silver is almost invariably associated with galena, and often in sufficient quantity to pay for separating, the lead ore of the Northwest has been frequently examined for this metal, but has never been found to contain enough of it to be of importance; indeed only the minutest trace of silver is present in most of the specimens from this region which have been assayed. The galena from Southern Illinois, on the other hand, although not rich in silver, has enough of it to be worth separating, under favorable circumstances. The following are the results of some assays made by Messrs. Chandler and Kimball at my request:

Locality.	Per cent. of silver in the ore.	Per cent. of silver in the lead.	Troy oz. silver in 2000 lb lead.
Roseclare, Ill	0.0283	0.0326	9½
Massac county, Ill	0.0043	0.00496	12½
Mineral Point, Wis	0.0088	0.0101	3
Rockville, Wis	0.00038	0.00043	⅛
Marsden Lode, Ill	0.00022	0.00025	1/14

All the assays which have ever been made of the lead ore of the Upper Mississippi region prove it to be very poor in silver. That from Mineral Point, yielding three ounces to the 2,000 pounds, is the richest yet assayed. If there was reason to believe that the ore of lead occurring in Southern Illinois existed in any considerable quantity, the question of the existence of silver in connection with it would be one of importance. There seems to be little reason to suppose, however, that this is the case, although I cannot, in this instance, speak from personal examination of the localities.

All mining engineers who have been accustomed to deep mining, in other parts of the world, are astonished, on visiting the Upper Mississippi lead region, to find that the mines have never, in any instance, been carried to any great depth; that in a large majority of cases they have been wrought for a limited time only, and have then been abandoned; that many of them have been, for a certain period, exceedingly remunerative, a large amount of ore having been raised with a small expenditure; that instead of a large body of miners, working under a company with a costly *plant* (as the machinery and fixtures of a mine are called), there will be usually only a small number of men employed in any one crevice, and in a majority of cases only two; and that their machinery will be limited to a windlass and a bucket, with the addition of the simplest mining tools. It is natural enough, perhaps, for those who have not looked into the matter closely, and examined the region and the mode of occurrence of its ores, to suppose that this system of mining is something for which the miners themselves are responsible, and not the nature and extent of the deposits. With this opinion we are entirely unable to concur, believing, as we do, that the nature of the mining operations here followed is in strict accordance with what is demanded by the nature of the deposits worked, and that, although some changes may be made for the better in this respect, *in the main* the same system will be pursued for a long period to come, or until the conditions of value of labor, ore, etc., shall have greatly changed from what they now are. To maintain that the ore deposits of the Northwest are continuous in depth, and can be worked downward indefinitely, is to ignore all the characteristic features of the lead region, and to attempt to convict all the miners who have worked here of imbecility. In some cases it is, indeed, true that valuable bodies of ore have been left going down, on account of water and the necessary expense to be incurred in removing it; but this is because the general experience in this region has fully impressed the miners with the belief that, in a large majority of cases, the outlay required for the costly machinery, with which deep mines are kept free from water, will not be reimbursed, as the distance to which the crevices can be followed, and ore found in them, is always limited, and does not generally extend far below the point at which the water becomes too abundant to be kept under by simple machinery. No lead-bearing crevice has ever been traced into the Upper Sandstone for more than a few inches, at the most, in any part of the lead region; and within the limits of Illinois we have no evidence even that the Blue limestone contains any workable or productive deposits of ore, although farther north this rock can be worked with profit. Therefore, the extreme limits in depth to which a mine might be carried, if extended from the top of the productive rock to the bottom of that portion of the strata in which any workable deposit of ore has been found, would be only about 325 feet, which is the thickness of the Galena and Blue limestones, where each is fully developed and no portion removed by denudation. In point of fact, however, no mine has ever been wrought to anything like that depth, since, in the region where the whole body of Galena limestone remains, as near Dubuque and Fair Play, there has never been any discovery of importance made in the lower part of that rock, and much less in the Blue limestone; although both are exposed, in natural sections, on the rivers, so that if this part of the series was metalliferous, there would be no difficulty in ascertaining the fact. The deepest workings in the lead region are near Dubuque, but I know of no instance in which they have exceeded 180 feet, while, in a large majority of instances, it is certain that the whole mining ground is comprised within less than 100 feet, while the productive portion, or the "openings," as they are called, occupy much less vertical space than that. Some of the heaviest lodes near Galena have been productive chiefly in the upper opening, being high up in the Galena limestone, and when sunk upon for lower openings, have failed to give any satisfactory results.

It may be safely asserted, therefore, that there is no evidence that the lead-bearing crevices are continuous in depth, or that they can be worked as persistent mines. The crevices, although in some respects analogous to what are called "true veins," are, in other important points, quite different from that class of deposits.

The ores of the lead region are deposited in a great variety of forms, but the predominant ones are the vertical crevices, the flat sheet and the flat opening. The vertical crevice is almost exclusively the characteristic form exhibited in the lead deposits which occur in the middle and upper portions of the Galena limestone, while the flat sheet openings are chiefly confined to the lower part of that rock and the Blue limestone. Hence the diggings in the vicinity of Galena are almost all of the first named class.

The term "crevice" indicates a fissure in the rock, and is nearly synonymous with the terms vein or lode, as used in other mining districts. In this respect the lead-bearing crevices resemble true veins, that they are fissures in the rock, into which mineral and metalliferous substances have been introduced. They differ, on the other hand, from this class of deposits in being limited in depth, and also in the nature and arrangement of the limestone or gangue —that is to say, the earthy or non-metalliferous minerals accompanying the ore. True veins are generally supposed to have been formed by some deep-seated cause acting from below, by which the whole series of rocks have been fissured from below any point attainable by mining operations, up to the surface. Thus mines opened on this class of deposits, if productive in ore, may be presumed to hold downwards, and to be capable of being worked to an indefinite depth.

The crevices in the lead region belong to that class of mineral deposits which have sometimes been called "gash veins," a term applied to masses of ore found occurring in fissures confined to a particular set of strata and not continuous in depth; this mode of occurrence is characteristic of the unaltered sedimentary rocks, and more particularly of the dolomites and crystalline limestones of palæozoic age. These crevices are supposed to have been produced by some cause limited in its action to the particular set of beds in which they occur, and hence they do not extend into strata of a different character from those in which they originated. This is the character of the lead deposits in the Galena dolomite; but in the Blue limestone the condition of things is materially different, as might be expected from the different lithological character of the rock. In the Blue limestone there are no crevices with openings, properly speaking; but only fissures or cracks leading down to "flat openings," or horizontal beds of mineralized rock, which have been brought into this condition by metalliferous solutions finding their way from above.

The formation of the fissures in the dolomite was undoubtedly due to a general cause acting throughout the whole extent of the lead region, although limited in vertical range to the set of beds forming a single geological group. This we infer from the strong tendency to parallelism in the crevices, which is observed over the whole district, and especially in that part of it where the Galena limestone is most fully developed. A glance at the map or diagram of the lead-bearing crevices in the vicinity of Galena, accompanying this Report, and still more at the larger diagram of the same kind, published in the Wisconsin Report, will convince every one that there is, everywhere in the lead region, a strongly marked, although not absolute, parallelism in the main crevices in each district, and that the same statement holds good, taking the whole mining region into consideration, although less completely than where a limited area is observed. There is also, in almost every portion of the lead region where the crevices are well defined, a tendency to the development of two sets of fissures or crevices, one of which is nearly at right angles to the other; one set, however, being usually the productive one, while the other carries only a small amount of ore, or none at all.

The origin of these crevices seems to be the same cause by which what are called "joints" by geologists, have been formed in almost

NOTE.—No provision was made for the reproduction of the maps published in the original reports, and they are consequently omitted in this republication.

every variety of rock occurring in large, homogeneous masses, and especially where a decided crystalline texture exists in them. Thus heavy strata of metamorphic limestone, dolomite, sandstone, basalt and trap rock, are almost invariably divided into prismatic or cuboidal blocks by two or more sets of fissures or cracks, which are the more perfectly developed and more closely parallel in proportion as the mass is more homogeneous and crystalline in its texture. In the dolomitic rocks of the lead region, we have all the conditions which usually occur in the formation of a well developed jointed structure, and it is to this class of phenomena that we are inclined to refer the lead-bearing crevices of the district under consideration.

Not only is there this tendency to a jointed structure in the Galena dolomite and the consequent formation of two sets of fissures in the lead region, but it is also a marked feature of the district that the fissures have an approximately east and west or north and south direction—a fact which is everywhere recognized by the miners, and which is of great practical importance. All through the mining disdricts, indeed in Wisconsin and Iowa, as well as in Illinois, the heaviest diggings will usually be found on crevices varying but little from east to west in their general direction. Some groups of crevices vary as much as fifteen or twenty degrees from a true east and west course, but this only in exceptional cases.

The norths and souths, on the other hand, or those crevices which have a course approximating to the meridian, are much less important, although these, in some instances, are the main productive ones of portions of the lead regions. Thus, in Illinois, the Council Hill diggings are chiefly worked on sets of crevices, which run from ten to thirty degrees to the east of north, while those having an approximate east and west course are very subordinate in importance. In the other sub-districts in Illinois the norths and souths are rarely productive, and are usually mere seams or cracks in which but little ore has been deposited.

Taking the whole lead region into consideration, the ore occurring in the north and south fissures or crevices is mostly in the sheet form, or in thin bodies, wedged in closely between walls of solid rock, while in the east and west crevices, openings have been formed by the widening of the fissures and subsequent decomposition of the rock adjacent to the previously deposited ore.

It is probable that the east and west course of the principal crevices has been determined by the fact that this is the direction of the axis of upheaval by which the whole lead region has been slightly elevated along the north boundary of the district, and which will be seen to have determined the drainage of the region, on inspecting the map and noticing the east and west direction of the water-shed between the rivers flowing north into the Wisconsin, and south directly into the Mississippi, or into tributaries flowing in that direction. This axis of upheaval may have determined the course of the main set of fissures, while the tendency in all the masses of rock thus situated to the formation of a subordinate set, nearly at right angles to the principal ones, may not be unreasonably looked on as the origin of the norths and souths.

To go into the particulars of the mode of deposition of the ore in the fissures, and the subsequent chemical and mechanical reactions by which the deposits of metalliferous matter have assumed their present form and position, would require more space than can here be given to that branch of the subject. Some general remarks may be made, however, which will throw some light on these complicated and difficult questions.

In the first place, it may be asserted, with the greatest confidence, that the deposition of the ore in the fissures took place from an aqueous solution, or in the humid way, and not, as some have maintained, by sublimation or injection from below, or other direct igneous agencies. Everything connected with the position of the ore in the crevices, and in relation to the surrounding rocks, prove this most conclusively.

Again, the metals lead, zinc and iron, found occurring in the lead-bearing crevices, were originally deposited as sulphurets, or in combination with sulphur, which is everywhere the most important "mineralizer," both in the metamorphic and the unaltered sedimentary rocks. Since the deposition of the sulphurets of lead, zinc and iron, they have undergone decomposition to some extent, but in quite different degrees. The ore of lead, galena, almost invariably remains in its original forms; only very insignificant quantities of the oxydized combinations of this metal, such as the carbonate, sulphate or phosphate, which are so common in some mining regions, are found here. The sulphuret of zinc (black-jack of the miners) has undergone decomposition to a considerable extent, giving rise usually to the carbonate (dry-bone); but in such cases the evidence is not wanting that the sulphuret was the original forms in which the metal was deposited, and that the carbonate was formed by its oxydation. The same is the case with the sulphuret of iron, or pyrites, called "mundic" by the miners. This ore was almost everywhere thrown down in connection with the sulphurets of zinc; but it has undergone decomposition to a much greater extent than the sulphurets of either of the last named metals, and is now found largely intermixed with, or entirely converted into, ochre, which is an impure earthy hydrous peroxyde of iron, a common result of the action of air and water on the sulphuret. Hence the dark red color of much of the earth in the vicinity of the lead diggings, and the occurrence of considerable bodies of brown iron ore in the crevices, as well as of ferruginous clay, is very common.

Again, it may be observed that the filling of the crevices with the metalliferous matter is shown, by many circumstances connected with the mode of occurrence of the ores in this region, to have taken place from above downwards as a general thing, while evidence of the introduction of the metalliferous solution from below, by thermal springs or otherwise, seems to be wholly wanting. The termination of the crevices before reaching the Upper Sandstone, the entire absence of ores in this rock, and the impossibility of procuring evidence of the existence of deeply-seated disturbances of the rocks, or faults, are among the most convincing proofs of the mode of deposition having been from above, while the several instances have been observed in which the position of the mass of ore was such as to show, beyond the possibility of a doubt, that the metalliferous solution could not have been introduced into the fissures from below.

Taking into consideration these facts, which it is impossible to avoid admitting after a careful study of the region in question, the following is a brief *résumé* of the theoretical views to which we have been led while endeavoring to account for the deposition of the metalliferous ores in the lead-bearing crevices. In the first place, it seems evident that the metals in question must have been in solution in the oceanic waters from which the rocks of the northwest were thrown down. In this supposition there is no difficulty whatever, except to explain why the metalliferous combinations continued to be held in solution, or, in other words, why they were not deposited in the strata which underlies the lead-bearing formation, namely: the Upper and Lower sandstones and the Lower Magnesian limestone. What new conditions occurred after the deposition of the Blue limestone, the lowest productive stratum, to cause a precipitation of the metals which had remained in solution during the whole period which had elapsed previous to the formation of this rock? The only answer we have been able to give to this question is, that the decomposition of the metalliferous combinations existing in the oceanic waters was effected by the agency of the organic matter contained in the rocks where these mineral deposits are now found occurring—a theory which harmonizes better with the facts than any other which has yet been put forward.

We know, from the observations of chemists and the study of natural phenomena, that the action of decomposing organic matter on solutions containing sulphates of the metals, causes a reduction and precipitation of the metals in the form of a sulphuret, where the conditions are favorable to the reaction. Nothing can better illustrate this fact than a reference to the coal fields of the West, in which the carbonaceous matter is so universally found associated with the sulphuret of iron, which occurs in it either in bunches or nodules, or else filling all the seams and fissures by which the coal is traversed. The oxyd of iron is never found in this association, except when the mass has been exposed to the action of the air by denudation at the outcrop. The same reaction has been imitated, on a small scale, in the laboratory, by allowing animal matter to decompose in contact with metalliferous solutions. The occurrence of the sulphuret of iron in the form of various fossils, as is very commonly the case, is another fact illustrating this mode of formation of the sulphureted ores.

To make the application of this theory to the lead region, we have to notice the following conditions: The Upper and Lower sandstones and the Lower Magnesian limestone appear to be almost wholly destitute of organic remains, except over a few very limited areas. Through the whole mass of the Upper sandstone not a trace of a fossil has ever been found. In the Lower Magnesian only a few obscure shells have been discovered, near the top of the series. Hence we are justified in asserting that, during the deposition of these rocks, there was but a very small amount of organic matter present in them, so that there was no efficient cause which could act to produce a deposition of metalliferous matter from the ocean in which the formation of the rocks was taking place. To have rendered these strata mineral-bearing, the ores must have been introduced from below by thermal springs or otherwise, a method, as we have seen, not supported by the facts developed in this survey.

When we have risen as high in the geological series, however, as the Blue limestone, we find a sudden and enormous development of animal life; so that a large part of the strata composing this group is made up, almost exclusively, of the remains of crustaceans, corals, mollusks and other of the lower types of organized existence. And it is precisely in these strata, so crowded with fossils, that the first important deposits of the sulphurets of zinc and lead are found—a coincidence which can hardly be looked on as accidental. The Galena limestone above is apparently much less fossiliferous, and this might be urged as an objection to the theory here advocated; but on close examination it will be found that there is reason to believe that portions, at least, of this member of the series are, to a large extent, made up of the remains of marine plants, whose structure has become partially obliterated by the process of crystallization which the rock has undergone since its deposition. The surfaces of many of the beds, especially in the lower and upper parts of the Galena limestone, are wholly covered with branching forms, which undoubtedly represent what was once a vigorous growth of marine vegetation, and which may have largely contributed to the accumulation of the material of the rock itself, by its development and decay. We have been shown, by the researches of eminent chemists, and especially by FORCHHAMMER, that many of this class of plants contain a large amount of the sulphates, and that in their decay they evolve sulphureted hydrogen gas, the most efficient agent in the precipitation of the metals. Here we have another important influence at work in the same direction as that previously noticed.

If the idea of the precipitation of the metals from the primeval oceanic waters, as sulphurets, by the agency of decomposing organic matter, be adopted—and that it is not in opposition to what chemistry requires is certain—we shall have a key to some of the most interesting questions in the geology of metalliferous deposits. We have in the Azoic* series a vast mass of rocks, deposited from water before the introduction of organic life on the globe, as far as the evidence goes, at least; and from the result of all explorations up to the present time, it would appear that this is a formation by no means rich in metalliferous ores, excepting those of iron, which have apparently been poured out from the interior of the earth in mountain masses, but in the oxidized form, and not as sulphurets. Nothing can be more striking than the absolute freedom from sulphur, as an impurity, in the protoxides which occur in such vast quantity in the Lake Superior and Missouri iron regions, which both belong to the Azoic series.

---

* Since this report was written, the Canadian survey has brought to light facts establishing the existence of organized beings during the deposition of the so-called Azoic rocks, This, however, does not necessarily invalidate the views here expressed by Prof. WHITNEY, since it is by no means probable that animals or vegetables existed in sufficient numbers, during the early periods of the earth's history, to exercise any perceptible influence in the way of causing, by their decomposition, the precipitation of the metallic sulphurets. A. H. W.

It seems, from all that can be learned of the occurrence of the metalliferous ores throughout the world, that they are much more abundant in the lower portion of the great fossiliferous series, namely, the Silurian, than in any other of the higher groups, and that there is a gradual decline in the number and magnitude of the veins worked in different parts of the world, as we proceed upwards in the geological scale. That the great storehouse of metals all over the world is the Palæozoic series of rocks, will probably be admitted by all, and it can be shown that, in many cases, where metalliferous deposits are found in higher groups of strata, they have been conveyed upwards by the action of thermal springs from the great depositories of ore in lower formations. In many cases, no doubt, the deposition in the lower rocks took place uniformly through the mass of the stratum, circumstances not favoring an accumulation in veins or crevices. Where the rock was a solid, compact material, the absence of fissures would prevent such deposits from taking place as are found in the lead region; and although a large amount of metalliferous matter might be really accumulated in a given stratum, it might escape notice from the fact of its being so uniformly distributed through it. Chemists have not, until recently, directed their attention to this mode of occurrence of the metalliferous combinations, and they have naturally been overlooked as not presenting inducements for mining enterprise. What is called "metamorphic action," by which term geologists and chemists designate the long series of chemical changes which have taken place in the rocks over certain wide areas, converting them into hard and crystalline masses, has usually developed veins, frequently of great economical importance, in rocks of Palæozoic age; and the mining geologist expects, almost as a matter of course, to find such rocks more or less rich in workable veins or other deposits of ore.

To follow out these views in detail must be reserved for another opportunity. It is sufficient here to have given a general idea of the processes by which deposition of the ores of the lead region may have taken place. There are still many difficult points to be investigated, to which we hope to direct our attention at some future time.

Detailed Description of Some of the Principal Diggings in Illinois.

The following are such particulars as have been collected with regard to the principal crevices and diggings worked near Galena and in Northwestern Illinois; but it must be premised that the information obtained is in many respects defective, partly from want of time to do the work thoroughly, but still more from the difficulty of getting reliable information concerning old crevices long since worked out and abandoned. In many cases the miners who worked the old lodes are either dead or have left the district, or have forgotten or failed to notice the particulars of the occurrence of the ore.

The principal groups of diggings or mining sub-districts, as they may be called, in Northwestern Illinois, are: 1st, diggings in the vicinity of Galena; 2d, the Vinegar Hill diggings; 3d, the Council Hill diggings; 4th, the Apple River diggings, with which a few scattered and unimportant ones near Warren may be connected; and 5th, the Elizabeth diggings, also on Apple River, and which may be called by this name to distinguish them from the mines near Apple River station.

The *Galena diggings* are situated in a circle of somewhat over three miles in diameter, of which the city would be the centre. The most important ones now worked are to the north of the city, although some very heavy deposits have been mined to the southwest.

A little east of the city, on section 21, and especially on the east half, there are many groups of crevices, forming mineral lots. Of these the following may be specified:

The *Gaffner range* runs south 87° east; worked 62 feet deep; ore occurs in a crevice with decomposed rock and flints; yield estimamated at 300,000 pounds.

Kloepfer range, a little southeast of the Gaffner; the southernmost of a group of crevices, having a course about south 78° east; worked 35 feet; ore in hard rock, apparently in the lower flint beds of the Galena limestone; has yielded 50,000 pounds.

Barrow lot, a group of crevices running south 87° east, crossed by some norths and souths; worked about 60 feet deep; some dry-bone and black-jack found here, in decomposed rock and ochre; yield 1,000,000 pounds.

There are several groups of short crevices, which vary little from east and west, worked on the southeast quarter of this section (21), along the branch which runs into Fever river from the southeast. *Morelli & Monti* worked one group of east and west to the depth of 35 to 60 feet; ore in sand and ochre; yield given as 100,000 pounds.

The Albert Smith diggings, near the quarter-post on the south line of section 21, are worked on a short set of easts and wests, from 25 to 40 feet deep, and have yielded 100,000 pounds.

On the northwest quarter of section 16, just north of the section last noticed, there are several small groups of diggings, but none of them on heavy lodes. They are on the bluffs which overhang the city to the north and extend up Furnace creek. The *Binsemer diggings* are at the centre of the section; they are worked on a group of short easts and wests, to a depth of 30 to 35 feet; yield 50,000 pounds. *Beber diggings*, worked from 20 to 80 feet deep; have yielded some dry-bone with the lead ore, in ochre and decomposed rock; yield 400,000 pounds. *Evans diggings*, ore in hard rock; depth 25 to 38 feet; yield 50,000 pounds.

Section 9, just north of the one last noticed, has on it some of the heaviest lodes yet worked in this vicinity, or, indeed, anywhere in the lead region. There is a group of five ranges on the south half of the southwest quarter of the section; these have been worked or traced from a quarter to a third of a mile in length, and are from 200 to 160 feet apart. These ranges are very nearly east and west, ranging from two to five degrees to the north of east. The most southerly of these has been recently opened, and has not produced much. North of this, at a distance of 200 feet, is the *Shuster range*, worked 50 feet deep; has yielded from 50,000 to 75,000 pounds, in disintegrated rock and ochre. North again, 220 feet, is the *Graves range*, worked 40 feet deep; has yielded 100,000. *Gaffner range*, worked 80 feet deep; a very heavy range on a crevice opening, filled with ochre, disintegrated rocks and galena; yield estimated at 2,500,000. *Whitham range*, worked about 90 feet deep, on a crevice running nearly east and west; yield estimated at 5,000,000 pounds.

Another group of ranges lies about one-fourth of a mile northwest of the last noticed; they are six in number, but three of them only are of importance. The famous *Buck lode*, which was one of the first, if not the first, worked in the region, and which is said to have been known to the Indians, and mined by them, is one of this group. This crevice makes a very wide opening, almost up to the surface on the top of the ridge, which is about 200 feet above the Blue limestone, as near as could be made out. A shaft three or four feet deep in the rock, to the cap, is pointed out as having been opened before the first white man came to this country; but along most of the lode the cap-rock has fallen in, and the crevice is open to the surface, there being here no clay or detritus upon the rock. The upper opening is about 25 feet deep in vertical height, and from 10 to 15 feet wide, with a key-rock, two or three feet in width, running through the centre. Almost the whole of the ore was obtained from this opening, and the yield is estimated at from three to ten millions of pounds; no one knows accurately how much this lode has produced, but all agree in making it one of the heaviest which has ever been worked in the lead region. A second opening, six feet high, was struck at 20 feet below the main one, and a third, 45 feet below the second, but I have never seen any ore raised from this opening. The crevice has a course north 87° east, at the point where it is the widest and richest. The *Cringle lode* is a little south of the Buck; it has been worked 85 feet deep, and has yielded, as is reported, from one to one and a half millions. The *Doe lode* is next south of the Cringle; it is said to have been worked about 75 feet deep, and to have yielded about 150,000 pounds.

A group of ranges in the northwest quarter of the northwest quarter of this section (9) has been recently worked with considerable activity and success. Of these, the *Sanders range* is the largest. These ranges are worked to the depth of from 60 to 80 feet into the flint beds, and have yielded from 100,000 to 300,000 pounds of ore each.

On section 12, in the adjoining township west (township 28, range 1 west), there are on the northeast quarter of the section a considerable number of important ranges which have been, and are still, profitably mined. There are several small groups of crevices south of the line dividing the section through the centre east and west. These are worked from 60 to 80 feet deep, but are not very productive. The *Sanders lot* is on this line, and has been worked to the depth of from 60 to 90 feet, turning out about 1,500,000 pounds. Farther north, nearly in the centre of the quarter section (northeast quarter, section 12,) are several very heavy ranges, near each other and almost exactly parallel. Of these, the *Crombacker range* is said to have yielded 1,500,000. It has been worked from 60 to 90 feet deep. The *Brandel*, *Eberhardt*, *Widmer & Voltz*, *Monti & Leonhardt*, in order from south to north, are other crevices, worked recently, and to a depth of 70 to 85 feet. Some of these have yielded handsomely. The *Morehead lot* is near the north line of the section. It has several parallel crevices on it, of which the *Wallis*, *Leonhardt* and *Klein* may be specified. These are worked from 50 to 90 feet in depth, and the lot is said to have yielded 1,500,000. The *Comstock range* is a little north of the section line on section 1. This range has been worked over a quarter of mile in length, and has yielded from 1,500,000 to 2,000,000. The depth to which it was mined is stated at from 70 to 95 feet.

Passing to the southwest, we find, on section 14, two miles west of Galena, several groups of crevices, all running nearly east and west. The *Wallis diggings* are worked from 20 to 35 feet deep, and are reported as having yielded 500,000. The *Mannett & Bassett* diggings are chiefly in the adjoining section west. They have produced from 400,000 to 500,000. The *Strickel diggings* are east of the last named, and are from 15 to 25 feet deep, having yielded 200,000. The diggings in this vicinity are shallow, and water is struck near the surface.

On the next section south, namely, section 23, there are several productive mining lots. The *Sanders lot*, on or near the central east and west line of the section, is worked to a depth of 75 feet, and has produced 1,500,000. The *Tomlin lot*, a quarter of a mile north of the *Sanders*, and nearly in the middle of the northeast quarter of the section (23), is a group of diggings covering considerable space, and worked from 30 to 80 feet deep. The *De Toya lot*, on the northeast quarter of the northwest quarter of the southwest quarter of the section, has yielded 200,000 to 300,000, and good ore is said to have been left going down in the water at a depth of 45 feet. The *Flege diggings*, near the centre of the section, have been worked 30 to 88 feet deep, and have yielded about 50,000.

On the next section south, namely: section 26, township 28, range 1 west, there are some very heavy diggings, called the "Low diggins." Bennett & Harris' is the principal range. This has been worked 30 to 50 feet deep, on five parallel east and west crevices, about 50 feet apart; they have yielded several millions. Water is reached here at 50 feet in depth. The *Marfield* diggings are in the northeast corner of the section, and are worked about 60 feet deep, and have yielded 500,000. The *Bennett & Harris diggings* were worked on flat sheets in the rock, these being all in the lower beds of the Galena limestone. Water is reached in this vicinity at a comparatively small depth, and good bodies of ore are said to have been left in some places on account of this difficulty.

Passing now about six miles north of the city of Galena, we have an extensive series of diggings, having a general northeast and southwest development over an area of about three miles in length, beginning in the southwest corner of section 25, township 29, range 1 west, and extending by Vinegar Hill to Fever river where it intersects the State line. Here this series meets another, coming in from the southeast from Council Hill. The Vinegar Hill diggings, as the above specified area is called, have been very extensive, but are now of much less importance.

On section 25, township 29, range 1 west, there are considerable diggings, near the centre of the southwest quarter of the section. *West-*

wick's lot has on it a large number of short crevices, running from south 68° to south 82° east. Water is struck here at only 20 feet from the surface. The lot has turned out, it is said, 1,500,000. The *Harvey Mann lot* is adjacent on the east. It is traversed by numerous crevices, having a course about north 80° west. There is water near the surface. Yield given as 50,000. In the northeast corner of the section, and crossing the line into the adjacent fractional section east, there are several groups of diggings of some importance. The *Feehan diggings* are in the northeast quarter of the section, a little south of the centre of the quarter. They are shallow diggings in the clay, and have yielded 50,000. There are a great many crevices running across the east line of this quarter section. Of these the *Trewett lot* has produced 100,000; the *Feehan* 50,000. These diggings are worked from 70 to 90 feet deep, the ore being in the flint beds of the Galena. The *Pfeiffner diggings*, a little north of the last named, have yielded from 200,000 to 300,000. The depth to which they have been worked is from 60 to 90 feet. The south half of section 20 and the southwest quarter of section 21, are covered with diggings. The village of Vinegar Hill is on section 20. The diggings are worked on lots of parallel crevices running nearly east and west, and crossed by norths and souths. They are generally from 50 to 70 feet; sometimes as much as 90. The following yields are reported as the amounts produced by the different lots in this vicinity: Four groups of diggings in the northeast quarter of the southwest quarter of section 21, on crevices running 5° to 10° north of west, have yielded, in all, as is reported, from 3,000,000 to 5,000,000. The ranges in section 20 have also yielded several millions. But little was doing here, however, when this place was last visited, and consequently it was difficult to procure any reliable information.

On the fractional sections 14 and 15, township 29, range 1 east, there are several important groups of diggings close by the State line, or intersected by it. On the centre line of section 14 are the *Waterman ranges*, worked from 50 to 70 feet deep. They are on crevices running about north 60° east, and traversed by others nearly at right angles to this direction; yield of both diggings 140,000. The most important range in section 15 is the *Widow Gray range*, which crosses the State line and runs about 5° north of east. It has produced nearly 1,000,000 pounds.

Of the other groups of diggings about Vinegar Hill, there is but little to communicate of importance.

Not having made any special examination of the Council Hill diggings, not much can be said in regard to them. According to Mr. SCHELLER's surveys, there is a heavy group of ranges running nearly northeast and southwest, over half a mile in length, and distant about an eighth of a mile from Council Hill street and village, and to the northwest of that place. This group is said to have yielded 10,000,000 pounds.

South of Council Hill, on the southwest quarter of the northeast quarter of section 25, are the *South diggings*, on numerous crevices, running north 5° to 10° east. These are worked from 30 to 55 feet in depth, and have yielded about 1,500,000. The *Negro diggings*, at the south corner of section 25, township 29, range 1 east, and section 30, township 29, range 2 east, are nearly parallel with those last named, and have yielded about the same quantity of ore. The *Alderson lot*, a little east of the Negro ranges, and on the southwest quarter of the southwest quarter of section 30, have worked from 15 to 60 feet deep, and have produced about 500,000 pounds.

To the west and southwest of the Council Hill station, on the Illinois Central Railroad, are extensive ranges of diggings. The *Rocky Point diggings*, on the southeast quarter of the northeast quarter of section 36, township 29, range 1 east, are on a group of crevices about north 30° east. These are worked from 15 to 75 feet deep, and have yielded about 2,000,000 lbs. The *Drummond lot* and *Tunnel diggings*, on the north half of the southwest quarter of the northwest quarter of section 31, township 29, range 2 east, are on east and west crevices, and have produced together about 750,000. South of the railroad, on the southeast quarter of section 36, are several mineral lots, with groups of crevices, which are about north 20° east, across the quarter section. Of these the *Enner lot*, worked 65 feet deep, has produced 500,000 lbs. The *Simcox & Co. lot* about the same, and the *M'Lane*, also 500,000. There are other scattered ranges, without names, on the northeast quarter of the southeast quarter of section 36, which are nearly parallel to those last mentioned. *Bolt's lot*, on the west half of the southwest quarter of section 31, township 29, range 2 east, is traversed by numerous nearly parallel sets of crevices, having a course of north 15° to 30° east. This lot has yielded about 4,000,000 pounds.

The Apple river and Elizabeth diggings, formerly of considerable importance, have now much fallen off in productiveness. At Apple river heavy bodies of ore are occasionally struck near the surface, on the east and west open crevices, but they have not been found to hold their richness to any considerable depth. The Elizabeth diggings, which, soon after being struck, gave employment to 800 miners, are now but little worked. When visited by me, in 1857, they were said to be producing from 400,000 to 600,000 per annum. The crevices usually have been found to close up before reaching the flint beds of the Galena, which is from 130 to 150 feet below the surface. It would be possible to sink 15 or 20 feet in the flint without trouble from water, but there has not been much encouragement to do it. In some cases, however, this has been done with tolerable success. At the Haggerty diggings, which were working in 1857, a shaft had been sunk 130 feet to the flint beds, and from 5 to 15 feet in thickness of that rock, worked out partially over an area of 350 feet east and west by 140 feet north and south. The ore was found in flat sheets, in the hard rock, connected by vertical fissures, as usual in the flat openings in this geological position. Of the total amount produced at the Elizabeth diggings I have no information.

NOTE—Since the above was written, I learn from E. H. BEEBE, Esq., of Galena, that there are five furnaces running within the limits of Illinois, which produce about 125,000 pigs per annum or 8,750,000 pounds, or nearly 4,000 tons (of 2,240). Some of the ore smelted in these furnaces is brought from Wisconsin, but what proportions I am unable to say. The total production of the lead region will probably be found to have been considerably larger in 1860 than in any of the preceding five or six years. It will hardly fall much short 20,000 tons

CHAPTER VI.

THE COAL FIELD OF ILLINOIS.

Of all the mineral products of our mother earth, none are more important for the comfort and general well being of the human race than the fossil fuels that are hidden beneath the surface.

Coal has been aptly called the mainspring of modern progress, for it not only warms our houses and lights our cities, but it furnishes the motive power of our varied industries, and the material by which our vast resources of mineral wealth are reduced to their refined metallic forms, and thus made available for man's use. Cheap fuel cheapens transportation, and reduces the cost of manufacturing the raw products of the country to the lowest rates, so that steam becomes the successful competitor of water power in the great manufacturing industries of the age.

Coal is undoubtedly of vegetable origin, but whether it is the product of marine or land plants, is a point not yet fully determined. Until a very recent period, geologists have pretty generally agreed that coal was, for the most part at least, derived from land plants growing in low, boggy marshes upon the spot where the coal is now found. This view seemed to be well sustained by the prevalence of land plants both in the roof shales as well as in the underclays of the coal, and the occurrence of thin layers of mineral charcoal between the more compact layers of the coal itself. But in this State, the coal and the shales containing land plants in profusion, are often found enclosed between limestones filled with the remains of marine animals, leaving no doubt that these limestones were of marine origin, and thus leading some to suspect that the coal itself was also derived in part, if not wholly, from marine plants.

Assuming that the coal has been derived wholly from land plants, we must also assume that during the entire coal-producing period, oscillations of the surface were of constant occurrence, elevating the whole area of the coal field above the surface of the ocean as often as there are distinct seams of coal, and the subsequent subsidence of the whole, to permit the accumulation of the sandstones, shales and limestones that intervene between the various beds of coal. This assumption is not sustained by any known phenomena of modern times, and furthermore requires a period of time for the formation of our Coal Measures far greater than has generally been conceded to any of the main divisions of the Palæozoic series.

As early as 1861, Dr. Fred. Mohr, in his work on Chemical Geology, argued very forcibly in favor of the theory that coal was formed by the massing together of marine algæ, or seaweeds, in bays or other quiet waters, through the action of ocean currents, analogous to the accumulations in the Sargasso Sea of modern times. This view, however, did not gain the general approval of American geologists, mainly, perhaps, from the fact that nearly all the fossil plants found in connection with the coal were such as grew only upon the land, including, in some cases, whole forests of *Sigillarids* and *Lepidodendroids*, whose roots penetrated the underclay upon which the coal rested, while their stems had apparently gone to form, in part at least, the solid structure of the coal itself.

During the present year, however, Prof. REINSCH† has published a work on the microscopical structure of coal of different ages, from the true Carboniferous to the Trias; basing his conclusions upon the examination of 1,200 carefully prepared microscopical sections of the different varieties of bituminous coal, and his observations are worthy of more than a passing notice. He found the organic forms that abound in the coal to consist mainly of *Protophytæ*, or plants without distinct cell structure, of which *Bacterium*, *Vibrios*, etc., are analogous living forms. His specimens were no doubt obtained from European coals, but there is no reason to suppose that the coals of Europe and America have not been formed under similar conditions. His observations seem to point to the conclusion that fresh-water plants enter largely into the structure of European coals, but we are left in doubt as to whether the strata with which the coal seams are there associated, are of marine or fresh-water origin.

Whether Prof. REINSCH's theory of the origin of coal will obtain a general acceptance, the future must determine, but it would certainly

† *Neue Untersuchungen ueber die Microstructur der Steinkohle des Carbon, der Dyas und Trias.* Von Paulus Frederich Reinsch. Leipzig: T. O. Wiegel, 1881.

relieve the subject of some of its most difficult aspects, if we could substitute accumulations of fresh-water or marine plants, brought together in extensive basins by water currents, for successive growths of land plants, as the probable origin of our western coal deposits. But whatever the origin of coal may have been, whether it is due to the growth of land or marine vegetation, its use and importance to the industrial prosperity and power of a nation will scarcely be called in question.

The geographical extent of the Illinois coal field within the borders of the State, may be placed in round numbers at about 35,000 square miles, and its boundaries may be briefly defined as follows: Commencing on the northeastern border, in Grundy county, its northern boundary extends nearly due west to the Mississippi river a few miles above Rock Island, and from thence its western boundary extends down the river nearly to the north line of Henderson county, where it trends inland for a few miles from the river, leaving a belt of older rocks between the Coal Measures and the river on the western border of the State, varying in width from ten to thirty miles, as far south as the southern part of Jackson county, from whence it trends eastward through Johnson, Pope and Hardin counties, crossing the Ohio river near Battery Rock, and extending thence into Kentucky and Indiana, and covering a large area in both of those States.

The term Coal Measures applies to all the beds of rock with which the coal is interstratified. They consist, for the most part, of sandstones, sandy and argillaceous shales, bituminous shales and limestones, with the coal seams and fire clays on which they rest, and attain an aggregate thickness of 1,200 feet or more in some portions of the State.

During the progress of the geological survey, sixteen different coal seams were recognized, ranging from one to nine feet in thickness. These have been numbered consecutively from the bottom upwards, and the following section of the lower portion of the Coal Measures has been constructed from the coal shafts in the vicinity of Springfield, and the boring at Riverton, in Sangamon county, and is designed to give a general idea of the relative position and range of thickness of the lower coal seams in Central Ilinois, and the average thickness and lithological character of the rocks that separate them:

GENERAL SECTION OF THE LOWER COAL MEASURES.

60 to 70 feet.	Sandstone and shale.
	Coal No. 8—1 to 2 feet.
80 to 95 feet.	Sandstone, shale and limestone.
	Coal No. 7—1 to 9 feet.
20 to 30 feet.	Sandstone, shale and limestone.
	Coal No. 6—0 to 6 feet.
20 to 30 feet.	Shale and limestone.
	Coal No. 5—4 to 6 feet.
60 to 80 feet.	Sandstone and shale.
	Coal No. 4--0 to 5 feet.
60 to 70 feet.	Sandstone and shale
	Coal No. 3—0 to 4 feet.
40 to 60 feet.	Shale, sandy and argillaceous.
	Coal No. 2—1½ to 5 feet.
30 to 80 feet.	Sandstone, shale and limestone.
	Coal No. 1—1 to 5 feet.
20 to 50 feet.	Sandstone and shale.
	Lower Carboniferous Limestone.

The boring at Riverton showed the existence at that point of three workable beds of coal below No. 5, the one worked at the present time, each ranging from 4 to 5 feet in thickness.

Southeastwardly from the central portion of the State, through the counties of Macon, Moultrie, Christian, Montgomery, Shelby, Coles, Cumberland, Effingham, Clay, Jasper, Wayne, Richland, Edwards, Wabash, Lawrence and Crawford, the upper division of the Coal Measures are the prevailing rocks, and there are no coal beds known to outcrop near the surface that attain a greater thickness than two or three feet. All the seams in the foregoing section are several hundred feet below the surface in all the counties above named, and we must rely upon careful explorations with the drill to determine whether or not the lower seams preserve their normal thickness over this portion of our coal area. Hence the importance of obtaining and collating all definite and reliable data in regard to the development of the lower coals over this wide area; and as the desired information can be obtained most economically with the drill in the hands of competent experts, it is a matter of paramount importance to the complete development of our coal interests, that every experiment of this kind should be accurately made, and the results registered as the work progressed, so that we may be able, in due time, to state approximately the amount of fuel that is obtainable from the lower Coal Measures in the center of the Illinois coal basin.

The following approximate section of the upper division of the Coal Measures has been constructed from the detailed surveys of the counties above named:

GENERAL SECTION OF THE UPPER COAL MEASURES.

80 to 90 feet.	Sandstone and shale.
	THIN COAL—6 inches.
100 to 120 feet.	Sandstone, shale and limestone.
	COAL No. 16—1½ to 3 feet.
75 to 90 feet.	Sandstone and shale.
	COAL No. 15—1 to 3½ feet.
50 to 60 feet.	Sandstone and shale.
	COAL No. 14—1½ to 2 feet.
80 to 90 feet.	Sandstone and shale.
	COAL No. 13—0 to 3 feet.
75 to 80 feet.	Sandstone and shale.
	COAL No. 12—0 to 1 foot.
20 to 25 feet.	Shales and limestone.
	COAL No. 11—0 to 1 foot.
30 to 40 feet.	Shales.
	COAL No. 10—0 to 1 foot.
80 to 90 feet.	Sandstone, shales and limestone.
	COAL No. 9—0 to 2 feet.
	Fire clay and shales.

Nos. 9, 14, 15 and 16 of the above section range in thickness from eighteen inches to three feet, and all have been worked in a limited way along their line of outcrop.

The compact limestone over coal No. 9 is a very persistent bed, and has received the local names of "Carlinville limestone," "Shoal Creek limestone," etc., from its points of local outcrop. We have considered this the dividing bed between the upper and lower Coal Measures, because its position is about midway between the base and the top of the coal formation, and it can be much more readily identified at widely separated localities than any of the sandstones or shales with which it is associated. On the eastern borders of the State it outcrops at several localities in Edgar and Clark counties, and the following species of fossils may usually be obtained from it. *Athyris subtilita, Spirifer cameratus, S. lineatus, Terebratula bovidens, Meekella striato-costata, Pleurotomaria turbiniformis, Lophophyllum proliferum, Campophyllum torquium,* and some other less conspicuous forms. Wherever this limestone occurs, it forms a reliable horizon for determining the relative position of the main coal seams, and their probable depth beneath the surface. Coal No. 9, which underlies it, is variable in thickness, and is sometimes replaced by bituminous shale. In the vicinity of Highland, in Madison county, this seam ranges from eighteen inches to two feet in thickness, and was opened at an early day for the local supply of the town and vicinity with coal, but, since the opening of the lower seams, the work on this has been generally abandoned.

The only seams above this that have been worked to any considerable extent are Nos. 14, 15 and 16. No. 14 is known locally as the "Pana coal," and outcrops on Coal creek, a few miles south of Pana, where the seam is from 16 to 22 inches thick, and affords a coal of good quality. On Beck's creek, in Shelby county, the same seam outcrops, and has been worked in a limited way to supply the surrounding country.

No. 15 is the "Shelby coal," which varies in thickness from eighteen inches to three feet, and has been opened at various points in the vicinity of Shelbyville, where it affords a coal of good quality.

Coal No. 16 is known as "Nelson's coal," in Effingham county, which is reported to be three feet thick at Mr. Nelson's place, where the principal mining on this seam has been done. These upper seams are worked only on the outcrops, or near by, where the coal can be reached at 50 to 75 feet below the surface.

But little is known at this time in regard to the earliest experiments in coal mining in this State, or the exact locality where the first mine was opened. The first discovery of coal in the Unitep States, recorded in history, was made in Illinois. As early as 1669, more than two centuries ago, Father Hennepin, one of the earliest explorers in the Mississippi Valley, mentions the discovery of coal in the valley of the Illinois river, not far from where the city of Ottawa is now situated, but it is not probable that any mines were opened there until long after coal mining was commenced in Southern Illinois.

The first coal mining operations of which we have any record were in 1810, on the Big Muddy river, in Jackson county, where a flat-boat load of coal was mined and sent to the New Orleans market.

In 1822, Joseph Duncan, afterwards elected Governor of the State, loaded several boats at the Big Muddy mines for the same market. These seem to be the first recorded experiments in mining coal for shipment to a foreign market from this State. According to Peck's Gazetteer of Illinois, page 22, one hundred and fifty thousand bushels were mined in St. Clair county in 1833, and hauled in wagons across the Illinois bottom to St. Louis.

The Big Muddy mines are located on coal seam No. 2 of the general section, which crops out in the bluffs of that stream in the vicinity of Murphysboro, and were first worked by tunneling into the face of the seam along the outcrop. This seam is thicker in this county than it has been found elsewhere, attaining a thickness of about five feet, though it is here a double seam, the two divisions being separated by a few inches of clay shale. It is the same coal worked at Colchester, in McDonough county, and at various points in Grundy and the northwest border of Kankakee counties, for the supply of the northern portions of the State. It is characterized at all these localities by the presence of kidney-shaped nodules of argillaceous iron ore in the roof shales, enclosing leaves and stems of ferns, and other plants, in a fine state of preservation. The shales themselves, immediately above the coal, are also often filled with ferns, in a finely preserved condition, affording many choice varieties to enrich the cabinets of the naturalist.

Coal No. 1 is generally too thin to be worked to advantage, except at a few points about to be mentioned. In Rock Island county, it ranges from three to five feet in thickness, and has been worked for the past twenty-five years or more. The coal of Coal Valley has furnished the main supply for the city of Rock Island, and the river towns above, for many years. This coal is generally overlaid, in this county, by bituminous shale, enclosing a layer of dark colored chert from six to eighteen inches thick. At Seaville, on Spoon river, in

Fulton county, this coal is about three feet in thickness, and of good quality. At Battery Rock, in Hardin county, it was opened at an early day in the bluffs of the Ohio river, but being only from eighteen to twenty-two inches in thickness, it was soon abandoned after the thicker seams on the Saline river were opened.

In the counties of Saline and Gallatin the entire thickness of the lower measures is exposed, but only coals Nos. 5 and 7 are usually of sufficient thickness here to be worked to advantage. The mines on the Saline river, where the coals outcrop, were opened at an early day, the product being used in part in evaporating the brine obtained from the salt wells, and in part for supplying the towns below, and the steamers on the lower Ohio and the Mississippi rivers. The Independent Coal Company work coals Nos. 2 and 3 in their shaft, the former being four feet and the latter three feet in thickness.

At the Bowlesville mines, coals Nos. 5, 6 and 7 are represented in their shaft, but No. 6 is too thin to be worked to advantage at the present time. No. 7, at its outcrop near Equality, has three feet of hard argillaceous limestone above it, which is separated from the coal by three feet of hard bituminous slaty shale, which forms an excellent roof. The following section illustrates the character of the lower Coal Measures in this portion of the State, and shows the variation in thickness as well as the lithological character of the rocks with which the lower coal seams are associated. The conglomerate sandstone which forms the base of the section attains a much greater thickness in this portion of the State than at points further north, and indeed at many points in Northern Illinois it is altogether wanting. Locally, it contains thin seams of coal in Southern Illinois, but they are usually too thin to be of any economical importance. This sandstone may always be relied on for determining the lower limit of the productive Coal Measures.

SECTION OF THE LOWER COAL MEASURES IN SALINE AND GALLATIN COUNTIES.

8 to 10 feet.	Limestone and shale.
	Coal No. 9—6 inches.
30 to 40 feet.	Shale.
	Coal No. 8—3 feet.
40 to 50 feet.	Sandstone, shale and limestone.
	Coal No. 7—5 to 7 feet.
40 feet.	Sandstone and shale.
	Coal No. 6—2 feet, 6 inches.
65 to 70 feet.	Sandstone and shale.
	Coal No. 5—5 feet.
80 to 90 feet.	Sandstone and shale.
	Coal No. 4—2 feet, 6 inches.
85 to 90 feet.	Sandstone and shale.
	Coal No. 3—3 feet.
25 to 30 feet.	Sandstone and shale.
	Coal No. 2—4 feet.
130 to 140 feet.	Sandstone and shale.
	Coal No. 1—1½ to 3 feet.
150 to 180 feet.	Conglomerate sandstone. (Resting upon the Chester limestone.)

From Gallatin county northward, along the valley of the Wabash river, no important mines have been opened in this State south of Vermilion county, and the borings made at different points have not shown the existence of workable beds of coal within easy reach of the surface at any of the localities where the experiments have been made.

There is, therefore, a considerable area in the southeastern portion of the State where the coal is wanting, or the borings made have failed to show its presence, either because they were not carried deep enough to reach it, or were conducted in so careless and unskillful a manner as to afford no accurate knowledge of the true character of the strata passed through by the drill. For the present I am inclined to impute this failure to the lack of thorough work in prospecting for coal in this portion of the State, and to believe that future and more carefully conducted experiments with the drill will show that coal may be found over the greater portion, if not the whole of the area known to be covered by the upper division of the Coal Measures.

Coal No. 7 outcrops in the vicinity of Danville, in Vermilion county, and has been extensively worked for many years. It ranges from four to seven feet in thickness, with a roof of pyritiferous shale. The coal at this point contains rather more than the usual amount of pyrite, but otherwise is of fair quality. According to the observations of Prof. F. H. Bradley, who made the detailed examination of Vermilion county, coal No. 5 outcrops near Georgetown and on Grape Creek, where it ranges from five to seven feet in thickness, and affords a coal in some respects superior to the Danville coal. It has a clay parting about four feet from the top of the seam on Grape creek, and the lower division of the seam appears to be sufficiently free from sulphur to be used in a raw state for smelting iron. The whole seam contains much less sulphur than the Danville seam, and the coal is preferred for domestic use. None of the seams below No. 5 have been found sufficiently developed in this section of the State to be of any value for practical mining operations.

In LaSalle county, on the northern borders of the Illinois coal field, Nos. 2, 5 and 7 have been worked at different times, though the two latter are the most important. No. 2 ranges from 3 to 4 feet in thickness; No. 5, from 5 to 6 feet, and No. 7, from 4½ to 6 feet. Nos. 1 and 6 seem to be wanting in the LaSalle section, but Nos. 9, 12 and 13 are present and represented by thin coals from six to twelve inches in thickness. The following approximate section will show the relative position and thickness of the workable coals in LaSalle county. This section has been constructed from the outcrops at LaSalle and the shafts that have been sunk through the lower Coal Measures at that point.

3 to 4 feet.	Shaly Clay.
	Coal No. 13—1 foot.
18 to 20 feet.	Shale and limestone.
	Coal No. 12—1 foot.
55 to 60 feet.	Limestone and shale.
	Coal No. 9—6 inches.
160 to 170 feet.	Sandstone, limestone and shale, with ½-inch Coal.
	Coal No. 7—4½ to 5 feet.
65 feet.	Sandstone and shale.
	Coal No. 5—4 to 6 feet.
154 feet.	Sandstone and shale.
	Coal No. 2—3 to 4 feet.
25 feet.	Sandstone and shale.
	(Resting on Silurian strata.)

In Peoria county, coals Nos. 5 and 6 outcrop in the bluffs of Kickapoo creek, and of the Illinois river, south of Peoria, and No. 5 is extensively mined for the supply of the city and adjacent region. This coal seam was numbered as coal No. 4 in the report on Peoria county (Geological Survey, vol. 5, page 238), but it is probably identical with No. 5 of the general section. It averages about 5 feet in thickness, and affords a fair quality of coal, though inferior to that obtained from No. 6, which is usually thinner, ranging from 3 to 5 feet, and quite free from sulphur. This latter seam is, however, quite irregular in its development, and is, therefore, generally neglected, except where a superior quality of coal is required for the use of the blacksmith.

In Fulton county, all the seams of the lower measures, except, perhaps, No. 4, outcrop on Spoon river and its tributaries; but Nos. 1, 5 and 6 are the only ones that have been worked to any extent, or that promise to be of any considerable value for future operations. No. 1 is mined at Seaville, on the west side of Spoon river, where it averages about 3 feet in thickness, affording a good quality of coal. Further down the river it dwindles to a thickness of 1 foot or less. Nos. 5 and 6 are worked at Canton and Cuba, where they are from 4 to 5 feet in thickness. No. 7 ranges from 1½ to 3 feet in this county, but has not been worked, except in a limited way.

Along the Alton and Chicago railroad, from Bloomington to Carlinville, a distance of about 100 miles, coal No. 5 has been found at every point where a boring or shaft has been carried down to the proper level. The South Shaft at Bloomington has been sunk to one of the lower seams, probably No. 2 or 3 of the general section, which was found to be 3½ feet in thickness, and afforded a better quality of coal than that of No. 5.

In the vicinity of Springfield, No. 5 is reached at a depth of 175 to 250 feet, and the coal averages about 6 feet in thickness, with a good roof of bituminous shale and limestone. At Virden, it is 320 feet below the surface, and at Carlinville 266 feet.

At Alton a lower seam is worked, that probably is the equivalent of No. 1 of the general section, as its position is very near the bottom of the Coal Measures. It is about 3 feet thick, and affords a coal of fair quality. At Edwardsville, and on Wood river, southeast of Alton, the seam known in this portion of the State as the Belleville coal, is reached by shafts of 75 to 100 feet in depth. This coal is No. 5 or 6 of the general section. It outcrops at Belleville, in St. Clair county, and along the bluffs, on the east side of the Illinois bottom, from Caseyville to the old Pittsburg mines, southeast of St. Louis, and has been penetrated by shafts from the highlands in various parts of the county. The fossils that characterize its roof-shales are different from those usually most abundant in the roof of No. 5, and for that reason I have been disposed to consider it the equivalent of No. 6 of the general section. If this conclusion is correct, the lower seams, except the seam at Alton, are not represented in Madison or St. Clair counties, so far as is known at this time.

The Belleville coal outcrops at Sparta, in Randolph county, and near Pinckneyville, in Perry county, and is penetrated by shafts from 50 to 75 feet in depth at Duquoin and St. Johns, on the Illinois Central railroad.

This brief review of the general distribution of the main coals of the lower Coal Measures, around the northern, western and southern borders of the Illinois Coal Field, will afford a general idea of the extent and value of these fuel deposits, where they are so near the surface as to be easily accessible; and it is a matter of paramount interest to the future prosperity of that portion of the State, where the main coals, if developed at all, are from 500 to 1,000 feet or more below the surface, that careful experiments should be made with the drill, to determine their existence if possible, so that they may be made available hereafter, when the demand for coal will justify the outlay of the capital required to reach it at greater depths. Hence it is all important that every boring made through the upper Coal Measures should be extended down to the bottom of the coal formation, if a workable seam was not sooner reached, and the work should in all cases be placed in charge of thoroughly competent and reliable persons, so that a thorough knowledge may be obtained in regard to the development of the lower coals over the whole area of our extensive coal field. The time is not far distant when a seam of coal five feet in thickness can be profitably mined at a depth of a thousand feet or more, as is now done in Great Britain. There is no mineral resource of our State that possesses a tithe of the value of our coal mines, and nothing should be left undone that will tend to their full and complete development.

Although coal is by far the most valuable product of the Coal Measures, it is by no means the only one to be found in that formation. Excellent free-stone abounds in it at many localities, and coarse grit-stone suitable for grindstones, and refractory sandstones for furnace hearths; fire-clay and potter's-clays of various qualities, and limestones adapted to the various uses to which such material is applied. The stone for the old capitol building was obtained from a Coal Measure limestone on Sugar Creek, seven miles south of Springfield; and a bed of limestone lower down in the series, which outcrops south of Petersburg, in Menard county, affords layers that take a good polish, and may be used as an ornamental stone. There are but few counties within the area of our coal field where valuable quarries of building stone may not be found.

Iron ore also abounds in this formation, and although the bands or seams are generally thin, yet there are some localities where the variety known as "kidney ore" is quite abundant, and will no doubt be utilized for the production of iron and steel at no distant day.

These useful minerals add greatly to the wealth and prosperity of the commonwealth by diversifying labor, and thus enhancing the value of the products of the soil. There is no other geological formation in this State that can for a moment be considered comparable with the Coal Measures in the intrinsic value of its economical products, and the wide area which it covers renders these valuable mineral resources available over a large portion of the State, without the cost of extended lines of transportation.

CHAPTER VII.

ON THE ORIGIN AND FORMATION OF PRAIRIES.

By Prof. Leo Lesquereux.

The question of the formation of the Prairies, after a long time of repose, has lately come again under examination, and has been reviewed, first, by myself, in 1856, then by Professor Whitney, in the first chapter of the Report of the Geological Survey of Iowa, and more recently by Professor Winchell, in Silliman's Journal (2), volume 38, page 332. As this question is of great importance for the State of Illinois, and a clear understanding of it may give valuable indications for the best management and cultivation of the soil of the prairies, I have, by direction of the State Geologist, prepared for this Report a short account of what I have formerly published on this subject.*

Prairies are, at our time, in process of formation along the shores of our lakes,—Lake Michigan, Lake Erie, etc.,—as also along the Mississippi and some of its affluents, especially the Minnesota river. The formation of these recent prairies, whose extent is not comparable to that of the primitive ones, is peculiar, and has the greatest analogy with that of the peat bogs. Where the lake wears or currents strike the shores or the low grounds, and there heap materials, —sand, pebbles, mud, etc.,—they build up more or less elevated dams or islands, which soon became covered with trees. These dams are not always built along the shores; they do not even always follow their outline, but often enclose wide, shallow basins, whose waters are thus sheltered against any movement. Here, the aquatic plants, sedges, rushes, grasses, etc., soon appear, these basins become swamps,

* *Bulletin de la Soc. des Sci. Nat. de Neuchatel* (1857), Silliman's Journal, volume 2.

and, as it can be seen near the borders of Lake Michigan, though the waters may surround them, the trees never invade them, never grow upon them, even when the swamps become drained by some natural or artificial cause. Along the Mississippi and the Minnesota rivers the same phenomenon is observable, with a difference only in the process of operation. In time of flood the heaviest particles of mud are deposited on both sides of the principal current, along the line of slack-water, and, by repeated deposits, dams are slowly formed and upraised above the general surface of the bottom land. Thus, after a time, of course, the water thrown on the bottoms by a flood is, at its subsidence, shut out from the river, and both sides of it are converted into swamps, sometimes of great extent. Seen from the high bluffs bordering its bottom land, the bed of the Minnesota river is, in the spring, marked for miles by two narrow strips of timbered land, bordering the true channel of the river, and emerging like fringes in the middle of a long, continuous, narrow lake. In the summer, and viewed from the same point, the same bottoms are transformed into a green plain, whose undulating surface looks like immense fields of unripe wheat, but forms, in truth, impassable swamps, covered with rushes, sedges, etc. By successive inundations and their deposits of mud, and by the heaping of the detritus of their luxuriant herbaceous vegetation, they become, by and by, raised up above the level of the river. They then dry up in the summer, mostly by infiltration and evaporation, and when out of reach of floods, they become first wet and afterwards dry prairies.* In that way admirable locations for river towns have been built up. On the Mississippi, Prairie du Chein, Prairie la Fourche, Prairie la Crosse, etc., are, as indicated by their names, infant towns located on formations of this kind. These splendid patches of prairies, though of a far more recent origin than the immense plains above them, are, nevertheless, true prairies. Bordered on one side by the high, timbered banks of the bottoms, a fringe of trees separates them still from the actual bed of the river; nevertheless, the trees do not invade them.

This peculiarity of formation explains, first, the peculiar nature of the soil of the prairies. It is neither peat nor humas, but a black soft mould, impregnated with a large proportion of ulmic acid, produced by the slow decomposition, mostly under water, of aquatic plants, and thus partaking as much of the nature of the peat as

*The lowest or deepest part of these alluvial prairies is, of course, farthest from the river, along the bluffs. There, generally, the percolation of water through the banks forms springs and deep swamps often transformed into peat bogs.

that of the true humas. In all the depressions of the prairies, where water is permanent and unmixed with particles of mineral matter, the ground is true peat.

It is easy to understand why trees cannot grow on such kind of ground. The germination of seeds of arborescent plants needs the free access of oxygen, for their development; and the trees, especially in their youth, absorb by the roots a great amount of air, and demand a solid point of attachment to fix themselves. Moreover, the acid of this kind of soil, by its particularly antiseptic property, promotes the vegetation of a peculiar group of plants, mostly herbaceous. Of all our trees, the Tamarac is the only species which, in our northern climate, can grow on a peaty ground; and this, even, happens only under rare and favorable circumstances—that is, when stagnant water, remaining at a constant level, has been invaded by a kind of mosses, the *Sphagnum*. By their power of absorption, their continuous growth and the rapid accumulation of their remains, these mosses slowly raise the surface of the bogs above water, and it is then, in this loose ground, constantly humid but accessible to atmospheric action, that the Tamarac appears.

Now, let us examine the prairies according to this idea of their formation, and see if, from the first trace of their origin to their perfect completeness, there is anything in their local or general appearance that is not explained by it, or does not agree with it.

The Bay of Sandusky is now in process of transformation to prairies, and is already sheltered against the violent action of the lake by a chain of low islands and sand-banks, most of them covered with trees for a long time—at least, judging from the size of the trees. All these islands are built up with the same kind of materials, shales, with lacustrine deposits, either moulded into low ridges under water, or brought up and heaped by waves and currents. Around the bay, especially to the southwest, there are extensive plains, covered with shallow water. Their bottom, in the depressions towards the lake, and when the aquatic vegetation is only at its origin, is sandy clay. But in more shallow places, the clay is already muddy and blackened at its surface by the detritus of the herbaceous vegetation which has grown upon it. Further towards the borders, and in proportion to the shallowness of water, the detritus thickens; and still further, we have wet prairies with exactly the same vegetation as that of the lake swamps, and a black soil with a substratum of clay; same materials also as those of both the deeper and the more shallow swamps of the lake.

In receding from the borders of the lakes towards the high prairies, the transition from wet to dry prairies is by such insensible degrees that it would be impossible to fix a point of separation between them. All the surface appearances are the same. Vegetation is here and there modified by the presence of some peculiar species of herbaceous plants; but nothing more. The homogeneousness of the soil is still more striking. It is the same kind of clay, or sub-soil, overlaid by the same kind of black, spongy mould. And if here and there we see knolls covered with trees, the cuts of the railroads show that the materials of which they are made differ in their compound from the ground of the prairies, even if they are scarcely elevated above the general level, and that they are of the same nature and of a similar formation to those of the wooded, low islands of the lakes.

Reporting now our observations on the numerous lakes which dot the high rolling prairies, especially in Western Minnesota, we see there the process of formation of the prairies still repeated in the same way. These lakes are of every size; small sometimes, and circular, true ponds; as large sometimes, also, as thirty to forty miles in circumference, and in this case, shaping the outlines of their shores according to the undulations of the prairies; dividing into innumerable shallow branches, mere swamps covered with water plants, and emptying themselves from the one to the other, passing thus by slow degrees toward the rivers, not by well marked channels, but by a succession of extensive swamps. These are the sloughs which separate the knolls of the prairies, or, so to say, the low grounds of the rolling prairies. They are nearly dry in summer, but covered in the spring time by one to three feet of water. Their vegetation is merely sedges and coarse grasses. I have never seen fishes in these sloughs, but plenty of craw-fishes, and a great quantity of fresh water shells.* Wherever the borders of the lakes are well shaped, not confounded with or passing into swamps, they rise from five to six feet above the level of the water, and are timbered mostly with Oak and Hickory. This elevated margin is more generally marked on the eastern side of the lakes; a record of the action of the waves under the prevailing winds. The heaped materials are the same as those of the bottoms of the swamps, or as those over which the prairies have been formed. But they have been removed from the influence of stagnant water; that is the only difference.

---

* Especially *Planorbis trivaloris*, *P. lentus*, *Lymnæa appressa*, *L. emarginata*, *L. decidiosa*, etc. The lakes have the same species, with many bivalves, and a great abundance of fishes, especially cat-fishes, *Pimelodus*.

From these facts no other conclusion can be taken than this: that all the prairies of the Mississippi valley have been formed by the slow recess of sheets of water of various extent, first transformed into swamps, and by and by drained and dried. The high and rolling prairies, the prairies around the lakes, those of the bottoms along the rivers, are all the result of the same cause, and form a whole, an indivisible system.*

But how is it, then, that the prairies are not everywhere perfectly horizontal? And, as there is some uneavenness of surface, have not the undulations of the rolling prairies been formed like the low islands of the lakes? And why, then, are they not timbered? I believe that, though undulated the surface of the prairies may be now, it has been originally horizontal enough to form shallow lakes, and then swamps, like those which now cover some parts along the shores of Lake Erie, Lake Michigan, etc. Where this horizontality has disappeared, it is only by very slow degrees, under the erosive action of the water in its slow movement, to follow every change of level, seek an outlet, and thus to establish channels of drainage. I have followed, for whole days, the sloughs of the prairies, and have seen them constantly passing to lower and well marked channels, or to the beds of the rivers, by the most tortuous circuits, in a manner comparable to the meanderings of some creeks in nearly horizontal valleys. Indeed, the only difference is, that in the high prairies there is not a definite bed, but a series of swamps, extending, narrowing, winding, in many ways. This explanation appears to me so natural that I could not understand how high prairies could be perfectly horizontal. Along the lakes, and in their vicinity, the horizontality is a necessary consequence of the primitive evenness of the bottom, and of the proximity to water. The level of the low prairies being scarcely above that of the lakes, their surface, after an overflow, becomes dry by percolation and evaporation, rather than by true drainage. But wherever the rivers have cut deeper channels, as is the case in the north part of the Mississippi basin, where they run sometimes from one to three hundred feet lower than the surface of the high prairies, the drainage has constantly taken place towards those deep channels, and the water, though its movements may be very slow, furrows the surface in its tortuous meanders, and from this results that irregular wavy conformation of surface, generally and

* ATWATER, in Silliman's Journal, volume 1, page 116, and BOURNE, *ibid*, volume 2, page 30, have both considered the prairies as originating from swamps, without, however, giving an explanation of the phenomenon.

appropriately called *rolling*. In Indiana and Illinois, in the vicinity of the Wabash river, for example, there are some high prairies, as at Terre Haute, surrounded by a margin of low wooded hills, which have been originally shallow lakes of difficult and slow drainage. Moreover, their horizontality is rather apparent than absolute. Some parts of them are already dry enough to be plowed and cultivated in the spring; some other parts are used as wet meadows, while others are covered with water, and inaccessible. This apparent horizontality results from the great width of what we may call already channels of drainage. These will, by and by, contract and deepen, and thus the prairies become undulating.

Contrary to this opinion, it has been supposed that the irregularities of the surface of the prairies have been caused by currents at the time they were under water, for it is said. the spaces between the knolls are not deep and narrow sloughs, or simple trenches, but broad depressions, broader than the knolls themselves, and this could not be the case if they had been formed by erosion of water.*

This objection, I think, is groundless. As we have seen it, in considering the surface of the low and of the flat prairies, the drainage being insensible, water cannot have any action in digging trenches. In the spring, or after heavy rains, its slow movements extend over the whole breadth of the low grounds, scarcely displacing and taking away the thinnest parcels of matter. This cannot be considered as an erosion; nevertheless, it is certain that all the sloughs of the rolling prairies find their way to lower and deeper channels, where they definitely shed their water. It is certain, also, that in reaching the Mississippi, the Minnesota, etc., the sloughs are deeper and nearly perpendicular to the direction of the rivers. Thus the *rolling* of the prairies along the great rivers resembles a succession of fronting abutments. Prof. Whitney, in the first chapter of the Geological Report of Iowa, makes a corresponding remark when he says (p. 17): "*The streams of the prairies usually take their rise in small depressions of the high prairies, scarcely to be noticed as being below the general level of the region. As their course continues, the beds generally sink, etc.*" Indeed, the bottoms of our lakes, and of the ocean, also, are marked along the shores by swells and deep furrows; but they are of quite a different form from that of the knolls of the prairies, and whenever, by the receding of the water, they appear above the surface, they are immediately covered by a luxuriant arborescent vegetation, and from the timbered islands of our lakes or the long peninsulas bordering

* Prof. Desor, *Bulletin Soc. Science Nat. de Neuchatel*, Dec., 1856.

the ocean. The timbered coteaux of our prairies, *coteaux des bois, coteaux des bois rouges*, etc., are certainly caused by such swells of the primitive bottoms.

That the prairies have been originally covered with water to their highest points, is a fact acknowledged by geology and proved by the traces of submergence and deposits left along the course of our rivers to the highest point of their sources, even to the prairie near the base of the Rocky Mountains, at an altitude of 5,000 feet above the ocean. The Glacial epoch, marked by the formation, or, rather, the dispersion of the drift, has been followed by a period of subsidence—the Champlain epoch;* and this, afterwards, by a period of slow upheaval and slow drainage, still in activity on our North American continent. The records of this movement are marked in denudations, deepening of channels, moulding of terraces along the lakes and rivers,† and in the prairies formed were all the horizontal surfaces which were successively left, covered with vast sheets of shallow water, during the process of slow emergence.

Prof. Whitney, in the same report mentioned above, examining the same question of the formation of the prairies, and admitting their original submersion, considers the absence of trees as caused by the fineness of the soil, which he attributes in part to the nature of the rocks underlying it, and, in part, to *the accumulation, in the bottom of immense lakes, of a sediment of almost impalpable fineness under certain conditions.* This explanation, I think, cannot satisfy the mind. Prairies cover every kind of geological formation, even granite rocks—as in Minnesota, between St. Peters and Fort Ridgley. Most generally they overlie the drift. It is evident that the black soil of their surface, as well as the clayey sub-soil, whatever the thickness of these strata may be, have been formed in place by the agency and growth of a peculiar vegetation. In stagnant water, whenever water is low enough to admit the transmission of light and air in sufficient quantity to sustain vegetable life, the bottom is first invaded by Converræ, and especially by Characeæ, and a peculiar kind of floating moss (*Hypnum aduncum, Hedn*). These plants contain, in their tissue, a great proportion of lime, alumina, silica, and even of oxyd of iron,‡ the elements of clay. When exposed to atmospheric influence, the Characeæ become covered with an efflorescence of scarcely carbonized or pure iron. Moreover, this vegetation of the low stagnant waters

* Dana's Manual of Geology, p. 547.

† The Terrace epoch. Dana's Manual of Geology, p. 554.

‡ DeCandolle Physiol. Veget., pp. 183 to 188.

feeds a prodigious quantity of small mollusks and infusoria, whose shells and detritus greatly add to the deposits. The final result of the decomposition of the whole matter is that fine clay of the sub-soil of the prairies, which is indeed truly impalpable, when dried and pulverized and unmixed with sand. This kind of formation has been observed and described a long time ago, especially by Chrome, who correctly attributes it to the decomposition of Conferræ, Characeæ, etc., the clay over which peat bogs generally grow, and which, by its appearance and compound, is nearly the same as that underlying the prairies. A large pond in the King's garden, at Fredericksburg, in Denmark, is every year filled with about one foot of clayey matter, by the decomposition of Characeæ, small mollusks and infusoria. But we have no need to go far to examine a kind of formation observable in nearly every open swamp of ours. In the lakes of the high prairies the phenomenon presents sometimes a peculiar character. At the depth of from one to three feet, the above named plants, Mosses, Conferræ and Charas, form a thick carpet, which hardens, becomes consistent, like a kind of felt, and, floating about six inches above the bottom, is nearly strong enough to sustain the weight of a man. This carpet is pierced with holes, where fishes pass to and fro; and the bottom, under it, is that fine impalpable clay, evidently a residue of the decomposition of its plants. At the depth of three and a half to four feet this vegetation suddenly ceases, and the bottom of the lakes is pure sand and pebbles, with shells. Nearer to the borders, on the contrary, at a depth of one foot, the carpet of mosses, etc., begin to be intermixed with some plants of sedges, which become more and more abundant in proportion as the depth decreases. As soon as the blades of these plants reach above the water, they absorb and decompose carbonic acid, transform it into woody matter, under atmospheric influence, and then their detritus is, at first, clay mould, and then pure black mould, the upper soil of the prairies. Of course, near the borders of the rivers, or under peculiar circumstances, the formation is somewhat modified by the addition of transported matter or of foreign elements. The clay may thus take a different color, have a somewhat different composition, but the process of formation does not materially change.

Considering the whole explanation of the formation of the prairies, as it is exposed in this paper, I think that it covers the whole ground, and applies to most of the cases, if not all, where the ground is naturally naked or without trees. It gives the reason of the presence of the prairies from the base of the Rocky Mountains to the borders of the Mississippi river; of the prairies around the lakes and of those of the broad flat bottoms of our southern rivers; of the *plates* of the Madeira river; of those of the Paraguay; of the *pampas* of Brazil; even of the desert plains of our western Salt Lakes—for this formation is produced in the same manner in the salt marshes of the sea as in the fresh water swamps of our lakes. And if, passing to other continents, we examine in Europe the low natural meadows of Holland, the barrens or heaths of Oldenburg, all the plains on the shores of the North and of the Baltic seas, and in Asia the vast steppes of the Caspian, etc., etc., we find everywhere the same appearances, the same results of a general identical action, modified only by local, mostly climatic circumstances.

In a paper recently published*, Prof. WINCHELL, of Michigan, has contradicted my opinion on the formation of the prairies, in a few words, which merit an examination not only in consideration of the high authority in which they come, but also in order to have a full and clear understanding of the most important phenomena accompanying the formation of the prairies. He says: *that a theory often urged is the considerable humidity of the soil of certain prairies, which prevents the growth of trees*, and he supports it by this mere assertion: that it is singular that such an opinion could be entertained when it is so well known that there is no situation so wet but certain trees will flourish in it: *the Willow, the Tupelo, the Water Oak, the Tamarac, the American Arbor Vitæ, etc.* And considering Prof. WHITNEY'S supposition that the extreme fineness of the prairie soil is the cause of the absence of trees, he puts it off in the same way by another assertion: *that the fatal objection to this theory and all the theories which look to the physical or chemical condition of the soil for an explanation of the treeless character of the prairies, is discovered in the fact that trees will grow on them when once introduced.* As it is not proper to refute an assertion by a contrary one, let us examine under what circumstances trees may grow in some swamps, and what the highest scientific authorities have to say on the subject.

It is a well known fact of Botanical Physiology, that trees absorb by their roots a certain amount of oxygen necessary to their life. It is in accordance with this principle that trees, to thrive well, ought not to be planted too deep; that most of the species of trees perish when their roots are buried in a stratum of clay impermeable to air, or underlaid by clay impermeable to water: that whenever the water of a creek is dammed to make a pond, all the trees are

* Silliman's Journal, vol. 38, p. 343.

killed on the whole flooded space. Current water, even when its movement is slow, furnishes to certain species of trees (most of the species cited by Prof. WINCHELL), whose roots, when immersed, have the property of dividing themselves into innumerable filaments, a sufficient amount of air and oxygen for their life. Hence such trees grow in swamps inundated by the water of adjacent rivers, or periodically invaded by the tides. The water of such swamps is not permanent, and its whole mass is subjected to some kind of movement. It is thus that in the South, the Bald Cypress and the Tupelo grow even in the middle of creeks and bayous. But look everywhere else, along the rivers and on the sea and lake shores, and wherever a sheet of shallow water is sheltered against the waves, the tides or currents, you find, invariably, treeless swamps passing to prairies.*

The single fact, to my knowledge, which could be mentioned as sustaining the assertion under consideration, is, that peculiar kinds of shrubs, the Button-Bush, the Swamp Rose, etc., form thickets around some true swamps in the forests. But in examining the process of germination of the seeds or the young shoots, it is easy to see that the germs are not developed in water, but in the dry, decayed matter of rotten, prostrated trees. In summer, and only when the margins of the swamps are dry, the swamps become in that way surrounded by a belt of shrubs, but its central part is open and inhabited by herbaceous plants only.

Now, what says DECANDOLLE, in his classical book on Vegetable Physiology? "That a constant irrigation necessary for the rice culture in Lombardy, has a great inconvenience, because the water penetrates the ground of the neighboring properties, and *kills the trees*." That "water left stagnant for a time on the ground rots the trees at their column, prevents the access of oxygen to the roots, and *kills them*." That "in the low grounds of Holland they dig, for planting trees, deep holes, and fill the bottom with bundles of bushes, as a kind of drainage for surplus water, as long as the tree is young enough to be *killed by humidity*." That "the true swamps and marshes have no trees, and cannot have any, because stagnant water *always kills them*."† Authorities like these could be cited by volumes.

The second assertion, that *trees will grow on the prairies when once introduced*, or planted, is certainly true. But we should take care

*Some species of trees, like the Magnolia, grow on the southern peat bogs, by the same reason that Tamaracs grow on the peat bogs of the North.

†DeCandolle, Physiology of Vegetation, p. 1206 to 1212.

to make a distinction been the results of an artificial process and those of a natural one. When trees are planted on the prairies, the soil is conveniently pre-prepared. The clayey sub-soil mixed with the black mould forms a compound which combines density of certain parts with lightness of others, and contain a great proportion of nutritive elements. If the clay of the sub-soil is not too thick to be impermeable to water, and thus to retain it around the roots, this prepared or artificial ground is indeed very appropriate to the growth of trees. But, has ever anybody seen Oaks or Hickory, or any other kind of trees, grow in the prairies from a handful, or from a bushel, of acorns or of nuts thrown upon their surface? Why, then, if *trees will grow* on the prairies, do we not see those isolated and far-between clusters of trees, which appear here and there on the borders of ancient lakes, cover a wider area, and by and by invade the whole prairies? Some of these trees have lived there for ages; their trunks are strong and thick, and their branches, widely expanded, are shaken, and their fruits swept away by the impetuosity of the autumnal storm; and nevertheless their domain is restricted by the nature of the ground to limits which they have never surpassed.

To close this examination, we have still to test the value of the above remarks by comparing them with what we know, from agricultural experience, of the nature of the soil of the prairies. Its thickness is first to be considered. In Illinois it varies from one to four feet, and even more.* How has been produced this enormous coating of black mould which covers the clay sub-soil? And, also, how has this subsoil been produced if not under the influence and action of water? Complete oxydation of vegetable remains has never resulted in the heaping of such a peculiar thick compound as is the soil of the prairies. Even in our oldest and still virgin forests the humus is never so deep. In some bottoms, perhaps, the arable ground may be found as thick; but it is not the result of vegetable decomposition, but of successive accumulations of mud by floods. We must then consider this prairie soil as formed under peculiar chemical action, by a slow oxydation or decomposition of vegetable matter, retarded in its action by water, in preventing the free access of oxygen, as it has happened in the formation of the peat. But

* In the oldest and highest rolling prairies, the soil has been often washed away and its thickness reduced, by the same agency which has moulded the knolls, or by water. There, the black mould is generally heaped in the low grounds or sloughs. It is well understood, also, that the general thickness of the soil of the prairies depends, for each locality, on the length of time during which they have been covered with water.

in this last matter, the oxydation is much slower and less complete; and water being permanent, not exposed to change of levels, cannot bring into it the elements of fertility which it gives to the soil of the prairies. This soil is then, as we have said, half peat and half humus.

The great proportion of ulmic acid contained in the prairie soil, is perceivable in its slow decomposition when exposed to atmospheric action. The overturned sod of the prairies would scarcely become decomposed and pulverized in two or three years, if its disintegration was not helped by repeated plowings. It is this acid which in too large proportions, renders sometimes the soil hard or sour. But it has also the property of preserving for a longer time the fertilizing elements mixed with it. Hence, it is one of the causes of the long continued productiveness of the prairie soil. Under the influence of stagnant water, and the remains of animals which have inhabited it while the soil was in process of formation, silica especially, with alumina, ammonia, and other elements, have entered it in sufficient proportion, and caused its extraordinary fertility, and especially its inexhaustible productiveness for grasses; for by the impermeability of the under clay, the fertilizing elements have been left in the soil. As natural meadows, our prairies have fed for centuries innumerable herds of Buffalo, Deer, etc., which roamed over them, and now they will feed and fatten our herds of cattle for as long a time as we may want it. More than this, from the peculiar compound of the soil, the prairies under cultivation may produce, for an indefinite length of time, crops of cereals, corn, wheat, etc. as rich as may be obtained from the richest bottom land, and without any apparent diminution of the productive capacity of the soil. Even if, by successive crops of the same kind, the upper soil should become somewhat deprived of its fertilizing elements, especially of the silica, lime and alumina, so necessary for the growth of corn, do we not know by experience, as we know it from details of its formation, that the sub-soil is a real mine of these fertilizing elements, and that deep plowing will return to an exhausted prairie land its primitive fertility.

For the culture of trees, also, our explanation of the formation of the prairies give directions the most in accordance with what experience teaches us to be right. To plant trees which do not like humidity—fruit trees, especially—dig deep holes, pass through the clay to the drift and thus establish a natural drainage. Fill, then, the bottom of the hole with loose materials, pebbles, bushes, sod or mould, and thus you have the best ground that can be prepared for the health and long life of trees. When this cannot be done and shade trees are desirable, for example, plant, in any hole deep enough to contain the roots, elms, buttonwood, white locusts, etc., all species which live generally along the rivers and support a certain degree of humidity, and they will thrive, if only they get some air through the ground which covers them.

We cannot consider the prairies as resulting from some kind of casualty of nature, but as the visible expression of one of its laws, printed, so to say, by the hand of Divine Power. They are as much in harmony, agree as well with the destiny of our American people, as our immense coal fields and their rich deposits. Like these prodigious sources of combustible mineral, they clearly point out the future of the race of men which is called to inhabit them and profit by their fertility. While one of these formations is destined to furnish an immense population the elements of industrial greatness, the other is ready to provide it with both the essential elements of life—bread and meat. Hence the prairies have their place marked in the future history of mankind. They do not indicate or prophecy luxury, laziness and dissipation of life, but hard work, abundance, and the enjoyment of freedom and true manhood.

CHAPTER VIII.

CHEMICAL REPORT FOR THE GEOLOGICAL SURVEY OF ILLINOIS.

By Dr. J. V. Z. Blaney.

Prof. A. H. Worthen, State Geologist:

Dear Sir—The limited time since the receipt from you of specimens for analyses, has permitted the completion of a part of them only. The number of coal specimens being the greatest and forming the most complete series, I commenced with them; and with the valuable assistance of Mr. Geo. A. Mariner I have been enabled to report the results of the whole number—fifty-nine specimens. I have reported to Mr. McChesney the results of the analyses of two limestones, in regard to which I was only desired by him to ascertain the proportions respectively of carbonate of lime and of carbonate of magnesia. A limestone, labeled "From DeWitt C. Dougherty's place, Union county—to be tested for hydraulic properties," gives the following result:

Carbonate of lime	89.257
Carbonate of magnesia	9.300
Clay, oxide of iron	1.399
	99.956

This result gives too large a proportion of carbonate of lime and magnesia, compared with the proportion of silicates of alumina and iron, to warrant the supposition that it would make good hydraulic lime. Comparison with the following, extensively used for the manufacture of a hydraulic cement, which is highly esteemed, will confirm this opinion. This specimen was forwarded for analysis by Mr. J. H. McChesney, and labeled "Limestone used at Clarke's Cement Mills, at Utica, LaSalle county":

Carbonate of lime	43.50
Carbonate of magnesia	30.07
Carbonate of protoxide of iron	2.00
Clay (silicate of alumina)	20.00
Silica (free)	1.00
Alumina (free)	a trace
Potash	0.18
Water	3.00
	99.75

The limestone from Union county contains so small a proportion of ingredients other than carbonates of lime and magnesia, that it should make, by burning, an excellent lime for building purposes.

Three specimens of Iron ore were received for analyses, all from Hardin county. They were labeled, "Iron ores, Hardin county, Illinois; from the vicinity of Illinois Furnace."

Specimen No. 1.—This was a very close, heavy pipe-ore—the imitative form of the pipe-stem well observed; scarcely any ochreous admixture. It gave the following results:

Water	11.46
Silica	3.155
Alumina	1.680
Peroxyd of iron	81.220
Oxyd of maganese	0.145
Magnesia and lime	none
	97.660

No. 2.—Was a pipe-ore of less regular structure, and with much ochreous deposit between and around the "pipes." It gave the following analysis:

Water	12.265
Silica	3.960
Alumina	3.160
Peroxyd of iron	81.220
Maganese, magnesia and lime	none
	100.605

No. 3.—This is an ore of hydrated protoxyd of iron, which might be termed "Limonite." It was heavy, compact, massive; without imitative form, but slightly cellular. Superficially, and within the larger cells, was a thin ochreous deposit, partly yellow or buff and partly vermilion, in colors. It gave the following analysis:

Water	10.985
Silica	2.900
Alumina	2.140
Peroxyd of iron	84.620
Peroxyd of magnese	a trace
Lime and magnesia	none
	100.645

As regards the soils which were sent, I regret to say that the time intervening between the receipt of the specimens and the time at which this report was received was too short to permit their complete analysis; and unless complete, they would be useless. They are consequently not reported.

The analysis of soils is so important, in view of the immense preponderance of the agricultural interests of the State, that it is to be hoped that the Legislature will make appropriations which will secure the analysis of a large series of soils. This should be done with reference to the character of virgin soils, known to produce largely of certain crops, as compared with the same soils which, by constant cropping, have ceased to be productive. This would, if the number of analyses were sufficient, give valuable and reliable suggestions in regard to the proper rotation of crops and the character of manures required to restore productiveness. The nature of subsoils should also be examined on a somewhat extensive scale, to ascertain whether or not the specific ingredients wanting in worn-out soils may be restored, and soils naturally poor may not be improved, by deep, sub-soil plowing. The specific wants of different soils for special crops, for fruit culture, etc., and many mooted points in agriculture and horticulture, might thus be settled.

Herewith I transmit a report explanatory of the table of analyses of coal specimens, and which you will use at your discretion.

I am, sir,

Yours, respectfully,

JAS. V. Z. BLANEY.

Report accompanying the Table of Coal Analyses, by James V. Z. Blaney, A.M., M.D.

In accordance with your request, I append some remarks on the practical application of fossil fuel, which, while claiming but little on the score of originality, may be of value to some readers of the report.

The inexhaustible stores of fossil fuel which the State of Illinois holds concealed in her bosom, has scarcely begun to claim the attention which its immense importance demands. The small proportion of the State covered with timber, compared with the vast extent of prairie, indicates that at no distant day the numerous railroads which intersect the State, in all directions, will be forced to resort to mineral fuel as an unavoidable necessity; while for manufacturing and domestic purposes its almost exclusive use will soon be equally imperative. In addition to its uses simply as fuel, the comparatively recent chemical inventions, by which illuminating and lubricating oils are economically extracted from bituminous coal, gives an additional reason for encouraging, by legislative action, and otherwise, the development of the vast deposits of this variety of fossil fuel which Providence has so bountifully provided within the limits of our State.

I shall endeavor, as briefly as possible, to indicate the relative value of different kinds of fuel, and more particularly the mode of judging from the results of analysis of the special applications of the various qualities of bituminous coal. As preliminary, a few remarks on the characteristics of the different species of fuel will not be amiss.

Previous to the discovery of the combustible properties of mineral fuel, wood furnished the exclusive fuel for man, and, if we except certain manufacturing districts, still furnishes the principal fuel of the world. It was not, indeed, until the development of steam power, as the grand element of national wealth, that a more effective fuel was demanded. The effective value of any fuel is found to be directly proportionate to the amount of *oxygen* consumed in its combustion. A fuel which contains a certain amount of oxygen already combined with one or other of its combustible constituents, will then give out less heat in burning than another which contains less oxygen, and the most effective fuel for a given weight would be one which contained no oxygen. All fuel consists of carbon, hydrogen and oxygen, in varying proportions. One pound of carbon, in burning, will combine with $2_{66/100}$ lbs. of oxygen, and one pound of hydrogen will combine with 8 lbs. of oxygen. Hence to find the real value of any fuel, it is only necessary to know the portions respectively of carbon, hydrogen and oxygen it contains; then multiply the number of pounds of carbon in 100 lbs. of the fuel by $2_{66/100}$, and the number of pounds of hydrogen by 8, and from the sum subtract the amount of oxygen contained already, and the result gives the effective value of the fuel—for every pound of oxygen effectively consumed will heat 29 lbs. of water from 32° to 212° Fahr., *i. e.* from the freezing to the boiling point. Having, then, the *ultimate* analysis of any kind of fuel, we can easily estimate its real value. But certain kinds of fuel, wood in particular, contain water, mechanically absorbed and retained with much force by capillary attraction. This water is termed the "*Hygrometric*" moisture. It is obvious that a part of the effective heat of combustion of any fuel must be lost in converting this water into steam. Now, one pound of oxygen consumed will convert about $5_{22/100}$ lbs. of water, at 212° Fahr., into steam. If, then, neglecting the heating of the water to 212°, we divide the percentage of water by $5_{66/100}$, we have the correction to be applied for the loss of heat due to the presence of water. To show the importance of this correction, I refer to the following table, which gives the amount of water in several different kinds of fuel:

		PER CENT.	
Oak wood, recently cut, contains		34.70	water
Oak wood, air dried	"	16.64	"
Beech wood, green,	"	39.70	"
Beech wood, air dried,	"	18.56	"
Poplar wood, green,	"	50.60	"
Poplar wood, air dried	"	19.55	"
Bituminous coal		from 2.00 to 12.00	"

I shall have occasion hereafter to refer to another effect of the presence of "Hygrometric moisture" upon the value of coals for special purposes.

From the table given further on, of the ultimate analyses of different kinds of fuel, it will be seen that wood contains more oxygen, and is consequently much less effective for any given weight, than other kinds of fuel.

Fossil fuel may be divided into four classes, characterized geologically by their relative age, and chemically by their greater or less departure from the constitution of woody fibre or ligneous matter, from which they all originated. There are, first, Peat or Turf; second, Brown Coal or Lignite; third, Pit Coal, Sea Coal, or Bituminous Coal; fourth, Anthracite.

In order to exhibit the composition of each variety, and the greatest transition from wood, as the starting point, and anthracite as the ultimate result, of a gradual decomposition which has been the work of ages, I give the following ultimate analyses of different kinds of fuel:

Kind of fuel.	Carbon.	Hydrogen.	Oxygen.
Oak wood	49.10	6.30	44.60
Peat or turf	60.10	6.10	33.80
Fossil wood	57.80	5.80	36.40
Lignite	72.30	5.30	22.40
Bituminous coal	82.60	5.60	11.80
Anthracite	94.04	1.75	4.21

From this table we see that in the transition from woody-fibre to bituminous coal, if we except the fossil wood, there has been a much larger proportional loss of oxygen than of hydrogen, and with a proportional increase in effective heating power. In changing from bituminous to anthracite coal, we notice a great loss of hydrogen as compared with the loss of oxygen. Now, the loss of oxygen in the former instances is effected mainly by the formation of carbonic acid or "choke damp," by its combination with the carbon; and the loss of hydrogen in the conversion of bituminous into anthracite, is by combination of the hydrogen with carbon to form carbureted gas or "fire damp." The experience of miners goes to show that from the lower coals the fire damp is emitted in largest proportion, and the "choke damp" from the newer coals.

Of these several varieties of mineral fuel, the third, or bituminous coal, is the only one which occurs in such quantity in our State as to deserve our special consideration.

The bituminous coals differ so much, in several particulars, that they may be classified in several different ways, viz: 1st, by variety in their structure; 2d, by their behavior in the fire; and lastly, by their chemical constitution. The last-named mode only can be considered scientific, but the others have a practical value which entitles them to some consideration.

The classification based on the structure of the coal is as follows:

1st. "*Cubical Coal.*"—The celebrated Pittsburg seam is the type of this kind. It is black, shining, compact and tolerably hard. It is particularly characterized by breaking into cubical masses, from the existence of natural joints or planes of separation, perpendicular to the plane of stratification; the cleavage in the plane of stratification has, in some specimens, a tendency to a conchoidal fracture. The powder of this variety is frequently brown. In general, it cokes very much, and, if free from sulphur, is generally a good blacksmith coal.

2d. "*Slate*" or "*Splint Coal.*"—This variety is distinguished by the facility with which it separates into lamina or slaty plates in the direction of the plane of stratification, with a difficult cross fracture. It seldom, if ever, cakes much on the fire. It usually contains more ashes and is heavier than the former variety. It is not a good blacksmith coal, but is, if not containing too much ashes and sulphur, an excellent steam coal, and may be used without coking in the blast furnace. In general, it bears transportation better than the cubical variety.

3d. "*Cannel Coal.*"—This variety is easily distinguished from other varieties by the absence of the shining fracture. Its fracture is dull and earthy or resinous. It cleaves with difficulty in the lines of stratification, and is still more difficult in the cross fracture. Its texture is close, and in the best qualities it gives a dull, woody sound on being struck. It is a difficult coal to mine, and the "seams" are not as reliable as those of the other varieties. The best qualities are exceedingly rich in bituminous matter, and, as a class, this variety yields, by distillation, more oils than others. There is a greater variety of composition in this than other kinds, especially in the amount of ashes contained, which varies from 2.50 to 50.C0 per cent. In the latter cases it scarcely deserves the name of coal, but is more properly termed "bituminous shale," and its coke is entirely useless. Upon the fire it retains its form, and is apt to decrepitate, splinters or flakes being thrown about by the escape of moisture as steam. A thin flake lighted in a candle continues to burn for some time after removal.

4th. *"Glance Coal."*—Very closely resembles anthracite, and is of an iron-black color. It has a beautiful metallic lustre, does not soil, and its fragments are sharply edged. It cokes with difficulty.

The second mode of classifying, or rather of describing, varieties, is by their behavior in the fire, as follows:

1st. *"Close Burning Coals,"* or *"Coking Coals."*—By this is meant, that when thrown upon the fire the coal becomes pasty or adhesive, and the fragments, large and small, become cemented together into a single mass. This kind of coal varies in the degree of its "coking" quality, and has its advantages and disadvantages. It is valuable alone, or mixed with other kinds, for the manufacture of coke, as good coke being made of the *"slack,"* or fine coal, as of the lumps. It is mostly "cubical" in structure, and is eminently a blacksmith's coal, as it forms a hollow fire. It burns well in open grates, even the finest dust coking to form a mass. As a steam coal it is in general inferior to the dryer coals, as it does not permit as free draught, and requires to have the doors opened more frequently to break up the masses of coke which obstruct the draught. This admits cold air, with a proportional loss of heat. From the same causes producing a deficiency in the supply of oxygen, in close furnaces and stoves, a certain proportion of the volatile matters is apt to escape combustion, with loss of value and clogging of flues. This difficulty is in part obviated by increasing the surface of grate-bars and stoking in thinner strata. The invention of perfect smoke-consuming furnaces for steam boilers and locomotives is as yet a desideratum, and when effected, will add largely to the value of this variety of coal. The caking quality is generally considered as the result of the presence of a very large proportion of bituminous matter in the coal, but this is by no means invariably the case, since the coal of Anzin, in France, is represented as a caking coal, and, by the analysis of Barthier, contains 70.5 per cent. of fixed carbon, with but 25.0 per cent. of volatile matter. On the other hand, a coal from Calder, near Glasgow, in Scotland, yields, according to the same analyst, but 51.0 per cent. of fixed carbon, and 45.0 per cent. of volatile matter, and is classed as a dry or open-burning coal. The composition of a coal is not, then, a sure indication of its behavior in the fire, experiment alone determining the fact.

2d. *"Dry Coals,"* or *"Open-Burning Coals."*—This variety is characterized by the opposite qualities to the last. In structure they are mostly "splint" coals. On the fire they generally cement together somewhat where they are in contact, but do not melt and run into a single mass. Some specimens scarcely lose their form in burning, and these (other things being equal) furnish the best steam coals, a continuous draught being kept up through the interspaces between the lumps. The slack of this variety, on the other hand, is almost useless, as it cannot be made into coke, except by large admixture with coking coal, and in furnaces, not cementing on the fire, it runs into the interspaces between the lumps, and impairs the draught. This kind has been successfully used raw in the blast furnace provided with the hot-blast, but is not applicable to the blacksmith's forge.

3d. *"Very Dry," or semi-Bituminous Coals.*—As the name implies, this variety has a much larger proportion of fixed carbon, relatively to the bituminous matter, than the others. They do not cement together at all on the fire, and thus are eminently open-burning coals. They are most highly and deservedly valued as steam coals, and are used almost exclusively by the British Marine steamers, and also by those of France and Egypt. They may be used raw in the blast furnace, but are not valuable for coking or blacksmith's purposes.

The arrangement of bituminous coals into distinct classes, according to their chemical constitution, is not easily made. The most important distinctions are founded on the relative proportions of volatile combustible matter and of fixed carbon. We might thus divide them into 1st, highly bituminous or fat coals; 2d, moderately bituminous, and 3d, semi-bituminous coals. The arrangement into a list, including all coals of known composition, commencing with those which contain the largest proportion of volatile combustible matter and ending with those having the least, would be the most satisfactory method of comparing them and be of the most practical value.

I come, now, to speak of the value of analysis in suggesting the practical applications of coal, and in enabling us to arrive at its true fuel value.

There are three several modes of analysis of coal, all of which should be practiced on the product of a seam of coal, in order to arrive at a complete knowledge of its real value and its peculiar applicability. These are 1st, proximate; 2d, ultimate, and 3d, practical analysis. The first, or *proximate analysis*, is the most easily and expeditiously, and hence the most frequently performed. When well made, it is sufficiently suggestive for most purposes. In the table No. III, accompanying this report, will be found the proximate analysis of fifty-nine specimens of coal. In every case the results there given are the average of two determinations of each ingredient—excepting of the ashes, in some cases. A single determination is not perfectly reliable, even in the most practiced hands. Two should always be made; and if the results differ, to any considerable extent, a third examination should be made.

The first column of figures gives the specific gravity of the specimen; the second, the weight of a solid cubic foot, calculated from the specific gravity. From these two columns we are able to judge somewhat of the structure of the coal, whether loose or compact; of the relation between weight and measure, and hence the number of bushels corresponding to a ton weight. We have also the data from which to calculate the number of tons to a given area of coal land for a seam of given thickness, the amount of room required to store a given weight of coal, and other deductions of practical value.

The third column of figures gives the "moisture." By this is meant the weight per cent. of water which is retained mechanically by the coal, and which is given off at a temperature of about 250° Fahr.—a temperature at which no decomposition of the volatile combustible matters take place. In the analyses reported in most of the works of authority on coals, this moisture is not separately determined, but is included in the estimation of the volatile combustible matters. This detracts much from the value of the analysis, for the hygrometric moisture not only is of no value, as combustible matter, but absolutely diminishes the effective value of the fuel, as shown in a former part of this report. The estimation of this moisture has other bearings of practical importance, which we shall notice presently. The amount of moisture in coal is always greatest at the time of removal from the mine, excepting, of course, after exposure to melting snows or soaking rains. For most purposes all coals improve in value by exposure, *under cover*, to a free circulation of air. This process of "seasoning" permits the escape of a large proportion of the mechanically retained moisture. There is a great difference in the ca acity of different coals to retain moisture, even after long seasoning; and its retention to any large amount must be considered as a detraction from the merits of the coal. There can be no doubt but that the presence of water in any coal diminishes, to a great extent, the amount of illuminating gas which it would otherwise produce. From experiments made in France, by M. PENOT, the following results were obtained:

One kilogram of coal, containing 10 per cent. of water, gave—

Gas of good quality	160 litres.
Gas of poor quality	92 "
Total	252 "

The same coal, previously dried, gave—

Gas of good quality	240 litres.
Gas of poor quality	92 "
Total	332 "

The difference in the product of gas due to the presence of 10 per cent. of water is 80 litres—a little over 24 per cent.; and it is to be noticed that the gas of poor quality is the same in both cases, the whole loss being in gas of good quality.

The analyses of coals celebrated as gas coals, as compared with those not esteemed for that purpose, also show that the former contain but little water as compared with the latter.

The analysis of the Youghiougheny coal of Pennsylvania, which gives a large yield of excellent gas, is reported by Prof. PETER, in the second volume of the Report of the Geological Survey of Kentucky, as follows:

Moisture	1.00
Volatile combustible matter	35.00
Carbon in coke	58.40
Ashes	5.60
	100.00

The analysis of the Briar Hill coal, the favorite at the Chicago Gas Works, gives, by my own analysis:

Moisture	2.40
Volatile combustible matter	28.00
Carbon in coke	67.60
Ashes	2.00
	100.00

There are many coals containing a much larger proportion of volatile combustible matter, but with a larger proportion of moisture, which yield much less and poorer gas than the two varieties given above. These results may be in part accounted for by the chilling of the retorts consequent upon the evaporation of the water, and in part by the fact that in the presence of steam the bituminous matters rise, as oil and tar, below the gas-making temperature. The fact that the tar increases as the gas diminishes, from any cause which lowers the temperature of the retorts, is known to all practical gas makers.

The fourth column of figures gives the volatile combustible matter. In the analysis of coal specimens this constituent is estimated by driving off the volatile matters from the coal by a high temperature. Unless conducted with care by a gradually increasing heat, variations will occur in several analyses of the same specimens. This is owing to the fact, that by rapidly heating the small quantity used for analysis, a much larger proportion of volatile matter may be driven off than by the slower process usual in coking coal in the large way. Consequently a single determination should never be considered satisfactory, but a second should always be made; and if the results differ widely, a third should be made, to secure accuracy.

It is decomposition by destructive distillation of this proximate constituent of coals, which furnishes the valuable illuminating and lubricating oils and illuminating gas; but the amount of these several products is not always proportionate to the amount of bituminous constituent, even when the process for their elimination from different specimens is conducted in the same way and at the same temperature. It is a matter beyond dispute that in different kinds of coals the bituminous matter is differently combined with the fixed carbon and ash, so that in some it is given off freely at comparatively low temperatures, while in others it requires a high temperature to effect the separation. It is, also, a fact, almost beyond doubt, that the nature of the bituminous matter is different in the different kinds of coal. Of this there can be no dispute, so far as the volatile matter of the cannel coals is concerned, as compared with that of other varieties. This supposition is reasonable when we consider the fact that there is great variety in the vegetable impressions found in the coal and the adjacent clays and shales, indicating a variety in the kinds of woody fibre from which the coal was produced. The chemical changes, also, which resulted in the transformation of wood into coal, may have been varied by the different conditions of temperature, moisture, pressure, etc., so as to have produced bituminous compounds of different constitution. The results of the ultimate analysis of a number of coal specimens of different character, sufficiently prove this to have been the case. The indications for the peculiar applications of the different kinds of coal for oil and gas making, from the results of their ultimate composition, will be noticed hereafter. I will only indicate here that in "coking" coals the bituminous matter is obviously more fusible than in the "splint" coals; otherwise splint coals containing the same or a greater amount of bitumen should also fuse and run. The former also undergo destructive distillation at lower temperatures than the latter; hence their freely blazing quality, and their greater liability to loss of value, in practice, by distillation of volatile products without burning. The greater heat which the splint coals must attain before any great amount of their volatile matter is given off, favors the more complete combustion of the gases produced, and hence the value of this variety as steam coal.

The lower temperature at which destructive distillation occurs, in the coking coals, would give them the preference for the manufacture of "coal oils"—not only the quantity, but also the valuable quality of those products depending, in a great measure, on the low temperature at which the distillation is made. The reverse is the case in gas manufacture.

But of all the varieties the cannel coals yield the volatile ingredients by destructive distillation at the lowest temperature, which, taken together with the peculiar composition of their bitumen, which will be referred to hereafter, gives to them, as a class, the preference over all others for the manufacture of "coal oils."

The fifth column of figures gives the amount of carbon in the coke. These figures, added to those of the next column (which gives the amount of ash), give the percentage weight of the coke. These two columns taken together, determine the value of the coal for coking, and for the manufacture of iron, and also to a certain extent as steam-making fuel. For all purposes, of course the less ashes the better, as the ash is incombustible. The determinations of the amount of carbon in the coke is not an absolute, but only a proximate indication of the amount of coke which may be obtained as a practical result on a large scale.

Coking in stacks or heaps gives a less amount of coke from the same coal, than when ovens are used, and still more coke is obtained from retorts. The quantity of coke obtained in practice, by the two latter modes especially, will be probably from five to ten per cent. more in weight than would be anticipated from the analyses as given by the figures of the last column, as the slow process of coke-burning permits a portion of the bitumen to be converted into coke, which, in the rapid process of analysis, escapes as volatile matter.

The quality of coke, as given in the table, gives some idea of the nature of the coal, whether caking or free-burning. The term "swollen" designates that the coke is inflated by the rapid escape of the gasses or vapors from the partially fused mass; hence, that the coal is a caking coal. The term "cellular" indicates that a fusion of the coal has occurred to a certain degree, but that it permitted a freer escape of vapors, and hence was less "caking" in character. The term "close" indicates that the coal is open-burning coal, with but little disposition to cake; while a "pulverulent" coke indicates a dry coal, not fusing at all in the fire. These qualities will exist, to a certain extent, in the coke made by practical process, though the slower the process of coking is effected, the larger the masses coked at a time, and the higher and longer continued the heat at the close of the process, the firmer and closer will be the texture of the coke, and the better it will bear transportation.

The last determination, the ashes, also deserves some notice. If more than five per cent. of ashes exists in the raw coal, it can scarcely be considered fit for the blast-furnace, since this amount is doubled in the coke.

The composition of the ash is also of importance as a means of judging whether or not the coal will "clinker," *i. e.*, the ashes fuse and form solid glassy masses like "slag," which adheres firmly to the grate bars of steam boiler and locomotive furnaces, or to the sides of close furnaces and stoves. If the ashes form much clinker, it is a great drawback to several practical uses. The property of forming "clinker" is dependent upon the presence in ashes of certain substances, which, at high temperatures, form a species of crude glass. This glass is formed by the combination of potash, soda, lime and oxide of iron, with silica. It is for the most part a large proportion of lime and oxide of iron in the ash, which forms with the silica, always present, the clinker. Many coals contain much lime, combined with sulphuric acid, to form gypsum, filling the natural joints, and if the coal at the same time contains much "pyrites," or bi-sulphuret of iron, which during its combustion loses its sulphur, and leaves peroxyde of iron, the materials from which to form clinker are furnished. It requires a high temperature to fuse these ingredients into a slag, and hence many coals which form no clinker in open grates, and are highly esteemed for domestic purposes, are totally useless in the high temperatures of the reverberatory furnace for remelting iron, or even for locomotive use. The *color* of the ash furnishes a correct mode of judging of the proportion of iron contained in the coal, and as most of it exists in the raw coal as iron pyrites, it gives a tolerably reliable means of judging of the relative amount of sulphur. The dark red and brown ashes contain the most iron, and the pink, ochre, fawn-colored, and gray, indicate diminishing proportions of iron. The white ash coals seldom clinker, and contain comparatively little sulphur.

In making the analysis grouped in the table, the sulphur was not specially estimated, simply because no two specimens from the same vein will ever yield the same result. To obtain any satisfactory result as regards the proportion of sulphur in the coal of any seam, it would be necessary to take considerable quantities from different parts of the seam, and, grinding the whole to powder, mingle the powder of the different portions thoroughly, and thus form an average. This is the mode pursued in obtaining averages of the value of copper and other ores.

Ultimate Analysis of Coals.—By this is meant the complete separation of the elementary constituents of the combustible matter of the coal. The strict application of the term would also require the separation of the elements constituting the ash, but this is seldom performed or required.

The ultimate constituents, or elementary bodies composing all coals, are carbon, hydrogen, oxygen, nitrogen and sulphur.

The two last named may, for most practical purposes, be disregarded.

The value of this mode of analysis may be judged of from what was said of the mode of estimating the absolute heating power of any fuel. Ultimate analysis alone can furnish the basis for the calculations.

Ultimate analysis receives an additional value from the results obtained from the valuable experiments of Professor PETER, as reported in volume 2, of the Geological Survey of Kentucky. He finds that the quantity of valuable oil obtained from different specimens of coal, which he submitted to a carefully conducted distillation, bears a certain proportion to the amount of hydrogen. I take the liberty of inserting here several analyses of several cannel coals reported by him, and the amount of crude oil which he obtained from them.

As the type of oil yielding coals, the Scotch Boghead cannel takes precedence, and is placed first in the following table of ultimate analyses of oil yielding coals:

Designation of Coal.	Carbon	Hydrogen	Sulphur	Nitrogen	Oxygen	Ashes	Crude oil in 1,000 grains	Ammoniacal water—Grains	Coke—Grains	Gas—Cubic inches
Boghead coal, Scotland	65.34	9.12	0.15	0.71	5.46	18.68	......	......	......	....
Breckenridge cannel, Ky.	68.128	6.489	2.476	2.264	5.833	12.3fl	318.0	52.10	455	445 good.
Haddock's cannel, Ky.	76.790	6.177	0.241	13.791		3.00	248.5	54.50	589	370 very gd

From this table we perceive that the greater amount of hydrogen the larger the proportion of oil obtained. We derive from this that ultimate anlaysis will give indications of value as regards their usefulness for oil manufacture. This branch of industry is, however, so new, and all facts in regard to the manufacture are so strictly concealed by those who find their interest in preventing its extension, that it is impossible yet to present all the economical considerations connected with it. This much may, however, be stated, that in locations where there is no present or prospective demand for coke, the cannel coals which are the richest in hydrogen, alone can be economically used; in other localities where coke is in large demand it becomes a matter of calculation and experiment to ascertain whether or not some of the ordinary bituminous coals, which yield less oil but more and better coke than the cannels, may not be made available for the manufacture of oils. It also remains for experiment to determine whether the oils derived from the ordinary bituminous coals, are the same or as valuable as those from cannel. It is only by a carefully conducted series of practical analyses of a large variety of coals, with a view to ascertain the proper conditions for extracting the largest amount of crude oil, and the further practical analysis of the crude oils, to determine the quantity and quality of the several oils contained in the crude oil, that this question can be solved.

This brings me to speak of the objects and the value of practical analyses of coals. The objects of this mode of chemical examination are various, according to the nature of the use to which the location of the coal seam directs its special application. The object in view may be the quantity and quality of the coke in view of its application to iron manufacture; it may be the amount and quality and ease of purification of the gas furnished by the coal, which is desired to be known. Deductions of value, it is true, may be furnished by the proximate or ultimate analysis of the coal, as before indicated, but the variety of characters of the coal, which may modify the practical results, are so numerous, that the actual production of the coke, gas or oils, on a scale of more or less magnitude, will alone determine absolutely the value of the coal for the special application proposed.

Analytical chemists are so seldom called upon to perform practical experiments of this character, that their laboratories are not usually provided with the requisite apparatus to conduct the investigation on a sufficiently large scale to give it practical value.

Provision should be made in the chemical departments of all geological surveys made under the auspices of States, which owe much of their mineral wealth to their coal deposits, to secure an extensive series of examinations of this character. It is to be hoped that the Legislature of Illinois will sufficiently appreciate the value of such researches, as to make appropriations sufficient to permit of having made for the next report a series of practical examinations of all the important coals of the State.

STATEMENT *of results of the Analyses of Coal specimens as furnished for that purpose by A. H. Worthen, Esq., State Geologist, as follows:*

	Bitumen. First determination.	Bitumen. Second determination.	Carbon. First determination.	Carbon. Second determination.	Water	Ash	Coke. First determination.	Coke. Second determination.	Average Composition. Water	Average Composition. Ash	Average Composition. Bitumen	Average Composition. Carbon	Average Composition. Coke
Dilse & Co.'s coal, near Coatsburg, Adams county, Ill	34.79	31.75	55.17	58 21	5.85	4.19	59.36	62.4	5.85	4.19	33.27	56.69	60.88
Piper's coal, two miles north of Canton, Fulton county, Ill	29.07	30.57	62.85	61.36	6.17	1.91	64.76	63.27	6.17	1.91	29.82	62.10	64.01
John Winterbottom's coal, 2½ miles south of Cuba, Fulton county, Ill	29.40	30.72	57.93	56.58	5.18	7.51	65.44	64.09	5.18	7.51	30.06	57.25	64.76
Effnour's coal, near Cuba, Fulton county, Ill	30.84	30.77	57.84	57.86	5.94	5.38	63.22	63.24	5.94	5.38	30.80	57.85	63.23

STATEMENT *of the Analyses of specimens of Iron Ore and Clay, as furnished by A. H. Worthen, Esq., State Geologist, as follows:*

	Iron ore from Chadsey's place, Schuyler county, Ill	Argillaceous iron ore from Pennsylvania, analyzed by Professor Rogers	Under-clay from Dilse & Co.'s coal, near Coatsburg, Adams county, Ill	Fire-clay used at Birmingham, Eng., in making glass-melting pots, analyzed by C. Cooker	Remarks.
Peroxyd of iron		.23			The Chadsey place iron ore is an argillaceous carbonate of iron, of excellent quality, comparing favorably wiih the Pennsylvania ores—the analysis of one of the best of which is given in the adjoining column.
Protoxyd of iron	52.31	53.03	4.57	1.0	
Lime	1.16	3.33	1.27	.5	
Magnesia	1.48	1.77	.70		
Silica	8.84	1.40	44.57	75.3	
Alumina	10.44	.63	38.07	16.8	The under-clay, from Dilse & Co.'s coal, is a good fire-clay, though (from excess of iron) inferior to that in the adjoining column, which is one of the best.
Water		1.41		6.0	
Carbonic acid	25.77	35.17	10.82	4	
Bitumen		3.03			
	100.00	100.00	100.00	100.00	

CHEMICAL REPORT OF

TABLE III—

Number.	County.	Specific gravity.	Weight of a cubic foot.	Moisture.	Volatile combustible matter.	Carbon in coke.	Ashes.	Total volatile matter.	Coke.	Color of Ashes.
	Bureau:									
1		1.2594	78.4858	12.4	28.4	54.0	5.2	40.8	59.2	Pinkish-gray.
2		1.3160	82.0131	11.2	28.8	57.6	2.4	40.0	60.0	Nearly white.
	Mercer:									
3		1.3349	83.1910	8.8	29.8	51 8	9.6	38.6	61.4	Fawn.
4		1.4005	87.2792	5.2	28.6	49.0	17.2	33.8	66.2	Pinkish-gray.
5		......	......	8.0	33.4	51.4	7.2	......	58.6	Nearly white.
6		1.2440	77.5261	8.0	31.2	56.4	4.4	39.2	60.8	Nearly white.
7		1.2167	74.8147	10.0	30.8	56.8	2 4	40.8	59.2	Fawn.
8		1.5860	98.8395	8.0	19.2	35.6	37.2	27.2	73.2	Nearly white.
9		1.2594	78.4858	6.8	30.8	53.2	9.2	37.6	62.4	Dark gray.
10		1.2755	79.4892	10.8	30.0	55.2	4 0	40.8	59.2	Ochre.
11		1.3089	81.5706	9.2	31.2	52.4	7.2	40.4	59.6	Nearly white.
12		1.3021	81.1469	6.0	32.2	56.2	5.6	38.2	61.8	Dark gray.
13		1.2594	78.4858	8.4	31.2	54.8	5.6	39.6	60.4	Fawn.
	Warren:									
14		1.3157	81.9944	10.0	23.0	58.6	8.4	33.0	67.0	Ochre.
15		1.2437	77.5071	10.8	28.4	56,4	4.4	39.2	61.2	Cinnamon
16		1.2755	79.4892	6.0	33.0	53.4	7.6	39.0	61.0	Lilac.
17		1.3089	81.5706	8.0	30.8	54.4	6.8	38.8	61.2	Ochre.
18		1.4409	89.7969	2.8	28.8	44.0	24.4	31 6	68.4	Dark gray.
	Marshall:									
19		1.2285	76.5601	11.2	30.2	55.8	2.8	41.4	58.6	Light gray.
20		1.3812	86.0764	8.4	28.4	52.4	10.8	36.8	63.2	Fawn.
	Knox:									
21		1.2285	76.5601	11.2	25.2	61.6	2.0	36.4	63.6	Dove.
22		1.2920	80.5174	9.6	27.8	61.0	1.6	37.4	62.6	Pinkish-gray.
23		1.2755	79.4892	10.4	27.6	55.2	6.8	38.0	62.0	Dove.
24		1.2755	79.4892	11.6	29.3	55.9	3.2	40.9	59.1	Ochre.
25		1.2919	81.5112	8.8	30.8	58.0	2.4	39.6	60.4	Light gray.
26		1.2594	78.4858	12.0	27.2	55.2	5.6	39.2	60.8	Pinkish-gray.
27		1.2594	78.4858	5.6	37.4	53.6	3.4	43.0	57.0	Fawn.
28		1.2932	80,5922	8.8	30.0	57.2	4.0	38.8	61.2	Pinkish-gray.
29		1.2500	77,9000	9.2	31.4	55.0	4.4	40.6	59.4	Nearly white.
	Peoria:									
30		1.3089	81.5706	11.2	35.8	51.8	11.2	37.0	63.0	Nearly white.
31		1.2652	78.8473	9.6	31.6	54.8	4.0	41 2	58.8	Lilac.
32		1.3624	84.9048	10.0	22.4	56.8	10.8	32.4	67.6	Ochre.
33		1.3192	82.2125	10.0	30.8	56.4	2.8	40.8	59.2	Nearly white.
34		1.2437	76.5074	12.8	25.8	58.6	2.8	38.6	61.4	Light gray.
35		1 2594	78.4858	9.6	29.6	59.6	1.2	39.2	60.8	Dove.
36		1.2652	78.8473	11.2	26.0	60.4	2.4	37.2	62.8	Dove.
37		1.3089	81.5706	12.0	26.2	59.8	2.0	38.2	61.8	Nearly white.
38		1.3022	81.1531	12.0	25.8	59.0	3.2	37.8	62.2	Dove.
39		1.3228	82.4369	12.0	25.2	53.2	9.6	37.2	62.8	Fawn.
40		1.3089	81.5706	10.8	26.0	55.6	7.6	36.8	63.2	Nearly white.
41		......	......	8.0	26.8	56.0	9.2	......	65.2	Nearly white.
42		1.3812	86.0764	10.0	26.6	53.0	10.4	34.8	63.4	Nearly white.
	LaSalle:									
43		1.2437	77.5076	10.0	27.4	55.0	7.6	37.4	62.6	Fawn.
44		1.2439	77.5198	10.8	28.2	55.0	6.0	39.0	61.0	Lilac.
45		1.2690	79.0841	10.0	29.8	55.8	4.4	39.8	60.2	Lilac.
46		1.2854	80.1061	12.0	26.0	57.6	4.4	38.0	62.0	Cinnamon.
47		1.2920	80.5174	10.8	27.8	56.2	5.2	38.6	61.4	Cinnamon.
48		1.3090	81.5769	10.0	27.4	54.6	8.0	37.4	62.6	Light gray.
49		1.2077	75.2639	11.2	28.6	58.2	2.0	39.8	60.2	Dove.
50		1.3888	86.5500	6.8	33.0	43.4	16.8	39.8	60.2	Cinnamon.
51		1.2209	76.0865	10.0	25.2	56.0	8.8	35.2	64.8	Cinnamon.
	Grundy:									
52		1.3193	82.2188	10.8	27.6	53.2	8.4	38.4	61.6	Cinnamon.
53		1.3441	83.7643	11.2	23.4	56.2	9.2	34.6	65.4	Lilac.
54		1.2594	78.4858	10.8	29.2	58.2	1.8	40.0	60.0	Light gray.
55		1.2776	79.0291	10.8	27.8	59.8	1.6	38.6	61.4	Dove.
	Randolph:									
56		1.3812	86.0764	9.0	22.6	56.0	12.4	31.6	68.4	Cinnamon.
57		1.3515	84.2255	7.4	27.8	58.4	6.4	36.6	64 9	Lilac.
58		1.2786	79.6824	7.0	29.6	58.2	5.2	36.6	63.4	Lilac.
59		1.2274	76.5926	8.0	28.8	58.0	5.2	36.8	63.2	Nearly white.

GEOLOGICAL SURVEY.

COALS.

Quality of Coke.	Designation.
Cellular slightly swollen	Sheffield Coal Company, below the clay seam.
Close, not swollen	Sheffield Coal Company—above the clay seam.
Close, not swollen	Carnahan's Mine—bottom part.
Pulverulent between fingers	Carnahan's Mine—below slate in centre.
Cellular not swollen	Carnahan's Mine—just above slate in centre.
Cellular slightly swollen	Carnahan's mine—upper part of seam.
Cellular much swollen	Collins' Mine—lower part of seam.
Pulverulent	Collins' Mine—middle part of seam.
Cellular not swollen	Collins' Mine—upper part of seam.
Cellular not swollen	Peas' Mine—town of Suez, 30-inch seam.
Cellular not much swollen	Shoemaker's Mine—lower part.
Cellular swollen	Shoemaker's Mine—middle part.
Pulverulent between fingers	Shoemaker's Mine—upper part, 4 feet.
Pulverulent between fingers	G. W. Mier's Mine—town of Spring Grove.
Cellular slightly swollen	Bliss' Mine—near Avon.
Cellular slightly swollen	W. H. Smith's Mine—Spring Grove—lower part.
Close, not swollen	W. H. Smith's Mine—Spring Grove, upper part.
Pulverulent	Chambers, Town & Co.'s Mine—near Avon.
Cellular swollen	William Fisher's Mine—Lacon Station, 3 feet 7 inch seam.
Close, not swollen	William Fisher's Mine—Lacon station, upper pt. of 3-ft.sm.
Cellular swollen	J. Bursan's Mine—bottom of seam No. 2. of Peoria county.
Cellular much swollen	J. Bursan's Mine—upper pt. of sm. No. 2, Kickapoo coal sm.
Cellular swollen	Barbus' Mine—near Maquon.
Cellular not swollen	Oneida Mine—Camp & Powel—below clay seam.
Cellular much swollen	Oneida Mine—Camp & Powel—above clay seam.
Close, not swollen	Oneida Mine—Camp & Powel—upper part of upper seam.
Cellular swollen	Benjamin Sinn's Mine—lower part of 6 feet seam.
Cellular swollen	Benjamin Sinn's Mine—lower part of 6 ft. seam, 2d sample
Cellular swollen	Benjamin Sinn's Mine- middle part.
Cellular moderately swollen	Aikin's Mine—lower past of seam No. 1.
Cellular much swollen	Aikin's Mine—middle.
Pulverulent	Aikin's Mine—upper.
Cellular swollen	Hammet's 3 feet seam.
Cellular much swollen	R. Howard's Mine—lower 2 feet, seam No. 2.
Cellular swollen	R. Howard's Mine—middle.
Cellular much swollen	R. Howard's Mine—upper 18 inches.
Cellular much swollen	Phelps' Mine—middle of seam No. 2.
Cellular swollen	Phelps' Mine—top.
Cellular not swollen	Isaac Brown's land coal seam No. 3.
Close, not swollen	S. S. Edwards' Mine—middle seam No. 1.
Close, not swollen	S. S. Edwards' Mine—2d sample.
Cellular not swollen	S. S. Lawrence's Mine—top of seam No. 1.
Cellular slightly swollen	Little Vermilion—Rockwell & Lathrop's Mine—coal seam [No. 1.
Cellular much swollen	Peru shaft—lower part of seam No. 1.
Cellular moderately swollen	Peru shaft—middle part.
Cellular swollen	Peru haft—top part.
Cellular slightly swollen	Northern Illinois Coal Company—seam No. 1.
Cellular moderately swollen	North. Ill. Coal Co—seam No. 2, middle 2d vein, lower part.
Cellular swollen	North. Ill. Coal Co—seam No. 3, lower part of top of 1st vein
Not swollen, pulverulent	North. Ill. Coal Co.—thin layer at top of seam No. 2.
Cellular not swollen	Geo. W. Feels' Mine—lower LaSalle coal seam.
Close, not swollen	Geo. Riddle's Mine—1½ miles south of Morris—upper part [best.
Cellular slightly swollen	Geo. Riddle's Mine—2½ miles, etc.
Cellular slightly swollen	A. Crum's Mine—2 miles northeast of Morris.
Cellular slightly swollen	P. W. Gates' Mine—1½ miles above Morris.
Pulverulent between the fing'rs	Pope's coal—lower stratum.
Cellular moderately swollen	Pope's coal—middle.
Cellular moderately swollen	Pope's coal—upper.
Cellular slightly swollen	Boyd's Mine—top coal.

CHAPTER IX.

GEOLOGY OF RANDOLPH COUNTY.

This county is located on the southwest borders of the State, and comprises an irregular district of country, triangular in outline, and bounded on the north by Monroe, St. Clair and Washington counties, on the east by Perry and Jackson counties, and on the south and west by the Mississippi river and Monroe county. It embraces a superficial area of about sixteen townships, or five hundred and seventy-six square miles. It is intersected from north to south, on the western border, by the Okaw or Kaskaskia river, which empties into the Mississippi about ten miles above the south line of the county, and on the east it is also traversed in the same direction by Mary's river, which enters the Mississippi about four miles below the mouth of the Okaw. In addition to these, we find Horse creek and Nine Mile creek, which are tributary to the Okaw, traversing the northern portion of the county, and the Little Mary, a tributary of Mary's river, intersecting the southern portion. These streams, with some others of less note, furnish this county with an abundant supply of water.

The topographical features of the county are somewhat varied. About one-third of its surface, comprising the northeastern portion, has a comparatively level, or gently rolling surface, sufficiently undulating, however, to furnish an effectual surface drainage, and comprises all the prairie region in the county. The prairies in this portion of the State are small, and possess a loamy soil of a chocolate-brown color, with a yellow clay sub-soil. These prairie lands, although not possessing the deep black soil so characteristic of the prairies in the central and northern portions of the State, are, nevertheless, very productive, yielding good crops of corn, wheat, barley, oats and grass, without manure, and may perhaps be considered as equal, in productive qualities, to the average of the prairie soils of the State. The prairie region is restricted, mainly, to that portion of the county underlaid by the Coal Measures.

Between this prairie region and the bottom lands on the Okaw and the Mississippi river there is a belt of country that is underlaid by the sandstones, shales and limestones of the Chester group, which is quite broken and hilly. This portion of the county was covered with timber in its normal condition, and a considerable portion of its surface is still occupied by the natural forests. The soil upon these timbered and broken lands does not appear to differ very much, in its appearance or productive qualities, from that of the adjacent prairies; and where the lands are sufficiently level to be cultivated, good crops are usually obtained. The yellow clay sub-soil of this region appears to possess all the essential elements of a good soil, and when brought to the surface and subjected to atmospheric agencies, it becomes quite productive. Hence, deep and thorough plowing that will bring this sub-soil to the surface, and intermingle it with the partially worn out surface soil, will no doubt be found greatly beneficial to those soils that, from long and injudicious cultivation, have become partially exhausted.

These broken lands are well adapted to the growth of every kind of fruit suited to a temperate climate, and peaches, apples, pears and all the smaller fruits may be successfully cultivated, even where the lands are two hilly for the cultivation of the cereals. Some of the enterprising German citizens of this country have already commenced the cultivation of the grape, and the manufacture of native wines, and have, so far, met with good success. It is still a question, whether the Catawba will succeed as well here as at more northern localities; but other varieties, as the Norton's Virginia, Concord, Delaware, etc., may, no doubt, be successfully cultivated here. The Catawba seems to be less liable to be affected by mildew or rot, in a climate as cold as it can stand without protection, than in a comparatively mild one, and hence its cultivation in Southern Illinois has generally proved a partial failure, while at localities much farther north it has been comparatively successful. That the broken and hilly lands along our principal streams, especially the bluffs of the Mississippi, and some other large rivers, where the marly deposit known as "loess" has been deposited, and is more or less intermingled with the soil, are admirably adapted to the growth of the vine, is no longer a doubtful problem, and the labors of the intelligent agriculturist have already demonstrated the fact, that Illinois is capable of producing, not only all the native wines required for home consumption, but also a large surplus for the supply of less favored regions. When pure native wines can be so easily produced in our own State, it is to be hoped that the time is not remote when its use will entirely supersede the nauseous and dangerous compounds that are now so commonly sold under the name of imported wines. Viewed exclusively as a matter of dollars and cents, there is no other product of the earth, the cultivation of which has been attempted in this portion of the State, that will afford as liberal a return for the labor expended, as may be obtained by the cultivation of the grape, and the time must surely come, and that at no very remote period, when all these broken lands now lying waste, and regarded as of little value except for the timber they afford, will be covered with vineyards, affording employment and sustenance to a healthy, moral and happy population.

The general elevation of these lands above the Mississippi, is from three to four hundred feet. The principal varieties of timber that they afford are, black oak, white oak and scarlet oak, shell bark and pig-nut hickory, sugar maple, linden, black-gum, persimmon, red, slippery and white elm, black ash, red-bud, dogwood and sassafras. On the bottom lands in this county we find sycamore, cottonwood, honey-locust, hackberry, box-elder, sweet gum, white ash, swamp oak, burr oak, white and black walnut, pecan and white maple. On the bank of the river, between Chester and the mouth of Mary's river, we saw a magnificent specimen of the American Wistaria, in full bloom, on the 20th of May. Its stem was about four inches in diameter, and it attained a height of from thirty to forty feet. This is the only locality in the State where we have seen this magnificent climber, except in the gardens of the horticulturist.

Surface Geology.—The surface deposits of this county comprise the three usual sub-divisions of the Quaternary system, designated as alluvium, loess and drift. The most important alluvial deposit in the county is that known as the American Bottom, which commences on the eastern shore of the Mississippi, just below the city of Alton, and extends southward to the mouth of the Okaw, forming a belt of rich alluvial bottom land in this county about twenty miles in length and about four miles in average width. This belt of bottom land is exceedingly productive, and were it not for the periodical overflows to which it is subjected from the high waters of the Mississippi, it would be esteemed as the most valuable land in the county. A considerable portion of it is only subject to overflow during seasons of extraordinary high water, which usually occurs once in about seven years. Some portions of it, however, are overflowed nearly every year, and are not cultivated. But these swampy portions are gradually becoming elevated above the water level by the accumulation of sediment deposited upon them by every overflow of the turbid waters of the Mississippi, and will eventually become sufficiently dry to be susceptible of cultivation. The soil on these bottom lands is quite sandy, but is intermingled with humus or vegetable mould, and clay, from the sediments of the river, forming a rich, warm soil that, for the production of corn and the cereals generally, is unsurpassed by any in the State.

The loess is a deposit of light brown or buff siliceous marl, sometimes, also, quite calcareous, as is the case in this county, and then it contains nodules of carbonate of lime, that have resulted from the leaching of the calcareous mass. It capps the bluffs of the Mississippi and other large streams in this county, and is also met with in some of the valleys in the interior of the county, and appears to have a variable thickness of from ten to sixty feet, or perhaps at some points even more. It generally contains great numbers of bleached shells, mostly of the fluviatile species still existing in the adjacent region. It gives origin to the bald knobs, that are often a conspicuous feature in the river bluffs. These are destitute of timber, and are but partially covered with scattering tufts of coarse grass.

The drift deposits of this county comprise a series of brown and yellow clays, intermingled locally with gravel and small pebbles, spread over the entire surface of the uplands and underlying the loess where both are present. Some large boulders of igneous and metamorphic rocks were seen in the valleys of the streams, but these are not so numerous as they are in the Central and Northern portions of the State. Specimens of galena, resembling the ores of Potosi, Mo., are frequently found beneath the soil in this county, and if they were transported by natural causes to the spot where they have been found, they would indicate the prevalence of easterly currents during the latter part of the drift period. But their proximity to the surface would seem to render it probable that they had been transported and dropped by human agency.

The stratified rocks exposed at the surface in this county include a portion of the lower Coal Measures, from the micaceous sandstone above coal No. 6 in the general section, to the base of the measures, together with the Chester group and the St. Louis group of the lower Carboniferous limestone series.

Coal Measures.—The beds exposed in the county that belong to the Coal Measures comprise a series of micaceous sandstones, limestones and shales, with two seams of bituminous coal. The thickness of the whole, including the conglomerate at the base, probably does not exceed two hundred and fifty feet. The following vertical section will show the succession and comparative thickness of these beds in this county:

Micaceous sandstone and shale	30 to 40	feet
Band of limestone	3	"
Shale	12	"
Limestone and bituminous shale, sometimes replacing each other	4 to 6	"
Coal (Belleville)	6 to 8	"
Fire-clay and nodular limestone	3 to 6	"
Shale or shaly sandstone	30 to 40	"
Limestone	3 to 4	"
Bituminous shale	3 to 5	"
Coal No. 5 (?)	2 to 4	"
Fire-clay	2 to 4	"
Shale and sandstone (conglomerate)	50 to 150	"

The western boundary line of the Coal Measures enters this county from the south, in the western part of township 7 south, range 5 west, and with a general trend of north northwest passes out of the county, on the north, in the eastern part of township 4 south, range 7 west. They underlie, therefore, about one-third of the entire area of the county, embracing the prairie region, which is usually considered also the best agricultural portion of the county. The sandstone and shales that form the base of this group of strata give origin to a more broken surface, along their line of outcrop, than the higher beds. They appear to be considerably thicker in the southern than in the northern portion of the county, thinning out towards the north with the lower members of the Carboniferous system. Along their outcrop, which forms a belt from two to five miles in width along the western border of the coal field in this county, the surface is generally broken, and approaches, in its topographical features, the belt of country still farther west, that is underlaid by the sandstones, shales and limestones of the Chester group.

The vertical section of the Coal Measures in this county includes the horizon of three coal seams; but only two of these appear to be developed in this county. These are the Belleville coal (No. 6) and a lower seam, probably No. 5. The Belleville coal seam is very regular in its development in this county, with an average thickness of about six feet; and, so far as we have been able to learn from the miners engaged on this seam in Randolph county, it appears to be free from the interruptions termed "*clay-slips*" and "*horse-backs*," that sometimes prove to be a serious impediment to the working of this seam in some of the counties further north. It almost invariably has a good roof, composed either of limestone or hard bituminous shale, either of which forms a substantial roof, and renders the working of the seam both safe and economical. The coal from this seam is tolerably hard, compact, of a bright color and intersected by thin vertical seams of carbonate of lime, with some iron pyrites in the lower part of the seam. The two upper layers of coal are generally free from pyrites, and afford a good article of smith's coal. This coal is sometimes underlaid by a thin bed of fire-clay, but this is frequently absent, and the coal then rests directly on a bed of nodular argillaceous limestone. The limestones, both above and below the coal, are locally fossiliferous, though no fossils have yet been found in this county in the bed below the coal. The limestone over the coal at Pope's coal-bank, on Mary's river, contains the following species of fossil shells: *Spirifer cameratus, Productus costastus. P. Prattenianus, P. longispinus, Chonetes granulifera, C. mesoloba, Hemipronites crassus, Discina nitida.*

The coal at Pope's bank is deposited in five distinct layers, measuring respectively sixteen, twelve, fifteen, sixteen and thirteen inches. This stratified character was observable at all the localities visited in this county, where this seam had been opened. Pope's bank is on section 21, township 5 south, range 5 west, and is about four miles southeast of Sparta. The outcrop is on the west bank of Mary's river, only about five feet above the river bed. This seam undoubtedly underlies all the highlands in the northeast part of the county, and outcrops on all the small streams in the vicinity of Sparta, and will probably be found to underlie the town at a depth of not more than one hundred and twenty to one hundred and fifty feet.

At Boyd's coal bank, one mile west of Sparta, the coal is obtained by a shaft sunk to the depth of about fifty feet, through the following beds:

Clay and gravel	20	feet
Limestone	2	"
Shale	15	"
Limestone	5	"
Coal	6	"

At this bank the coal has a slight easterly dip, and it presents the same general appearance as at Pope's bank.

Wood's coal bank is a mile and a half northeast of Boyd's, and the coal is mined by a shaft forty feet in depth. The coal is six feet thick, and is overlaid by bituminous shale and limestone.

Ritchie's coal mine is located on the southwest quarter of section 9, township 5 south, range 6 west. The coal is from four feet to four feet six inches in thickness, and is overlaid by limestone. This is probably the lower seam, as we infer from its westerly outcrop and the thickness and general appearance of the coal, although the limestone that forms the roof, as well as a nodular limestone below it, would seem to ally it to the Belleville coal.

Following down the small stream on which this coal bank is located, we found a nodular limestone underlaid by a band of chert or hornstone, and the latter by sandy shales with some concretions of bluish-gray sandstone and ferruginous and calcareous bands, and passing downward into the sandstone that forms the base of the Coal Measures.

On the east side of Mary's river the Belleville coal has been opened at several localities in the vicinity of Georgetown. The principal bank worked in this vicinity is that of the Messrs. Jones, on the southeast quarter of section 14, township 6 south, range 5 west. The coal in this vicinity lies about twenty-five or thirty feet below the surface, and is generally about six feet in thickness. At Jones' bank the roof is a bituminous shale, but on Mr. Doggett's place, a quarter of a mile southeast of this, the roof is a dark-blue nearly black limestone. Four miles south of Georgetown, on Mr. Steele's place, this seam outcrops in the bluffs of a branch of Cox's creek. The coal is here said to be six feet thick, though at the time of our visit the old diggings were full of water, so that the thickness of the coal could not be accurately measured. The coal is overlaid, at this locality, by about three feet of bituminous shale, and about six feet of hard, dark, bluish-gray, irregularly-bedded limestone. Three miles northeast of Georgetown, on the old Anderson farm, this seam has also been opened and some coal taken out, and it has been found at various other points, in this part of the country, in sinking wells, and generally at a depth not exceeding twenty-five feet below the surface. Owing to the want of proper facilities for the transportation of these coals to a good market, very little mining is done in this part of the county, at the present time, and this rich deposit of mineral wealth is quite unappreciated, and is only mined for the local supply of the neighboring blacksmiths, and one or two steam mills in the vicinity.*

*Since the original report on this county was published in 1866, two railroads have been constructed through this county, furnishing adequate transportation for its coal, as wel as all other products.

Below the nodular limestone, under the Belleville coal, there is a bed of shale of variable thickness that intervenes between the two coal seams as they are developed in this county. The lower coal, which we have referred to No. 5 of the general section, is variable in thickness, but always much thinner than the Belleville seam. It outcrops about two miles south of Georgetown, on section 22, township 6 south, range 5 west, on the lands of J. B. Holmes, Esq. It is here from eighteen inches to two feet in thickness, and is overlaid by bituminous shale and a thin band of brown limestone. Morrison's coal is probably the same seam, and is on section 26, township 5 south, range 6 west. The coal is from three to four feet thick at this locality, and is overlaid by about five feet of massive, light bluish-gray limestone. This coal appears to be somewhat harder than that from the Belleville seam, contains less carbonate of lime but more pyrites, though the upper part of the seam is said to afford a very good smith's coal. This seam is underlaid by fireclay, the thickness of which was not seen, and this passes downward into the sandy shale and sandstone that forms the base of the Coal Measures. The only fossils found in connection with this lower seam were a small *Bellerophon* and a *Naticopsis*, obtained from the band of brown limestone that overlies the coal at the locality two miles south of Georgetown.

No indications of the presence of the lower coal seams were observed in this county, and it is hardly probable that they will be found here.

Chester Group.—This important division of the lower Carboniferous limestone series is well developed in this county, and in thickness exceeds that of all the other groups in the county combined. The following vertical section will give a general idea of the comparative thickness and relative position of the different members of this group:

Gray compact siliceous limestone No. 1	25 to 30	feet
Shales and shaly sandstones, with fossil plants—*Sigillaria, Stigmaria, Lepidodendron* and *Knorrhia*, partially exposed	80 to 90	"
Shaly limestone No. 2	15 to 18	"
Massive brown sandstone, presenting a speckled color when freshly broken	40	"
Limestone No. 3, upper bed at Chester	40 to 45	"
Green and blue argillaceous shales, with plates of limestone	45 to 70	"
Arenaceous and argillaceous limestone No. 4, sometimes replaced with green shale	20 to 30	"
Massive and shaly sandstone, speckled on a freshly broken surface	15 to 20	"
Compact and granular gray limestone No. 5, with intercalations of blue, green and purple shales; thickness about	150	"
Massive quartzose brown sandstone	120	"
	613	"

This group attains its greatest thickness in the southern part of the county, and the upper divisions become considerably thinner in the aggregate in the extreme northern part. It composes the entire river bluff, from a point about two miles below the old village of *Prairie du Rocher* to the south line of the county, also the bluffs of the Okaw throughout its whole extent in this county. We did not find either of the two lower beds entirely exposed at a single locality so that they could be accurately measured, but the estimated thickness we have assigned to them will probably be found a near approximation to their average thickness in this county.

At the city of Chester, the middle portion of this group forms the greater portion of the river bluff, and the beds afford the following section at this point:

Green and purple shales	8 feet
Compact gray limestone, in regular beds	10 "
Limestone, in irregular beds, partly nodular and argillaceous, and passing downward into shale	32 "
Green and blue argillaceous shales, with thin plates of limestone and ferruginous bands	70 "
Compact gray limestone, with intercalated beds of blue and green clay shales	82 "
	202 feet

Above the upper limestone in this section there is a bed of quartzose sandstone that is partially exposed in the hilltops adjacent to the city. This sandstone is overlaid by another limestone which may be found underlying some of the ridges between the river bluffs and Gravel creek, northeast of the city. Going eastward from Chester to Georgetown, the upper beds of this group are partially exposed in the bluffs of the small streams beyond Mary's river, but the most satisfactory section of them can be made in the vicinity of Liberty. The thick bed of green and blue shales in the above section is quite variable in character, especially towards the base, where the shales are frequently replaced with sandstone and limestone. Not more than a hundred yards above the point where the above section was made, there is a bed of sandstone replacing the shale immediately above the lower limestone, and at Cole's Mill, a mile below; this sandstone is succeeded by an argillaceous limestone, which, with the sandstone, occupies nearly or quite one-half the entire thickness of the shale. The variable character of these beds in their lithological features, and the general specific identity of the prevailing fossils through the whole group, renders the identification of the various sub-divisions in the local and partial outcrops a matter of some difficulty.

The *lower sandstone* of the Chester group has heretofore been known as the Ferruginous sandstone, but as it presents no very different lithological appearance from the other arenaceous divisions of this group, and it seems proper that it should be included in the

Chester group, we have rejected the name heretofore used, prefering rather one that will express the true position to which this sandstone undoubtedly belongs. The best exposure of this bed that was met with in Randolph county was in the bluffs, below the village of *Prairie du Rocher*, where it forms a mural cliff, commencing about two miles below the village, and extending down for about four miles. The elevation of this sandstone cliff varies from fifty to one hundred feet. It is usually tolerably heavy-bedded, though at the upper end of the outcrop there are some thin beds in the lower part that afford good flagstones. It is generally of a rusty brown color on the exposed surface, and when freshly broken, is speckled from the presence of the brown oxide of iron. This peculiarity is more or less characteristic of all the arenaceous members of the Chester group. It hardens by exposure, and forms a reliable building stone. From the point of its first outcrop in the river bluff, it trends off in a northerly direction, forming a narrow sandstone belt, separating the St. Louis from the lower Chester limestone. No fossils have yet been discovered in it. The general trend of the river bluffs in this county is from northwest to southeast, and the easterly dip of the strata causes the disappearance of the sub-divisions of the Chester group successively, by dipping below the surface, from the northern limit of the county to its southern extremity.

About six miles below *Prairie du Rocher* this sandstone dips below the surface, and is succeeded by the lower limestone of the Chester group. This limestone is not well exposed on the Illinois side of the river, where it first appears, but is mostly hidden by the sloping talus of the hills. On the Missouri shore, just below St. Mary's, it is well exposed in the river bluffs, and the lower portions of the mass is found to consist there of coarse, granular, brownish-gray limestone in irregular beds, and partially concretionary, overlaid by alternations of red and green shales with some sandy layers. These beds appear, from partial exposures, to be from thirty to forty feet thick, and are overlaid by the heavy bed of limestone that forms the perpendicular escarpment of the bluff, just below Rozier's Landing, which is from forty to fifty feet in height. The lower portion of this limestone above the shales is semi-oolitic in structure, and contains a very interesting group of fossils.

As we approach the termination of the bluffs between the Okaw and the Mississippi, about six miles above Kaskaskia, this limestone becomes better exposed, and is found to consist of brownish-gray limestone, with intercalated beds of green and blue shales, the latter from a few inches to six or seven feet in thickness. The limestones are for the most part tolerably heavy-bedded, though there are always some thin layers intercalated in the mass. It constitutes all the limestone exposures in the river bluff, from the point where the sandstone disappears, six miles below *Prairie du Rocher*, to the terminus of the bluffs between the Okaw and the Mississippi. At this point the top of the limestone escarpment is about one hundred and fifty feet above the level of the American Bottom, and probably comprises the whole thickness of the lower limestone, though the lower part was entirely hidden by a sloping talus, so that its character could not be certainly determined.

In the bluff on the east side of the Okaw, opposite Kaskaskia, the limestone escarpment retains about the same elevation above the bottom lands on the river, though only about forty feet of limestone is seen at the top. The exposure here consists of regularly bedded gray limestones, the beds varying from six inches to two feet in thickness, with a few seams of clay shale interstratified with the limestone. At the old Menard farm, a half mile below the ferry, the lower portion of this limestone is well exposed on the small creek that intersects the bluffs at that point. The lower division, as it appears here, presents no essential difference from the upper beds, but the intercalated beds of shale are thicker, some of them being as much as six or seven feet in thickness. They contain numerous fossils in a fine state of preservation, among which are *Pentemites sulcates, P. godoni, P. symmetricus, P. pyriformis, Forbesiocrinus Whitfieldi, Zeacrinus Wortheni, Z. spinosus, Agelacrinus Kaskaskiensis, Athyris subquadrata, A. Royissii, Retzia vera*, and *Productus elegans*. It is quite possible that the upper part of the limestone in the bluff east of Kaskaskia, is the limestone that comes in above the lower bed at Cole's Mill, from which it is there separated by a bed of sandstone from fifteen to twenty feet in thickness.

From Menard's place to Chester, this limestone forms the lower part of the bluff, while the higher points contain the overlying shales as well as the third limestone, which forms the upper limestone escarpment at Chester. At the upper end of the city of Chester the top of this limestone is about eighty feet above the low water level of the river. It is here overlaid by a massive sandstone, about fifteen feet thick; but in less than fifty yards it passes into green shale, that rests directly upon the lower limestone. The thickness of this shale, measured just above Anderson's Hotel, is about seventy feet, and it is overlaid by the third limestone which forms the upper escarpment in the bluff at this point. It contains calcareous and ferruginous shales and thin sheets of limestone, that are thickly covered with fossil bryozoa and mollusca. A ferruginous band is often found just above the lower limestone, that contains fish teeth in considerable numbers; and towards the lower end of the city there is a band of limestone made up almost entirely of the stems of crinoidea and fish teeth. It is from six inches to a foot or more in thickness, and takes a good polish and makes a handsome marble. Its position appears to be about midway in the bed of green shale. The calcareous shales near the bottom contain great numbers of fossils, among which the most common are *Spirifer bisulcatus*, *S. Leidyi*, *Spiriferina octoplicata*, *Productus elegans*, *Zaphrentis spinulosa*, *Archimedes Swallovana*, *Athyris subquadrata*, *A. Rogissii*, *Lyropora*, and some other species of *bryozoa*.

The sandstone which is sometimes intercalated at the base of this shale, contains, at Chester, casts of a few small shells, of the same species with those found in the shales. It withstands the action of atmospheric influences, appears to become harder on exposure, and will no doubt form a durable building stone. At Cole's Mill this sandstone is not so massive, and shades upward into a sandy shale. The thickest layers in the lower part of the bed are only about one foot in thickness. It may be called the third sandstone of the Chester group, reckoning from the top downward. At Cole's Mill it is immediately overlaid by a limestone which is not fully exposed, but appears to be about thirty feet thick. It is partly shaly and argillaceous, and may be considered as limestone No. 4 of the Chester group. The dip of the strata appears to be nearly in the same direction as the trend of the bluffs from Chester to the south line of the county, which is to the southeast; and in following the bluffs down towards Liberty, we find the lower limestone passing below the surface at Mary's river, which is only about two miles below Cole's Mill, making a southeasterly dip of about twenty-five feet to the mile, the top of the lower limestone being, by measurement, fifty feet above low-water level at the mill.

About a mile below Mary's river a section of the bluffs gives the following succession of strata:

Calcareous shales with thin plates of brown limestone, containing numerous fossils, among which are *Retzia vera*, *Productus elegans*, *Athyris subquadrata*, and *Spirifer bisulcatus*, representing the lower part of the upper limestone at Chester	6 to 8 feet
Green and brown shale, the lower part arenaceous and the upper argillaceous, with a few inches at the top nearly black	52 "
Limestone No. 4, or middle bed at Cole's Mill	30 "
Covered slope to the level of the river	40 to 50 "

About a hundred yards below where this section was made, the upper limestone at Chester (No. 3) was seen overlying the calcareous shale that forms the upper bed in the above section.

At Manscoe's place, two and a half miles above Liberty, the bluff consists of the following beds:

Sandstones and sandy shales	80 to 90 feet
Gray cherty limestone (No. 2)	25 to 30 "
Blue shales, partly sandy in the lower part	40 to 50 "
Gray limestones, partly argillaceous and concretionary (No. 3), or upper bed at Chester, extending above the road at the foot of the bluff	52 "

Search was made at this locality for coal, some years ago, by digging in the blue shales above limestone No. 3, but none was found. The lower limestone in the foregoing section, which is undoubtedly the equivalent of the upper limestone in the bluffs at Chester, passes below the surface, probably not far from the south line of this county; for at the crossing the small creek which enters the Mississippi at the town of Liberty, its upper beds are only about twenty feet above the river level.

The following section of the strata just below Liberty shows the relative thickness and general character of the upper beds of this group:

Massive quartzose sandstone (conglomerate?)	50 to 60 feet
Gray compact siliceous and argillaceous limestone (No. 1, Chester group)	25 to 30 "
Shales and shaly sandstone, with fossil plants *Sigillaria, Stigmaria, Lepidodendron*, etc	80 to 90 "
Thin bed of limestone (No. 2)	15 to 18 "
Massive sandstone, presenting a speckled color when freshly broken	40 "
Limestone, upper bed at Chester (No. 3)	18 to 20 "

The foregoing sections will afford a general idea of the development and general character of this group of rocks in this county. It is by far the most important division of the lower Carboniferous series developed in Southern Illinois, both on account of its thickness and the extent of surface that it occupies. It outcrops over a belt of country from five to ten miles in width, and extending from northwest to southeast through the whole extent of the county. Except a very small area in the vicinity of *Prairie du Rocher*, it underlies the entire surface from the western borders of the coal field to the bluffs of the Mississippi. It crops out over nearly all the upland in this county between the Okaw and the Mississippi, and the lands underlaid by it are generally covered with timber, possess a somewhat broken surface, but a good soil, that is especially adapted to the growth of fruit and small grain. Of the six hundred feet or more of strata which comprises this group in this county, more than one-half is a good building stone, and is useful for nearly every purpose for which material of this kind is required.

The limestone No. 2 of the series crops out in the hills about one mile due north of Chester, though it is but partially exposed. Indications of its presence may also be seen about the same distance northeast of Chester, just beyond the top of the ridge that intervenes between the river bluffs and Gravel creek, where the surface is broken into sink holes, that indicate the presence of an underlying limestone. All the upper divisions appear to thin out towards the northern part of the county, and at Thompson's lime-kiln, on section 2, township 5, range 7, the limestone which appears to be the equivalent of No. 2 or No. 3, is directly overlaid by the conglomerate of the Coal Measures. The exposure of limestone here is from fifteen to twenty feet in thickness and dips slightly to the east. The beds vary in thickness from three inches to two feet, are compact, and afford a good quick-lime. This limestone resembles the upper bed at Chester, and affords many of the same species of fossils.

On Gravel creek, on section 35, township 6, range 7, the limestone No. 3 or upper limestone, in the Chester section, is well exposed, and abounds in the characteristic fossils of this division, which are *Pinna Missouriensis, Myalina angulata, Schizodus Chesterensis, Orthoceras anulo-costatum, Nautilus spectabilis, N. sub-globosus, N. Chesterensis, Allorisma clavata,* besides the common *brachiopoda* of this group. The entire thickness of the limestone exposure is about twenty-five to thirty feet. It is quite argillaceous at this locality, though some of the beds are burned for lime.

The fossil plants found in the shales above limestones No. 2 are the oldest relics of a terrestrial vegetation yet found in this State. They embrace the following species from this county: *Knorrhia imbricata, Stigmaria reticulata, S. minor, S. stellata,* and an undetermined species of *Lepidodendron.* Several additional species have been obtained from these shales in Pope county. It is somewhat remarkable that these fossils are all referable to European carboniferous species, and goes to show a very wide geographical range of species in the Carboniferous era, if this reference is correct.

The Chester group occupies the uplands between *Prairie du Rocher* and Red-bud, and exposures are met with on all the small streams. The bluff, at the village of *Prairie du Rocher,* is composed of the massive gray limestones of the St. Louis group, but before reaching the general level of the adjacent country we pass over the lower sandstone of the Chester group, and the limestones and shales of the higher beds are found exposed on all the small streams between the river bluffs and Red-bud. Four miles northeast of *Prairie du*

Rocher, the lower limestone (No. 5) is exposed on a small creek. The beds are alternately buff and gray in color, and contain the characteristic fossils of this group. The exposed portion of the bed does not exceed twenty-five or thirty feet in thickness. In the bed of Horse creek, near the bridge, some massive layers of brown limestone are exposed, which perhaps belong to the same bed. When we first visited this portion of the county, in 1858, we found that a shaft had been sunk a half mile north of Red-bud to the depth of seventy-seven feet, in search of coal. The following beds were passed through in this shaft:

Surface clay	18	feet
Gray limestone, containing characteristic fossils of the Chester group	13	"
Clay shale	46	"

This shaft appears to have commenced about the horizon of limestone No. 3, and penetrated forty-six feet in the argillaceous shale below. At Vogus' Mill there was an exposure of ten feet of argillaceous limestone above the beds passed through in the shaft that contained some of the same fossils found in limestone No. 3, on Gravel creek; and above this, in a neighboring field, we found partial exposures of brown shaly limestone, with bands of argillaceous iron ore, containing Archimedes, Orthoceratites, etc. As the shaft above named was commenced at a horizon at least two or three hundred feet below the Coal Measures, we informed the proprietor that there was no probable chance of finding coal by going to a greater depth, and the undertaking was consequently abandoned.

During the formation of this group of strata, the ocean in which its material was deposited must have been subjected to various abrupt changes in the prevailing conditions, and it was the receptacle of a great amount of sedimentary material, both sandy and argillaceous, which sediments now constitute a considerable portion of the limestones, as well as all the sandstone and shales that alternate with them, and comprise more than one-half the entire thickness of the group. It commences at the base with an accumulation of sand more than a hundred feet in thickness, which contains no trace of organic life, and scarcely any other mineral matter, except the brown oxyd of iron that seems to form the cementing material, and this constitutes the lower sandstone. Above this we have the lower limestone probably a hundred and fifty feet thick, a considerable portion of which is a tolerable pure carbonate of lime, and has been formed in part by the exuviæ of shell fishes, and the crinoidæ, and other radiata that swarmed in countless numbers in the oceans at this period, and in part by the carbonate of lime precipitated from the marine waters, so as to serve as a cement to the animal remains, and thus form the purest limestone of the mass. But during the formation of this limestone we find the frequent introduction of argillaceous sediments, or mud, which formed the thin layers of clay shale, that separate the limestone strata.

But finally the conditions change completely, and we observe at one locality accumulations of sand forming a second sandstone, and at another we find the sand replaced by a calcareous mud, giving origin to calcareo-argillaceous shales. These conditions alternate throughout the whole mass, the sediments becoming more abundant towards the top of the series, forming the greatest proportion of the strata, and imparting a siliceous and argillaceous character to the limestones themselves. The upper part of the group merges into the conglomerate sandstone of the Coal Measures so completely that it is often difficult to define the line which separates them, and hence Dr. D. D. Owen regarded the whole group as the stratigraphical equivalent of the Millstone grit of the British geologists. The teeth and spines of sixteen species of fishes have been found in the calcareous beds of the Chester group, nearly all of which were found in this county. They will be found described and figured in the second volume of the original Report.

St. Louis Limestone.—The outcrop of this limestone in this county is confined to the river bluffs in the northwest part of the county, commencing at the line separating Randolph from Monroe county, and extending down about two miles below the old village of *Prairie du Rocher.* The entire length of the outcrop along the bluff is about five miles. Just below the county line this limestone forms a bold perpendicular cliff a hundred feet or more in height, with a steep talus at the foot, and it is probable that nearly the whole thickness of the bed is above the surface at this point, or at least two hundred feet of its upper part. The dip of the strata carries this whole thickness below the surface about five miles below the north line of the county, where it is succeeded by the lower Chester sandstone.

At the village of *Prairie du Rocher* the escarpment of this limestone measures about one hundred feet in thickness above the level of the road in the village. The upper layers are thin-bedded and cherty, but towards the base of the bluff the rock is more massive, affording some strata two feet in thickness. Some of the beds are arenaceous, and others are separated by partings of buff colored shale. One mile and a half above the village, the lower part of the limestone is amorphous in its character, presenting only indistinct lines of bedding. Some of the beds in the vicinity of the village are fine-grained, compact, and appear to be a nearly pure carbonate of lime, and could be easily burned into quick-lime.

The fossils obtained from this limestone, near the village, were *Lithostrotion mamillaris*, *Hemipronites crenistria*, *Spirifer Keokuk*, and *Platycrinus Prattenanus*. The first named species would suffice to determine the geological horizon of the bed, if no others were obtained from it. It characterizes this limestone at nearly every locality where it is exposed, from Iowa to Alabama, and has never yet, so far as we know, been found in any other division of the lower Carboniferous series.

This limestone will furnish an inexhaustible supply of good building stone, and limestone for lime, while some of the thin arenaceous beds in the upper part will make good flag-stones. In the adjoining counties of Monroe and St. Clair, there is a bed of *hydraulic limestone* near the junction of the St. Louis with the Keokuk group, and if it is developed here, would be found at the base of the bluff, near the north line of the county. Its position, at localities farther north, is immediately above the geodiferous shales of the Keokuk group.

Economical Geology.

Soils.—The uplands in this county possess considerable variety in their soils, in part due perhaps to the present configuration of the surface, and in part to the lithological characters of the underlying strata. Where the lands are tolerably level, the organic matter has been more generally retained, and the soil is usually chocolate colored, and contains a considerable amount of decomposed vegetable matter. Where the surface is broken, the vegetable matters are washed down into the valleys by the rains, and the soil is usually of a light brown or buff color, with a comparatively small per cent. of organic matter. The sub-soil is generally a yellow clay, which, when brought to the surface, makes a strong and productive soil. Where the lands are underlaid by the sandstones and sandy shales of the Chester group and the conglomerate, there is a considerable amount of sand in the soil, giving a warm dry soil that is easily worked and very productive. Along the river bluffs the soil is formed from the loess, and is a rich sandy loam, often of great depth, and is preferable to any other in the county for the cultivation of fruit, and especially the vine. Where the underlying rocks are argillaceous, we find a stiff clay soil, which retains a superabundance of water in the spring, and suffers most from drouth during the dry seasons. But throughout the uplands in this county, wherever the surface is sufficiently level to be readily cultivated with the plow, the soil is found to yield good crops of corn, wheat, oats, barley, castor beans, tobacco, and even cotton may be grown here when the season is favorable for maturing it.

The lower extremity of the American Bottom forms a belt of alluvial land in the northwestern part of the county, about twenty miles in length, and from three to six miles in breadth, and embraces an area of nearly one hundred square miles in extent. The soil of this bottom consists of sand and clay deposited, in part, from the waters of the Mississippi during the periods of overflow, intermingled with a large per cent. of vegetable mould, from the growth and decomposition of the vegetable matter that grows upon the surface. It is one of the most productive tracts of alluvial soil in the west, and is not excelled in its productive capacity, even by the far-famed bottom lands of the Miami. They are, beyond doubt, the most fertile lands in the county, but they are subject to occasional overflow from the annual floods of the Mississippi, which detracts materially from their value for cultivation. The old town of Kaskaskia, the first point settled in this State, and the oldest settlement in the valley of the Mississippi, is situated on this bottom near its southern extremity. It was the seat of government for the Northwest Territory for many years, and the headquarters for the mining and trading expeditions of the early French settlers. For the last few years it has been gradually declining, and is no longer a point of any commercial importance.

In its original condition this bottom was in good part covered with a heavy growth of timber, interspersed with small bottom prairies. These timbered lands are by far the most valuable in the county, and sustain a growth of black and white walnut, sugar maple, hackberry, pecan, ash, elm, linden, hickory, and two or three varieties of oak.

Building Stone.—This county has an abundant supply of good building stone, not only sufficient for the demand at home, but enough to supply the whole State for centuries to come, if it could be properly distributed. The St. Louis limestone, which, in the northwest corner of the county, is at least two hundred feet in thickness, could all be made available for economical purposes, and will furnish suitable material for the heaviest masonry, as well as for outside and foundation walls for dwellings, flagstones, etc. The lower sandstone of the Chester group, more than a hundred feet in thickness, is an excellent freestone, can be sawed or cut easily when freshly quarried, and hardens on exposure. The other sandstones of this group will all furnish more or less building material and flagstones.

The lower limestone of the Chester group, a hundred and fifty feet in thickness, is nearly all fit for foundation walls, and some of the beds dress well and furnish a good material for architectural purposes. The upper part of limestone No. 3, of this group, is a granular semi-crystalline limestone, that dresses easily and makes a handsome cutstone for caps and sills and outside walls for fine buildings. The fire-proof building for a clerk's office in the city of Chester is built of this limestone. The two upper limestones of this group afford a good material for rough walls, but they appear to be more siliceous than the lower limestones and are too hard to be cut readily.

The conglomerate sandstone, at the base of the Coal Measures, outcrops through the central portion of the county, and will afford a tolerable good material for rough walls, and some good flagstones. However, it requires more care in selecting than is necessary with the lower sandstones, because it is liable to crumble on exposure to the atmosphere; and where it does so on a naturally exposed surface, it should never be used as a building stone. A rock that does not stand exposure in the outcrop without crumbling, should never be relied on as a building stone; but if it presents sharp angles and a hard surface at the natural exposure, it may generally be relied on in the wall.

In the northeastern and eastern portions of the county, where the surface is underlaid by the Coal Measures, good building stone is not abundant. The limestones that overlie the coal seams furnish some material that will answer for rough walls, but they are often argillaceous; and when they are so, they frequently crumble on exposure to the atmosphere. The limestone over the Belleville coal at Pope's bank, and various other localities in the vicinity of Sparta, is a dark bluish-gray limestone, somewhat argillaceous, but is said to slack readily when burned. It is from three to six feet thick. The micaceous sandstone above this is rarely exposed in this part of the county, and no very definite opinion could be formed as to its fitness for building purposes; but it seemed to be too soft to be of much value.

Limestone for Lime.—By far the best material for the manufacture of quick lime, in this county, may be obtained from the St. Louis limestone, in the vicinity of *Prairie du Rocher*. Indeed, this limestone is not surpassed by any calcareous deposit in the Mississippi Valley for the production of a superior quality of lime; and the Alton lime, which is made from this limestone, has an excellent reputation wherever it has been used. Some of the most calcareous beds of the lower Chester limestone, as well as the upper beds of No.

3, of the same group, are used for this purpose, and afford lime of a fine quality. On Gravel creek and at Thompson's quarries, on Nine-mile creek, the limestone used for this purpose is obtained from No. 3, and it appears to answer very well for this purpose, and affords a supply for the eastern and northeastern portions of the county.

Clays.—Both the coal seams in this county are underlaid by beds of fire-clay, which, at some points, will perhaps prove to be valuable, though at the exposures in the vicinity of Sparta, the only point where we had an opportunity to examine them, they did not seem to be sufficiently pure for the manufacture of fire brick. Clays suitable for the manufacture of common brick may be obtained from the sub-soil of the uplands anywhere, and nearly every farmer, if he chooses, may manufacture all the bricks he requires on his own premises.

Coal.—Bituminous coal is by far the most valuable and important mineral deposit in this county, and one that is destined, at no very distant period, to exercise a very decided influence on its economical interests. Unfortunately for the early development of this great element of material wealth in this county, the deposit is so remote from any accessible highway, that the cost of transportation has hitherto prevented the working of these mines, except to supply the neighborhood demand for coal. From what has already been said in regard to the Coal Measures of this county, it will be remembered that there are two seams of coal outcropping here, the lower one varying in thickness from two to four feet, and the upper one averaging about six feet. This upper seam underlies about two and one-half townships in the eastern and northeastern portions of the county, comprising the eastern part of township 6 south, range 5 west, and nearly the whole of township 5 south, range 5 west; the whole of township 4 south, range 5 west, and the eastern part of township 4 south, range 6 west. Its outcrop crosses Mary's river in section 28, township 5 south, range 5 west, and from this point it trends off northwest to the north line of the county. The lower seam underlies probably a greater surface than the upper one, but it is not so regularly developed, and is much thinner, seldom exceeding two or three feet in thickness.

The miner's estimate of the yield of a coal seam is one million of tons to the square mile for every foot in thickness of the seam, and consequently the yield of the upper seam would be about six million tons of coal to every section of land which it underlies. The yield of the lower seam would be about two and a half million tons to the square mile, making an aggregate of eight and a half million tons of coal to every section of land that is underlaid by these two seams.

The question now arises, what is wanting to make this large deposit of mineral wealth at once available and subservient to the development of the industrial interests of Randolph county? I answer, a cheaper means of transportation from this coal region to the Mississippi river. When once the Mississippi is reached by railroad from these mines, the entire southern market is opened for their products, as well as the constantly increasing home market for steam fuel at your own wharves. The favorable position of this county on the Mississippi, below all impediments to navigation, gives this a decided advantage over any coal region in more northern portions of the State, and the home market for the supply of the steamers that are almost hourly passing your wharves would be far more important than at any point above St. Louis. These considerations should stimulate the citizens of Randolph county to an energetic movement looking towards the early development of this great natural resource of material wealth, which has been so bountifully bestowed upon them.

The construction of a railroad from Chester to the coal region, a distance of only about fifteen to twenty miles, and over a country presenting no natural impediments to the cheap construction of such a road, but, on the contrary, abounding in stone for the construction of culverts, and timber for ties and bridges, would give a decided impetus to every branch of industry that would be felt throughout the county. The building of such a road would at once quadruple the value of all the coal lands in the county; it would stimulate manufactures, induce immigration, and add greatly to the general wealth and prosperity of the county, and make available the mineral resources that are now comparatively valueless for the want of cheap transportation to a good market. A road has been recently surveyed from St. Louis to Cairo, intersecting these coal lands in Randolph county, which, if completed, would open a market for these coals at Cairo, but it is questionable whether this road, if built, would be as beneficial to the industrial interests of this county as a road directly from the coal lands to the Mississippi river. For a qualitative analysis of the coals of this county, see Dr. Blaney's report, in a former chapter.

CHAPTER X.

ST. CLAIR COUNTY.

This county comprises a superficial area of a little more than eighteen townships, or about six hundred and fifty square miles. It is bounded on the north by Madison county, on the east by Clinton and Washington counties, on the south by Randolph and Monroe counties, and on the west by Monroe county and the Mississippi river. The surface of the county is generally rolling, and in the vicinity of the river bluffs it becomes broken and hilly. Between the bluffs and the river, there is a belt of alluvial bottom land from six to eight miles in width. The soil upon this bottom, wherever it is sufficiently elevated to be susceptible of cultivation, is a deep sandy loam, exceedingly fertile, and was originally in part covered by a very heavy growth of timber. The lands upon this alluvial belt are not surpassed in fertility by any in the west, and a large area, contiguous to East St. Louis, is devoted to growing vegetables for the St. Louis market. The principal varieties of timber on the bottom lands of this county are the same as those already enumerated in the foregoing report on the adjoining county of Randolph.

The uplands are generally elevated from one hundred and fifty to two hundred feet above the level of the Mississippi, and are beautifully diversified with prairie and timber. The prairies are generally of small size, and are mostly restricted to the central and eastern portions of the county. The varieties of timber noticed on the uplands are black, white and red oak, pig-nut and shell-bark hickory, black and white walnut, elm, linden, hackberry, sugar maple, honey locust, wild cherry, red bud, and sassafras. Two varieties of the wild grape flourish luxuriantly on the timbered lands, in this county. The summer grape (*Vitis æstevalis,*) abounds in the groves upon the uplands, and the winter or frost grape (*Vitis cordifolia*) is equally abundant in the timbered lands of the Mississippi bottom, and along the smaller streams. The abundant and luxuriant growth of the wild or native vines in this county may be regarded as a certain indication of the adaptability of the soil to the cultivation of the finer varieties of grapes, and for the production of a fine quality of native wine, and the uniform success with which some of the best varieties of grapes have been grown in this and the adjoining county of Monroe by the industrious German population of these counties, gives abundant assurance of the eventual success of this most important and profitable branch of horticulture. The Catawba grape has been grown for several years with tolerable success, though it is more subject to mildew here than two degrees further north, where it has been grown successfully for five or six years, without any serious loss from this cause. It will probably be found that some other varieties, such as Norton's Virginia, Concord, and Delaware, will prove to be better adapted to the soil and climate of Southern Illinois than the Catawba. Fruits of all kinds adapted to a temperate climate may be successfully grown in this county, especially in the vicinity of the river bluffs, and its proximity to St. Louis renders this a very desirable location for those desirous of engaging in this delightful pursuit.

The principal streams in the interior of this county are the Okaw or Kaskaskia river, which intersects the southeastern portion of the county, and Richland and Silver creeks, that empty into it on the north, and Mud creek on the south. Cahokia creek also intersects the northwestern portion of the county, and empties into the Mississippi nearly opposite St. Louis. These streams generally have their course in the Quaternary deposits, and exhibit but rarely good exposures of the stratified rocks, except along the bluffs of the Mississippi. By the aid of artificial sections, however, which have been obtained in various parts of the county, from the shafts and borings that have been made down to the Belleville coal seam, we have been able to obtain a correct idea in regard to the character of the strata that are deeply hidden beneath the surface, in the central and eastern portions of the county. It is very important that a journal should be kept at every shaft or boring made in any portion of the State, as in that way much valuable practical knowledge may be obtained that can be secured in no other way.

The geological formations that appear above the surface in this county comprise the usual Quaternary deposits, the lower three hundred feet or more of the Coal Measures, and about three hundred feet of the upper portion of the lower Carboniferous limestone. In the Quaternary deposits we include all the surface deposits of marl, clay, sand and gravel, which are spread over the entire surface of the county, to the depth of from twenty to one hundred and fifty feet. It includes the alluvial beds of the Mississippi bottoms, the marly clays and sands of the loess that caps the river bluffs, and the heavy deposits of clay, sand and gravel, that cover the stratified rocks in the central and eastern portions of the county, to the depth of fifty to one hundred and twenty feet. These deposits are comparatively of recent origin, and have accumulated since the appearance upon the earth of many of the existing forms of animal life.

These alluvial deposits are mainly due to aqueous action, and the sands and fine mud of which they are composed have been deposited in part by river currents, and in part derived from the material washed down by the rains from the adjacent highlands. This is the most recent or last formed division of the Quaternary. The loess is a deposit of marly sand that is found along the river bluffs in this county, which is of variable thickness, sometimes as much as fifty or sixty feet on the western slope of the bluff, but thins out rapidly as the level of the adjacent highlands is approached. Fine sections, forty feet or more in height, may be seen in the railroad cuts in the vicinity of Caseyville, where this deposit presents its usual appearance, and is filled with fossil shells. From its position on the slope of the river bluffs, and from the fact that it forms mounds of considerable height on the Mississippi bottoms, it seems probable that it was accumulated when the present valley of the river was occupied by a chain of lakes, the waters of which filled it nearly to the height of the adjacent highlands, and that it was originally spread over the whole surface of the valley. A considerable portion of it was no doubt removed during the drainage of the valley by the gradual elevation of the surface, and other portions have been subsequently removed by the action of river currents.

The drift clays, sands and gravel beds which cover the highlands generally are quite unlike either of the divisions of this formation already described, and have resulted from very different conditions, for the details of which the reader is referred to a subsequent chapter on the general character of the drift deposits of this State. They were, no doubt, accumulated when the whole surface was under water, and as the surface of the underlying rocks had in many places been eroded into valleys, they were subsequently filled with this material, and it is therefore considerably thicker at some localities than at others, even where the surface level is the same.

We usually find at the base of the drift deposits a bed of blue, plastic clay, containing sometimes small pebbles, at other localities there are stratified sands below the clay, that form the lowest beds of the deposit. At the Alma shaft, two miles west of O'Fallon, this deposit is seventy feet thick, but no account of the variation of the material in different parts of the bed has been preserved. At the Summerfield shaft the drift clays were but thirty-five feet thick, and in the vicinity of Athens it was found to be fifty feet, and consisted of clay and sand, with rounded boulders at the bottom. On the northwest quarter of section 20, township 1 south, range 6 west, the following beds were passed through in sinking a well, according to the notes of Mr. ENGELMANN:

Soil and yellow clay	14 feet
Reddish-brown gravel and sand in layers growing finer below	28 "
Blue clay	83 "

This makes an aggregate of one hundred and twenty-five feet of drift at this locality. At the Mascoutah shaft the drift was found to be eighty-two feet thick, showing the following divisions:

Soil and clay	20 feet
Quicksand	6 "
Blue, gray and reddish clay	50 "
Coarse quicksand, with bits of wood	6 "

At the shaft near Urbana the drift was found to be only forty-five feet, but no record was preserved of the different materials of which it was composed. From these sections it will be seen that it varies in thickness, in different parts of the county, from thirty-five to one hundred and twenty-five feet, and may be even thicker than that at some points. Boulders of any considerable size are rarely met with in this county, and the deposits consist, for the most part, of fine sand, clay and gravel, and usually presents some traces of an imperfect stratification.

Coal Measures.—This formation, as it is developed in this county, comprises a thickness of about three hundred feet of the lower part of the coal series, embracing the horizon of five coal seams, only two of which, however, appear to be of economical value at the present time. These measures underlie fully three-fourths of the entire surface of the county, embracing all the central and eastern portions. The western boundary of the Coal Measures intersect the river bluffs about two miles below Centreville station, on the Belleville and St. Louis railroad, and from that south to a point two miles south of the town of Centreville, and thence with a south-easterly trend it crosses the Okaw near Tamaroa. Northward from the point where the boundary line intersects the bluffs, it follows the course of the bluffs in a northeasterly direction to the south line of Madison county, just north of the village of Caseyville. All that portion of the county lying east of this line is underlaid by these measures, and at nearly every locality examined they contain valuable deposits of coal. The thickest coal seam outcrops in the river bluff and along the western borders of the Coal Measures in the southwestern portion of the county. The dip, though very moderate, is in an easterly direction, and in consequence the coal lies deepest below the surface in the eastern portion of the county. The following section of the measures containing coal, in this county, is compiled in part from the shafts sunk in the east part of the county, and in part from the natural outcrops of the strata that are found along the river bluffs. They comprise the following beds, commencing with those passed through in the shaft at Summerfield, in the northeast corner of the county, which afford the following section, commencing immediately below the drift clays:

Bituminous shale (No. 10 coal?)	3	feet	0	inches
Fire-clay	0	"	6	"
Gray shale and sandstone	35	"	0	"
Hard limestone (fossiliferous)	5	"	0	"
Sandstones and shales	90	"	0	"
Coal No. 8	0	"	4	"
Conglomerate, with ferruginous pebbles	4	"	0	"
Fire-clay	1	"	0	"
Clay shale (soapstone)	10 to 12	"	0	"
Coal	0	"	3	"
Fire-clay	0	"	8	"
Gray shales	20	"	0	"
Limestone	4	"	6	"
Gray and varigated shales	35	"	0	"
Limestone	8	"	0	"
Black and gray shales	25	"	0	"
Coal No. 6?	4	"	0	"

If the coal seam worked at Summerfield is really No. 6, there is a remarkable thickening of the shales between it and the limestone that ordinarily forms the roof to the coal; and the coal itself is considerably thinner than its average thickness in this and the adjoining counties, and is harder and more impregnated with the sulphuret of iron, and in that respect it is more like coal No. 5. Judging only from the lithological character of the lower beds in the above section, we should be inclined to regard the Summerfield coal as No. 5, and to consider the place of coal No. 6 to be occupied by the black shale immediately below the eight feet of limestone.

Continuing this section from the horizon of the upper limestone in the vicinity of Belleville, to the base of the Coal Measures, we find the following succession of strata:

Compact bluish-gray limestone	4 to 8 feet	
Sandy shales	10 to 15 "	
Limestone and calcareous shales	5 to 15 "	
Bituminous shale (local)	1 "	
Coal, Belleville seam, No. 6	5 to 7 "	
Clay shale (local)	1 "	
Nodular argillaceous limestone	4 to 8 "	
Shales	5 to 10 "	
Brown argillaceous limestone	4 "	
Bituminous shales	3 to 5 "	
Coal No. 5	3 "	
Clay shale, passing into sandy shale	20 to 30 "	
Bituminous shale	2 to 3 "	
Coal No. 1?	1 "	6 inches
Fire-clay	2 to 3 "	
Conglomerate sandstone (local)	5 to 8 "	

These beds form a continuous outcrop, from their first appearance in the river bluffs, about one mile and a half below Centreville Station, to the north line of the county, about a mile and a half north of the village of Caseyville.

The Belleville coal seam, No. 6, is the principal one worked, at the present time, and it was probably the first ever worked in the State. Its natural outcrop along the bluffs, in such near proximity to St. Louis, called attention to its value at an early day, and it was worked in open trenches, and by tunneling into the seam along the face of the bluff, long before its existence under the surface of the adjacent highlands was even suspected. Its general thickness in this county ranges from five to seven feet, and it has a substantial limestone roof, so that it can be worked with safety and in the most economical manner. This coal is generally quite regularly stratified, and the two upper layers, which vary in their aggregate thickness from sixteen to twenty-four inches, is much the purest in quality, and is usually separated from the lower coal, and is sold at about two cents per bushel higher, as a blacksmith's coal. The lower coal contains more sulphuret of iron, but the quality varies somewhat in different mines, and no general description would be applicable to every locality.

Above this coal there is sometimes a foot or more of bituminous shale, but more frequently the coal is directly overlaid by the limestone. The coal sometimes rests on a thin bed of clay shale, but sometimes this is absent, and it rests directly upon a nodular argillaceous limestone; and it is by no means uncommon, either in this or the adjoining counties, to find the coal directly inclosed between two beds of limestone. These limestones are both of marine origin, and contain fossil shells, at some localities, in abundance. At Caseyville the lower limestone contains *Spirifer lineatus, Athyris subtileta, Bellerophon nodocarinatus,* a remarkably elongated shell that appears to belong to the genus *Macrocheilus,* and an undetermined species of *Loxonema.* At the Hodge's Creek Coal Mines, on the west line of Greene county, this lower limestone is very fossiliferous, and contains many small spiral shells, besides two or three species of *Naticopsis,* and a large hemispherical coral in great abundance, which appears to belong to the genus *Chætetes,* and is probably *C. milleporaceus,* E. and H.

The limestone above the coal is more generally fossiliferous even than that below it, and the mines at Caseyville, Belleville and Pittsburg have afforded many fine specimens. The most characteristic species from this limestone are the following: *Productus costatus, P. Prattenanus, P. punctatus, P. longispinus, Athyris subtileta, A. Royissii, Chonetes mesoloba, C. granulifera, Spirifer cameratus,* with plates and joints of crinoidea. The occurrence of a heavy seam of coal inclosed directly between two beds of marine limestone is a fact that, so far as we recollect, has not heretofore been noticed in this country, and appears to form an exception to the generally accepted conditions under which the vegetable matter that has entered into the formation of the coal was accumulated.

Above the limestone which forms the roof to the Belleville coal we usually find bands of calcareous and sandy shales, varying in thickness from ten to twenty feet; and on the small creek just north of Belleville these shales terminate upward in a bed of light gray clay shale, resembling a fire clay. This bed of clay shale contains fish teeth and some other fossils, and is overlaid by another limestone from ten to twelve feet in thickness, which is generally quarried in that vicinity to supply the local demand for building stone. It is a brownish-gray rather argillaceous limestone, more regularly bedded than the limestone immediately above the coal seam, and may be easily distinguished from it. In the river bluffs at the old Pittsburg mines it is only about four feet in thickness, but it has afforded a few rare fossils from that locality, among which are *Bellerophon crassus, Euomphalus umbilicatus, Leda arata?* and *Naticopsis nodosus.* In the southwest part of Madison county this limestone is only two feet thick, and is underlaid by two feet of coal, which, at Belleville, is replaced by clay shale. In the shaft at Summerfield this limestone is four and a half feet thick, and this is probably quite as much as the average thickness of the bed through the county.

On Jack's run, about half a mile east of Urbana, there is a fine exposure of the strata above the Belleville quarry rock, showing the following succession of layers from the top downward:

Shale and sandstone, the latter micaceous and partly in massive layers	35 feet.	
Gray shale	20 "	
Blue clay shale, with bands of iron ore	15 "	
Coal	0 "	4 inches.
Clay shale	3 "	
Shaly gray limestone	1 "	6 inches.
Argillaceous shale	3 "	
Hard gray limestone (Belleville quarry rock)	10 "	

The lower limestone in the above section is a tough, irregularly-bedded gray rock, sometimes partially brecciated, and weathers to a dark reddish-brown color on the surface. Its lithological characters are quite different from those presented by this limestone at Belleville, but its stratigraphical position, about twenty feet above the main coal, would seem to leave but little doubt of its identity with that rock. Its first outcrop on Jack's run is about half a mile above its junction with Silver creek, and it continues to show itself on the last named creek for a half mile or more below the bridge. A partial exposure of the beds intervening between this limestone and the Belleville coal showed the following succession, in the descending order:

Ferruginous shale	8 feet.
Band of hard arenaceous limestone	1 "
Shales, partly hidden	10? "
Hard gray limestone	3 "
Bituminous shale (local)	1 "
Coal—Belleville	7 "

The clay shale above the four-inch coal, in the first of the above sections, is filled with marine shells, belonging to the genera *Bellerophon*, *Pleurotomaria*, *Polyphemopsis*, and *Nautilus*.

The main coal has been opened at many points in the neighborhood of Belleville, where it approaches near the surface in the ravines and on the main creek, and was first worked by drifting into the bank of the creek along its outcrop. On the railroad, between Belleville and the river bluffs, it is reached by shafts sunk to the depth of from fifty to one hundred and fifty feet.

At the Alma shaft, two miles east of O'Fallon, the coal was found at the depth of one hundred and seventy feet below the surface. The seam is there seven feet thick, and is overlaid by eleven feet of black shale and limestone. Above this there are seventeen feet of shale and sandstone, overlaid by about three feet of limestone, probably representing the quarry rock at Belleville.

At Mascoutah the coal is one hundred and thirty-two feet below the surface, and the seam is there seven feet thick, overlaid by limestone. Near Urbana the coal has been found at about the same depth below the surface, and six and a half feet thick.

The Belleville coal is also opened at many points along its outcrop in the southern part of the county. Teter's mine is about three miles nearly south of Urbana, and the coal is exposed on a small branch running into Silver creek. The coal retains, here, its full thickness of about seven feet, and is overlaid by two feet of shale, and, above this, limestone is seen near by. At Pfeiffer's place, on section 19, township 1 south, range 8 west, and at Belsha's place, four miles north of Athens, this seam is worked by horizontal drifts on the hill sides. At these localities it is from six to seven feet thick, and is overlaid by limestone. The general dip of the coal seams in this county appears to be a little north of east, and not more than five or six feet to the mile.

The next seam below the Belleville coal has only been opened at a single locality, so far as we have seen, which is at the old Pittsburg mines at the river bluffs, about one mile north of Centreville station. It is here about three feet thick, and is overlaid by bituminous shale and three feet of brown argillaceous limestone. The lowest seam we did not find exposed at the surface, but it was found in sinking a shaft at the foot of the bluff at this point. It is probably the equivalent of the Alton coal. It was too thin at this point to be of any economical value.

In addition to the Coal Measure limestones already mentioned in connection with the main coal seam, there is another bed holding a considerably higher position, which outcrops at two or three points in this county. It was first seen in crossing a tolerably high ridge about two miles north of Belleville. It is from four to five feet thick at this point. It outcrops again on Rock Spring branch, about two miles southwest of Lebanon, where there appeared to be two thin beds of limestone separated by three or four feet of shale. It dips gently to the eastward, the dip being a little more than the fall of the creek, which runs in the same direction. The rock is a very hard dark-gray limestone, and weathers to a dirty-brown color. It splits to fragments when exposed to frost, and is not reliable for a building stone. The stone used in the abutments of the railroad bridge near Lebanon was obtained from this bed. This may be equivalent to the limestone at Collinsville, which it somewhat resembles, and which is there one hundred and twenty-three feet above the Belleville coal. Many of the thin bands of limestone found in the Coal Measures are probably quite local in their development, and therefore are not to be identified over wide areas.

From what has already been said, it will be seen that the Coal Measures underlie nearly all the high land in the county, excepting only a narrow belt, from three to five miles in width, across the southwestern border; and the coal lands of this county are not only valuable for their mineral deposits, but they are among the most productive agricultural lands in Southern Illinois. As the most valuable deposits of coal in this portion of the State lie near the base of the Coal Measures, the thickest seams outcrop along the western and southwestern borders of the county, and are found at a greater depth below the surface in the eastern and northeastern portion. The Conglomerate appears to be quite thin in this county, and no exposure was met with where it was more than ten or twelve feet in thickness.

Lower Carboniferous Limestone.

Chester Group.—This group, which is at least six hundred feet thick in the southern part of Randolph county, has already thinned out, before reaching the southern part of St. Clair, to an aggregate of less than a hundred feet, and includes only the lower sandstone and a thin bed of limestone, which probably represents also the lower limestone division in Randolph county. These beds outcrop around the southwestern borders of the coal field in this county, commencing in the river bluffs about two miles below Centreville station, and extending southeasterly across this portion of the county, and crossing Richland creek a few miles above the north line of Monroe county.

The limestone is a coarse-grained, thin-bedded gray or brown limestone, with partings of argillaceous material, and contains numerous fossils characteristic of this horizon. Among these we may mention *Archimedes Swallovana, Pentremites Cherokeeus, P. godoni, Retzia vera, Spirifer bisulcata* and *Spiriferina octoplicata,* all of which were found at the exposure of this rock on Richland creek. The entire thickness of this limestone in St. Clair county may be as much as thirty or forty feet, but no single exposure was met with that exhibited a thickness of more than twenty feet. The principal outcrops seen along the west fork of Richland creek, from the northeast corner of township 2 south, range 9 west, to its junction with the main creek, and also along that to the south line of the county. On the south side of the anti-clinal axis that intersects the river bluffs just above the Monroe county line, there is an outlier of this limestone about fifteen feet in thickness, which is here separated from the underlying St. Louis limestone by about ten feet of sandstone. It is overlaid by the shales and argillaceous limestones of the Coal Measures, inclosing a thin coal seam. North of this axis we did not find this limestone exposed anywhere in the river bluffs in this county.

The lower sandstone of the Chester group underlies the limestone just described, and its outcrop is consequently over a belt of the country to the south and west of that occupied by the limestone. At Wm. Lark's quarries, in the western part of township 1 north, range 9 west, about thirty feet of the lower part of this sandstone is extensively quarried for building purposes. Part of the bed is in regular layers from one to three feet in thickness, and some portions of it present a concretionary structure, with but slight indications of stratification. It is a light brown freestone, even textured and soft enough to be cut or sawed in any desirable form. It hardens on exposure, and makes an excellent building stone, unsurpassed by any sandstone at present known in this portion of the State. A single contract was filled, by the owners of this quarry, to furnish material to the amount of fifty thousand dollars, for the construction of Grace church in St. Louis. With the proper facilities for cheap transportation from these quarries to St. Louis, they would afford an immense amount of excellent building material at a moderate cost, and would prove a source of great profit to the present owners. The underlying limestones of the St. Louis group outcrop immediately beneath the sandstones near these quarries.

From this point the outcrop of this sandstone trends off to the southeast, and it may be seen all along Stone creek, from its head waters to the Monroe county line. No fossils have yet been found in it, either in this county or elsewhere; but it is easily distinguished from the Conglomerate sandstone of the lower Coal Measures by its fine and even texture, soft brown color, and the absence of pebbles or coarse conglomerate in any part of the bed. As a building stone, especially where elaborate ornamentation is to be displayed, it is one of the most valuable freestones yet discovered in this State. We did not see its full thickness exposed anywhere

—16

in this county, in a single section, but we have estimated it approximately at from fifty to sixty feet.

St. Louis Limestone.—This important division of the lower Carboniferous series makes its first appearance in the river bluffs about three miles below the Centreville station, where it comes up from beneath the sandstones just described, and it forms the main portion of the bluff from this point to the Monroe county line. At the old lime kilns, four miles below Centreville station, it forms a mural cliff, from sixty to seventy feet high, and continues gradually increasing in elevation to "Falling Springs," where it measures one hundred and fifteen feet in thickness above the level of the Mississippi bottoms.

It presents here its usual character of a regularly-bedded, fine-grained limestone, of a light gray color and compact structure. The beds vary in thickness from three inches to two feet or more. The upper portion of the mass is a very pure carbonate of lime, and appears to be as well adapted to the manufacture of quicklime here as it is at St. Louis and Alton. As we approach the Monroe county line the beds continue to rise, and the brown magnesian and semi-oolitic limestones that constitute the lower division of this group are elevated above the surface, and compose the main portion of the bluff at the anti-clinal axis, about one mile above the southern line of the county. Immediately below the axis the upper beds of the group again form the entire bluff, and with a reversed dip, at an angle of about 30°, they plunge below the level of the Mississippi bottom.

The uppermost beds of this group are well exposed in the vicinity of Lark's quarries, about four miles from the Centreville station. At this locality the upper layers of the limestone are quite massive, and afford solid blocks of limestone from two and a half to three feet thick. These thick beds at this locality have furnished the material for the massive pillars of the new court house in Belleville. At the old lime kilns, above the "Falling Springs," we obtained some characteristic fossils of this limestone, among which were *Poteriocrinus Missouriensis*, *Graphiocrinus dactylus*, *Productus ovatus* and *P. tenuicostus*. This limestone outcrops only over a very limited area in the southwest corner of the county, probably not more than one-half of a single township.

The lower division of this group, as it appears just above the axis above referred to, is made up of alternations of brown and gray limestones, with seams of blue marly clay. There is also considerable cherty material interspersed through it, either in seams or lenticular masses. The rock is mostly thin-bedded and softer than the light gray limestone above, and has not been much used in this vicinity as a building stone, except at T. Miller's place, just on the county line, where quarries have been opened both for building stone and hydraulic limestone. The strata from which the latter is obtained is about six feet thick, and it appears to make a tolerable good article of hydraulic cement. It probably does not outcrop in any other part of the county. It appears very much like the hydraulic limestone on the Piasa, at the county line between Madison and Jersey counties, and holds, apparently, about the same stratigraphical position which is at the base of the St. Louis group. It is a bluish-gray earthy limestone, from four to six feet thick, and is quarried by drifting horizontally into the strata along its line of outcrop.

It is probable that the upper beds of the Keokuk group are elevated above the surface at the axis above referred to, but we met with no exposure of them in our examinations in this part of the county.

Economical Geology.

Coal.—Bituminous coal is by far the most important mineral resource of this county. More than four hundred and fifty square miles of surface are underlaid by the lower coal seams within its limits, two of which are of sufficient importance to be worked with profit, and, taken together, will afford nearly or quite nine millions of tons of coal to the square mile. There are but few counties in the State where so large a body of coal is found so near the surface, and where it can be worked so cheaply. Along the river bluffs, and in the southwestern part of the county, both the workable seams outcrop at or near the surface, and in the interior they are reached by shafts at depths varying from fifty to three hundred and fifty feet.

The upper or Belleville seam is the only one wrought, at the present time; but the lower seam affords a very good coal, and will eventually be resorted to when the supply from the upper seam becomes exhausted. The Alton seam, which lies below both those above named, has only been met with in this county at a single locality, and was there too thin to be of any economical value. It is but proper to say, however, that no search has been made for it at any other locality. The shafts that have been sunk in pursuit of coal all stop when the main coal is reached, and no effort has ever been made to ascertain the thickness of the lower seams away from their natural outcrop. A boring carried down from the main seam to the depth of seventy-five or one hundred feet would determine the thickness and consequent value of both the lower seams.

The following analyses of the Belleville coal were made by Mr. Henry Pratten, former assistant geologist and chemist of the Survey:

Caseyville Mines.

Specific gravity		1.304
Loss in coking	39.8	
Total weight of coke	60.2	
		100.00

ANALYSIS:

Moisture	6.0	
Volatile matters	33.8	
Carbon in coke	55.2	
Ash (pale red)	5.0	
		100.00
Carbon in coal	55.3	

Andreas Pfeiffer's Mine.

Specific gravity		1.293
Loss in coking	44.3	
Total weight of coke	57.5	
		100.00

ANALYSIS:

Moisture	8.5	
Volatile matters	35.8	
Carbon in coke	51.2	
Ash (pale red)	4.5	
		100.00
Carbon in coal	57.5	

Belleville Mines—Various Openings.

Specific gravity		1.293
Loss in coking	45.0	
Total weight of coke	55.0	
		100.00

ANALYSIS:

Moisture	5.5	
Volatile matters	39.5	
Carbon in coke	49.6	
Ash (gray)	5.4	
		100.00
Carbon in coal	54.6	

Belsha's Middle Drift.

Specific gravity		1.2966
Loss in coking	43.66	
Total weight of coke	56.34	
		100.00

ANALYSIS:

Moisture	8.10	
Volatile matters	35.56	
Carbon in coke	47.74	
Ash (gray)	8.60	
		100.00
Carbon in coal	54.50	

Dilg & Kempff's Mine—Average of Three Analyses.

Specific gravity		1.3407
Loss in coking	42.51	
Total weight of coke	57.49	
		100.00

ANALYSIS:

Moisture	4.43	
Volatile matters	38.08	
Carbon in coke	44.48	
Ash (gray)	13.01	
		100.00
Carbon in coal	54.28	

W. B. Churchill's Mine.

Specific gravity		1,315
Loss in coking	45.40	
Total weight of coke	54.60	
		100.00

ANALYSIS:

Moisture	6.00	
Volatile matters	39.40	
Carbon in coke	45.70	
Ashes (white)	8,90	
		100.00
Carbon in coal	52.63	

From these analyses it will be seen that the Belleville coal in this county will compare favorably with the average of western bituminous coals from other localities, either of this or the adjoining States.

Iron Ore.—In the section on Jack's run, about one mile east of Urbana, there is considerable brown carbonate of iron disseminated through a bed of argillaceous shale. The ore occurs in bands from two to three inches thick, and extends quite through the bed of shale, which is here about fifteen feet in thickness. The aggregate thickness of the iron ore, if in single stratum, would be at least two feet, and would then constitute a deposit of considerable value.

The junction of the Chester sandstones with the St. Louis limestone frequently exhibits ferruginous deposits of greater or less value, but so far as we were able to learn during our examinations in St. Clair county, no valuable beds of ore have yet been discovered at this horizon.

Fire and Potters' Clays.—Valuable beds of clay, suitable for the potter's use and for manufacturing fire brick, are very generally associated with the two lower coal seams, and especially with the lowest. But the outcrop of this seam is so generally hidden, that little yet is known of the character and value of the clays associated with it in this county. A careful search for this material, at the extreme southwestern borders of the coal field, would most likely result in the discovery of valuable deposits of this kind. The blue plastic clay, which forms the base of the drift in this portion of the State, appears to be adapted to the manufacture of common stone ware, and may, no doubt, be advantageously used for this purpose. In the vicinity of Lark's quarries, four miles south of Centreville station, we observed deposits of this clay five or six feet in thickness, of variegated color, and quite free from sand or gravel.

Hydraulic Limestone.—A bed of this material, six feet thick, is found at the base of the St. Louis group, on T. Miller's place, near the south line and in the southwest corner of the county. A cement mill has been in successful operation here for several years. The material is a bluish-gray earthy limestone, and is quarried by drifting horizontally into the bed along the line of outcrop. Owing to the absence of the proprietor, at the time we visited that locality, we were not able to obtain any statistics or reliable information in regard to the amount of cement annually manufactured here. The same bed may, no doubt, be found at other localities in this vicinity.

Building Stone.—St. Clair county contains an abundant supply of excellent building stone, though it is not generally distributed throughout the county, but is confined mainly to the southwest portion, where the lower Carboniferous limestones outcrop in the vicinity of the river bluffs. Nearly all the limestones and sandstones of this division of the Carboniferous system, that outcrop in this county, comprising a thickness of more than three hundred feet, may be made available for all economical purposes. The lower sandstone of the Chester group affords a beautiful yellowish-brown freestone, that is easily cut into any desirable form, and makes a valuable material for outside walls, where architectural beauty and taste are to be displayed. The quarries opened by Mr. Lark, four miles from Centreville station, present a solid face of this sandstone about thirty feet in thickness, and will afford an almost inexhaustible supply of this excellent freestone. It is, perhaps, too soft to be used in massive walls, though it apparently hardens slightly on exposure to the atmosphere. Some of the coarser layers of sandstone at these quarries have been manufactured into grindstones, for which it seems well adapted.

The overlying Chester limestone, though only appearing in this county in thin beds, will furnish a very good material for foundation walls, abutments, etc. The St. Louis limestone is more than two hundred feet thick in this county, and forms the main portion of the bluff from a point two miles below Centreville station to the south line of the county. Some of the upper beds are of the proper thickness for flagstones, while others are quite massive, affording dimension stone from two to three feet in thickness, and of any desirable size. Nearly the whole mass may be made available for building purposes, and it will furnish suitable material for all the ordinary uses to which building stone is applied. The light gray limestones of the upper part of the bed can be readily cut for caps and sills, and some of the compact fine-grained strata will take a fine polish, and may hereafter prove valuable as an ornamental marble. The lower beds of this formation, which overlie the hydraulic limestone above mentioned, are somewhat magnesian in their composition, and wherever the strata are thick enough for heavy walls, for culverts and abutments, they will afford an excellent material for such purposes.

There are three or four beds of Coal Measure limestone in this county that have been more or less used to supply the local demand for building stone in the immediate vicinity of their outcrop. Perhaps the most valuable of these is the second limestone above the Belleville coal, which is quarried in the vicinity of Belleville, where it appears to attain a greater thickness than at any other point where it has been seen in this county. It is usually of a light gray or brownish-gray color, and when free from argillaceous matter it stands exposure and becomes a reliable stone. It has been extensively used in Belleville for foundation walls, macadamizing material, etc. Its thickness at this point probably does not exceed eight or ten feet; and in the river bluff at the old Petersburg mines, as well as one or two other points where it was exposed in this county, it is not above four feet thick. The limestone that forms the roof to the main coal in this county is too irregularly bedded and too argillaceous to make it a desirable building stone. The limestone between O'Fallon and Lebanon furnished the abutments for the railroad bridge on Silver creek, west of Lebanon, but it splits on exposure to frost and moisture, and is not reliable. In the section on Jack's run, east of Urbana, there is a bed of sandstone twenty feet or more in thickness, which appears to stand exposure tolerably well, and will probably afford some good material for foundation walls if carefully selected. Usually the sandstones of the Coal Measures are rather soft and incoherent, and consequently crumble readily on exposure at the surface, but when they are sufficiently hard to withstand the weather, and present perpendicular walls along the natural outcrop, they may be accepted for economical use, and especially for dry walls.

Limestone for Lime.—The only material in this county really fit for making a superior article of quick lime, is that afforded by the upper beds of the St. Louis limestone. The principal outcrop of this limestone is in the river bluffs in the vicinity of the Falling Spring. This vicinity alone would furnish material enough to supply all the southern portion of the State with the best quality of lime, from exactly the same beds of limestone that are worked at Alton and St. Louis for this purpose. The near proximity of this limestone to the coal seams would make this a desirable point at which to carry on this branch of manufactures on an extensive scale, whenever proper facilities are afforded for transporting the product to market.

From what has been already said in the foregoing pages, it will be apparent that the natural advantages of this county are equalled by few in the State. It possesses a soil unsurpassed in productive capacities by any other portion of the Mississippi Valley of equal extent, and contains within its own borders inexhaustible stores of bituminous coal, that will furnish the most economical motive power for manufacturing purposes, mills, etc., thereby enabling the inhabitants to reap the full benefit of their great agricultural resources at home, without being compelled to share them with foreign manufacturers abroad. Its location near one of the most important commercial centres of the great West gives it the advantage of a near and easily accessible market for the various products of the farm and garden, that will not bear the delay or the cost of transportation to a remote market. With such natural resources, and peopled with a hardy and industrious population, this county may always retain its present enviable position as one of the most populous and wealthy counties within the limits of the State.

CHAPTER XI.

MADISON COUNTY.

This county is situated on the western border of the State, and comprises an area of about twenty-one townships or seven hundred and fifty-six square miles. It is bounded on the north by Macoupin, Jersey and Montgomery counties; on the east by Bond county; on the south by Clinton and St. Clair counties, and on the west by Jersey county and the Mississippi river. It is intersected by several small streams, among which are Wood river and Cahokia, Piasa and Silver creeks. These, with the Mississippi river, which forms the western boundary of the county, furnish an abundant supply of water.

The western portion of the county is diversified with hills and valleys, and the streams are all skirted with belts of excellent timber, that furnish an ample supply for the adjacent prairie. The principal varieties of timber found on the uplands in this county are black, white and red oak, shell-bark and pig-nut hickory, linden, wild cherry, honey locust, red-bud, dog-wood and sassafras. On the creek and river bottoms we find cotton-wood, sycamore, red and slippery elm, hackberry, black and white walnut, red birch, willow, soft maple, sugar maple, box elder, white and black ash, swamp oak, burr oak, pecan, mulberry and persimmon. The central and eastern portions of the county are generally level or gently rolling, and small prairies occupy the highlands between the streams. The general elevation of the uplands above the level of the Mississippi is from one hundred and fifty to three hundred feet.

The soil on the uplands is generally a dark, chocolate colored clay loam, except in the vicinity of the river bluffs, where it is of a lighter color and more arenaceous, from an admixture of the marly sands of the loess. The sub-soil is usually a brown clay, on all the uplands remote from the river bluffs; but as we approach the bluffs from the interior of the county, we find the sub-soil becoming more sandy until the soil rests directly upon the marly sands of the loess, which caps the bluffs throughout the county. These bluff lands, from the sandy character of the material of which they are composed, are readily and freely drained, and from the open, porous character of the sub-soil, are seldom charged with a superabundance of water, and are better adapted to the growth of fruit than any other lands in the county. They also produce good crops of all the cereals usually grown in this latitude.

The western border of this county is occupied by a belt of bottom land that comprises the northern extremity of the American Bottom, which commences just below the city of Alton and extends to the mouth of the Okaw, in Randolph county. Its width in this county varies from one to six miles. A considerable portion of this bottom is below the high-water level of the Mississippi, and is therefore subject to periodical inundations from the annual overflows of the river, while other portions are above high-water mark, and owe their origin to some other cause than the existing river. It seems probable, indeed, that a considerable portion of the area now comprised in this bottom, was originally occupied by deposits of drift clay and loess, that were deposited after the valley was scooped out of the lower Carboniferous limestones, filling the valley to the height of fifty or sixty feet above its present level, and were in part removed by subsequent erosion during the period of elevation and drainage that succeeded the Drift epoch.

In proof of this, there are many elevations scattered over the surface of this bottom, locally known as "*mounds,*" the formation of which have very generally been referred to human agencies. These elevations vary in height from ten to sixty feet or more above the level of the surrounding bottom, and when carefully examined are found to consist of drift clay and loess, remaining *in situ* just as they appear along the river bluffs, where similar mounds have been formed in the same way by the removal of the surrounding strata by currents of water. We had an opportunity of seeing a good section of the large mound in the upper part of the city of St. Louis exposed, by digging into the upper end of the mound for material to be used in filling the adjacent lots. It was found to consist of about fifteen feet of common chocolate-brown drift clay at the base, which was overlaid by thirty feet or more of the ash colored marly sands of the loess, the line of separation between the two deposits remaining as distinct and well defined as they usually are in good artificial sections in the railroad cuts through these deposits.

Hence we infer that these mounds are not artificial elevations, raised by the aboriginal inhabitants of the country, as has been assumed by antiquaries generally, but, on the contrary, they are simply outliers of loess and drift, that have remained as originally deposited, while the surrounding cotemporaneous strata were swept away by denuding forces. They are not found to occupy any fixed relative position in relation to each other, or to have any regularity of size or elevation, but our antiquarians appear to have inferred that they were raised simply to serve as burial places for the dead. But the simple fact that they were used for this purpose by the aborigines, which seems to be the main argument relied on as a proof of their artificial origin, seems to me entirely inadequate to sustain such a conclusion, and they were perhaps only selected by them for this purpose on account of their elevated position, for the same reason that they selected the highest point of a bluff in preference to any lower point, to serve as the last resting place for the earthly bodies of their relatives and friends. I have very little doubt that many of the so-called *Indian Mounds*, in this State at least, if carefully examined, would prove to be only natural elevations produced by the causes above named.

The soil on the American Bottom, in this county, is a deep, mellow, sandy loam, exceedingly fertile, and producing excellent crops of corn, oats, potatoes, etc., with but little labor. The city of St. Louis is mainly supplied with vegetables from the gardens that are established on this rich bottom land. Much of its surface is subject to overflow from the high water of the Mississippi, but wherever it is sufficiently elevated to be free from the danger of submergence, it may be considered as the most valuable land in the county. Some portions of it are low and swampy, and are too wet for cultivation. These wet places, however, are gradually filling up by the wash from the surrounding high lands, and will eventually become dry and susceptible of cultivation.

The loess attains a thickness in this county of from forty to eighty feet, and attains its maximum thickness on top of the river bluffs, thinning out gradually towards the interior of the county. Where the loess and drift are both present, the latter always underlies the former, but sometimes the drift appears to have been removed by currents previous to the deposit of the loess, and the latter then rests directly upon the stratified rocks. It is usually filled with land

and fresh water shells, and occasionally the bones of extinct land animals of the higher orders are found inclosed in it. A portion of a jaw-bone of a Mastodon, with the teeth remaining, was found in the lower part of the loess, just above the city of Alton. This specimen was found about thirty feet below the surface, and near the bottom of the loess, where it was only separated from the limestone by two or three feet of local drift. The bones were of a chalky-whiteness and in a very fine state of preservation.

A heavy deposit of drift originally covered all the uplands in this county to the depth of from forty to sixty feet or more, but it has locally been subjected to secondary influences that have, in some cases, partially or wholly removed it, and modified to some extent the original surface conditions and outlines. In the southeastern portion of the county the surface appears to have been subjected to an amount of erosion sufficient to remove a considerable portion of the upper part of the drift, leaving elevated mound-like ridges to indicate the former elevation of the whole surface. These elevations are usually covered with timber, and form beautiful sites for buildings.

The drift deposits in this county consists mainly of yellow and brown clays, intermingled with gravel; and occasionally a few boulders of considerable size are found, but they are not as abundant here as at more northern localities. At the base of the deposit there is usually a bed of blue plastic clay, from five to ten feet thick, and sometimes there are a few feet of sandy material between the blue clay and the yellow clays above. The sandy beds form the principal water horizon of the drift, and they serve as a medium for the reception and transmission of underground currents, that furnish an abundant supply of water for ordinary use.

The Quaternary deposits, which include the alluvium, loess and drift, are of the greatest economical value and importance, because the soil is everywhere based upon one or another of these subdivisions, and owes its peculiar features to the character of the strata on which it rests, and from which its inorganic matters have been derived. All soils consist mainly of the pulverized remains of preexisting rocks, and their fertility depends as much upon the mechanical condition of the material as upon its chemical composition. The conditions under which the drift clays were accumulated were such as to reduce the various rocks from which the material was derived to the condition of a fine sediment, that was deposited at the end of that period in the form of a finely pulverized clay, intermingled with silica in the form of sand, magnesia and lime, in such proportions as to form a soil of inexhaustible fertility, under a judicious system of cultivation. To these mineral ingredients have since been added the organic matter derived from the successive growths of vegetable and animal life, that have from year to year matured and decayed upon the surface, all of which have entered into, and gone to make up, the soil in its present condition. This organic matter has furnished the carbonaceous material to which the black color of the soil is mainly due, and the phosphates, the ammonia, and other animal substances which have added greatly to its productive qualities.

The presence of these deposits over nearly the entire surface of the State, gives that uniform character to the soil which forms so marked a feature in its surface geology, and makes it one of the finest agricultural regions on the face of the globe. The soils based upon the loess contain a smaller amount of alumina and a larger per cent. of silica than the ordinary drift soils, and from the porous nature of the sub-soil it absorbs water freely, and withstands the extremes of both wet and dry seasons much better than the ordinary clay soils. The calcareous and marly portions of the loess may be used to advantage as a fertilizer on sour and wet clay soils.

The stratified rocks in this county comprise the lower portion of the Coal Measures, and a part of the lower Carboniferous limestones. The Coal Measures in this county comprise a thickness of about three hundred and fifty feet, and include the lower portion of the measures from the base to the horizon of coal seam No. 9 of the general section. The following vertical section will give a general idea of the character of the Coal Measures in this county, and the relative position and thickness of the strata which they afford. The upper part of the section was obtained mainly from the shaft at Highland,* and the lower part from exposures on Wood river and in the vicinity of Alton:

Sandy shale exposed in the vicinity of Highland	15	feet	0	inches
Calcareous shale, with fossil shells	3	"	0	"
Compact blue limestone, weathering to a rusty brown color	4	"	0	"
Gray shale, with septaria	10	"	0	"
Coal No. 9	1	"	6	"
Gray shale	21	"	6	"
Calcareous shale, with fossil shells	2	"	0	"
Bituminous shale, with six-inch seam of coal	22	"	0	"
Sandstone and sandy shales, with three or four seams of bituminous shale about one foot in thickness	104	"	0	"
Limestone	1	"	10	"

* We are indebted to Mr. BANDELIER, of Highland, for a section of the strata passed through in the shaft sunk for coal at that point.

Bituminous shale and coal		feet	6 inches
Fire-clay	1	"	6 "
Clay shale	50	"	0 "
Coal passed through in the Edwardsville shaft (probably local)	2	"	0 "
Limestone and bands of calcareous shales	15 to 23	"	0 "
Coal No. 6 (Wood river and Edwardsville)	5 to 7	"	0 "
Fire-clay	3 to 6	"	0 "
Nodular limestone	5 to 8	"	0 "
Sandy shales	40 to 50	"	0 "
Bituminous shale (local)	1	"	6 "
Coal, Alton seam, No. 1	2½ to 3	"	0 "
Fire-clay and clay shale	3 to 6	"	0 "

The Coal Measures underlie nearly all the uplands in this county, and attain their greatest thickness in the eastern portion, but thin out towards the river bluffs on the west. The upper part of the measures outcrop on Silver creek, in the eastern part of the county, and also on Wood river, near the north line; but the exposures are limited, and sometimes widely separated, so that it would be quite impossible to construct a complete section from the natural exposures along the streams. The upper part of the measures in this county contain but one coal seam, and that seldom exceeds a thickness of eighteen or twenty inches, and is consequently of little economical importance. It outcrops in the vicinity of Highland, and has been worked at several points to supply the local demand for coal. It will probably be found also on Wood river and Silver creek, in the northeast part of the county, where it will, perhaps, be still too thin to work with profit.

The lower measures, as they are developed in the western portion of the county, contain the horizon of four coal seams, two of which are already known, and from these the present supply of coal is obtained. Below the nodular argillaceous limestone, which underlies the main coal on Wood river, we find in the adjoining county of St. Clair, first, a few feet of sandy or argillaceous shale, and then a band of brownish-gray argillaceous limestone, and sometimes a bituminous shale, that forms the roof to a lower coal seam, which at the old Pittsburg mines, on the north side of the Belleville and St. Louis railroad, is about three feet in thickness.

At Edwardsville the Belleville coal is found at a depth of from eighty to ninety feet below the surface, and in sinking the shaft at this point a thin seam above the main coal was passed through, representing, probably, No. 7 of the general section. The following section was made at the Edwardsville shaft:

Loess and drift clay and gravel	about 60 feet
Broken shale	2 "
Limestone	5 "
Coal	2 "

Hard, blue argillaceous limestone, alternating with bands of calcareous shale	16 feet
Coal (Belleville)	6 "

No attempt has been made, so far as we are aware, to determine whether or not any lower seams are developed at this point, but it is quite probable that one or two lower seams may be found here whenever the main seam becomes exhausted. The coal obtained from the Belleville seam at Edwardsville is of good quality, and presents the general appearance of the coals from this seam in St. Clair county. It appears to be more uniform in thickness, however, here than at Caseyville, and much less subject to the interruptions known as "clay-slips" and "horse-backs."

The *Madison Coal Company's* mines are located on Wood river, about eight miles northeast of Alton, where the following beds outcrop at the surface:

Coal	2 feet
Fire-clay	3 "
Calcareous shale, with fossil shells	10 "
Bluish-gray limestone	6 "
Bituminous shale	1 "
Coal (Belleville)	5 to 6 "
Fire-clay	2 to 3 "
Nodular limestone, partially exposed	2 "

The lower seam is the only one wrought at this locality, and is without doubt identical with the lower seam in the shaft at Edwardsville, and with that worked at Collinsville, Belleville and Caseyville, in St. Clair county. The quality of the coal does not differ materially from that at Edwardsville, but these mines are worked far more extensively than any others in this county.

In the vicinity of Alton a lower seam is found, that varies in thickness from two to three feet, and is separated from the lower Carboniferous limestone by only a few feet of fire clay or clay shale. This may be the equivalent of No. 3 of the general section. At Mitchell's coal bank, two miles north of Alton, this seam is overlaid by one foot of bituminous shale, and about forty feet of clay shale. At more northern localities this clay shale is replaced by sandy shales and sandstone. The coal seam No. 5, if present in this vicinity, would be found immediately above this clay shale, which may attain a thickness, altogether, of fifty or sixty feet. An analysis of this coal from four different mines in the vicinity of Alton, gave the following average results:

Specific gravity		1.2964
Loss in coking	44.04	
Total weight of coke	55.96	
		100.00

ANALYSIS:

Moisture	8.70	
Volatile matters	35.39	
Carbon in coke	50.88	
Ashes	5.07	
		100.04
Carbon in coal	54.19	

An analysis of four specimens from the Belleville seam in this county, two of which were from the Wood river mines, representing the top coal and the middle coal of this seam, one from the Edwardsville coal, and the other from Cook's mine, gave the following average results:

Specific gravity		1.3210
Loss in coking	50.82	
Total weight of coke	49.18	
		100.00

ANALYSIS:

Moisture	9.75	
Volatile matters	41.07	
Carbon in coke	42.12	
Ashes	7.07	
		100.01
Carbon in coal	48.67	

These analyses were made by Mr. HENRY PRATTEN, formerly an assistant geologist and chemist for the Survey, and were, no doubt, carefully made, and they show that the Wood river seam contains the largest amount of volatile matters, and would in consequence be the best for the manufacture of gas, while the lowest, or Alton seam, contains the most fixed carbon, and loses about 12 per cent. less in coking. These two seams furnish nearly all the coal that is mined in this county at the present time.

The seam that outcrops in the vicinity of Highland is too thin to be profitably worked in competition with the lower and thicker seams, and has consequently only been opened to supply the local demand in the neighborhood of its outcrop. It varies in thickness from twenty inches to two feet, and is associated with shales and limestone in the following order:

Calcareous shale, with fossil shells	3 feet.
Hard bluish-gray limestone	4 "
Bituminous shale	3 "
Gray shale, with band of septaria	10 "
Coal	2 "

The gray shale above the coal contains a few fossil ferns, and the limestone and calcareous shale above it contains fossil shells, corals and crinoidea. The best exposure of these beds is about one mile north of Highland. At another locality, about a mile and a half southwest of this, there is an exposure of about thirty feet of sandy shale underlying the limestone in the foregoing section, with no trace of the coal seam. This is only another evidence of the sudden change to which the strata of the Coal Measures are liable, even in local outcrops over very limited areas, and indicate the reason why coal is not always found in boring through strata that are known to include the horizon of one or more coal seams. A very slight change in the surface conditions of any given locality, during the deposit of a coal seam, would result in replacing the coal with some other material, forming either a sandstone, limestone or shale in its place; and even after the coal had been formed, it may have been swept away by the action of sub-marine currents, and its place supplied with sedimentary material.

The lower Carboniferous limestones of this county include a thin outlier of the Chester group, the St. Louis limestone, and the upper or geodiferous shales of the Keokuk group, and comprise a thickness, altogether, of about three hundred feet.

The Chester group is represented by the lower sandstone, about twelve feet in thickness, overlaid by a thin band of limestone two feet thick. The limestone is coarsely granular in structure and of a brownish-gray color, and is quite unlike any of the upper beds of the St. Louis group.

The sandstone is a massive brown rock, presenting the usual appearance of this bed in more southerly localities, where it is fully developed. These beds form the upper layers of the limestone escarpment in the bluffs just above the city of Alton. This group, which is over six hundred feet thick in Randolph county, has thinned out, in a distance of about eighty miles, to an aggregate of only about fourteen feet; and in the adjoining county of Jersey, we recognize a thin outlier of this group only about three feet in thickness, which is the most northerly point at which it has been recognized.

The St. Louis limestone is well exposed between the mouth of the Piasa and the city of Alton, forming a continuous bluff, averaging a hundred feet or more in height. The following section will illustrate the lithological character of this division of the lower Carboniferous system, as it appears in this county:

Green shaly clay, with nodules of limestone	4	feet
Massive arenaceous limestone, partially stratified	18	"
Massive light-gray limestone, with dendrites	10	"
Thin-bedded light-gray limestone	15	"
Gray limestone, in irregular beds	10	"

Irregularly-bedded dark-gray limestone, partly magnesian, with nodules of siliceous limestone and chert	8 feet
Thin-bedded gray limestone	10 "
Brecciated and concretionary limestone	30 to 50 "
Regularly-bedded gray limestones, the upper part rather massive and passing downward into thinner-bedded magnesian limestones, of a brownish-gray color	50 to 60 "
Brown earthy magnesian limestones, with some hydraulic layers and bands of semi-oolitic limestone, containing Pentremites and small shells, such as are characteristic of the same horizon at Bloomington and Spergen Hill, Indiana, and Warsaw, Illinois	40 to 60 "

The upper beds in the foregoing section thin out rapidly above Alton, and at the old lime-kiln, about four miles above the city, the whole series is probably not more than about one hundred and twenty feet in thickness. North of the Piasa we have not been able to recognize any of the beds that, in the vicinity of Alton, overlie the brecciated limestone.

As has been elsewhere observed, this is the most variable in its lithological characters of all the divisions of the lower Carboniferous series, except the Kinderhook group. Hence before it had been examined over wide extended areas, we were disposed to separate it into two divisions, which seemed to be clearly distinct and well defined, both by their lithological characters and by the specific characters of the fossils belonging to each. But it was found, on examination at many and widely separated points, that the lithological characters on which this division had been made were not constant, and moreover that many species of fossils which were supposed to be restricted to the separate divisions of this group, were found to extend through the whole. For example, the *Pentremites conoideus*, which occurs in the lower part of this group, three miles above Alton, and is also a characteristic fossil of these beds at Warsaw, Illinois, and Spergen Hill, Indiana, also occurs in Monroe county, in the upper division of this limestone, associated with *Lithostrotion proliferum* and other characteristic fossils of the upper limestones. This pentremite is quite common in the semi-oolitic beds three miles above Alton, and is associated with *Rhynchonella mutata, R. macra, Retzia Verneuilianus, Productus biserialis, P. Altonensis*, etc. The purer limestones above the brecciated bed contain *Athyris ambigua, Orthis dubia, Terebratula hastata, Productus ovatus, P. marginicinctus, P. tenuicostus, Lithostrotion mamillaris, L. proliferum*, and several undetermined species of *Bellerophon, Allorisma, Conularia*, etc.

No specimens of Archimedes have yet been found in the upper division of the St. Louis limestone in this State, though, according to Dr. B. F. Shumard, they have been found in Missouri in this horizon. Out of the one hundred and thirteen species of fossil fishes, from the Carboniferous rocks of Illinois, that are figured and described in the second volume of the original Report, nineteen were obtained from this division of the lower Carboniferous series; and it is quite probable that further investigations will add several more to the number already known to this horizon.

Keokuk Group.—At the base of the bluffs, on the Piasa, there is an outcrop of twenty-five feet of calcareo-argillaceous shales, which properly belong to the upper divisions of this group, and represent the geodiferous shales of Hancock and the adjoining counties. The shales at this point contain a few imperfect geodes, but afford no fine specimens, such as are found further north in this bed. It will probably be found at the base of the bluff, on the Piasa, nearly or quite to the bridge on the road from Alton to Jersey Landing. It affords no material of economical value.

Economical Geology.

Coal.—The coal beds of this county constitute by far the most valuable of its mineral productions, and as population increases and manufactures are extended, as they must necessarily do in so rich an agricultural region, these deposits of mineral fuel, which have been stored away in the bosom of mother earth for untold ages, will become a source of wealth undreamed of at the present time. As will be seen from the foregoing pages, there are two seams of coal now opened in the western portion of the county, and two thinner ones are known, which have not yet been worked to any considerable extent. The two lower seams are amply sufficient, inasmuch as they underlie nearly all the uplands in the county, for the supply of the entire demand for mineral fuel, in this county, for centuries to come. These two seams have an aggregate thickness of about nine feet, and will yield fully nine million tons of coal to every square mile of surface which they underlie.

But although the horizon of these coals extends over nearly the whole surface of the county, there may be localities where the coal is replaced by other material, and this seems to be the case at Highland, according to the journal of the boring made at the bottom of the shaft at that point. The shaft was sunk to a point about eighty feet above the Belleville coal, and a boring was then carried down forty-six feet below the limestone that usually forms the roof to that coal, without finding any trace of the coal seam; and if the journal kept by those prosecuting the work here is reliable (and we have no reason to doubt that it is so), then the

Belleville coal at this point is replaced by shale. It is greatly to be regretted that the boring had not been continued to the base of the Coal Measures, which would probably have been reached in fifty feet or less from the point where the work was suspended. This would have settled the question whether the two lower seams had also been replaced with other material at this point. At Summerfield, about twelve miles southwest of Highland, a four-foot seam of coal has been reached at a depth of about two hundred and seventy-five feet below the surface, but from the section given of the shaft at this point, it would appear that this is Coal No. 5, and that the Belleville seam is replaced by shale at this point also. It is to be hoped that borings will be made at other points in the central and eastern portions of the county, to determine whether the thinning out of the Belleville coal is confined to a limited area, or prevails over a considerable extent of surface.

Clays.—Good clays, suitable for the manufacture of potters' wares and fire brick, are frequently found underlying the lower coal seam in this county. It varies in thickness at different localities, ranging from two to ten feet. It is usually of a light buff, sometimes nearly white color, and is extensively used for economical purposes in various portions of the State. At Upper Alton a pottery has been in operation for several years, and is supplied with clay from a bed in the vicinity which comes from about the horizon of the lower coal. Other localities may no doubt be found, in the northwestern portion of the county, where valuable deposits of clay exist, and they will generally be found near the junction of the Coal Measures with the lower Carboniferous limestones. Clay, suitable for manufacturing bricks, may be obtained from the sub-soil clays almost anywhere on the uplands.

Hydraulic Limestone.—At the base of the St. Louis limestone, on the Piasa, there is a bed of hydraulic limestone about eight feet thick. It outcrops on the north side of the creek in the edge of Jersey county; and a mill has been erected there for the manufacture of hydraulic cement. The rock is a bluish-gray earthy magnesian limestone, and resembles that found at Miller's cement mills, near the south line of St. Clair county, and probably holds about the same stratigraphical position. This limestone may be found in the bluff on the south side of the Piasa, from its outcrop at the mill to the mouth of the creek. A considerable portion of the lower part of the St. Louis limestone is dolomitic in composition, and may afford other beds that will eventually be useful for this purpose.

Limestone for Lime.—There is perhaps no other point in the State where equal facilities may be found for the manufacture of a superior article of quick-lime, in almost unlimited quantities. The upper part of the St. Louis limestone, in the vicinity of Alton, is a nearly pure carbonate of lime, which, when burned, affords the best quality of quick-lime hitherto manufactured in this State. The quarries are immediately on the bank of the Mississippi, and the product of the lime kilns can be shipped to any point on the river without any expense of land carriage. Coal is abundant in the immediate neighborhood, and affords the necessary fuel at a moderate cost.

The manufacture of quick-lime commenced here at an early day, and for some years Alton supplied nearly all the river towns from St. Paul to New Orleans with this article. But more recently the manufacture of lime has been commenced at many points on the river, and an inferior article, manufactured nearer home, has been substituted for the Alton lime. The following history of the lime business at this point is taken from the *Alton Courier*, of November 28, 1857:

"One of the most important branches of manufacture in Alton is that of lime. Like all other enterprises beginning on a small foundation, it has developed and grown, year after year, until it now ranks second to that of no other in the Union. This is caused almost solely by its superior qualities, which cause it to be sought after with avidity wherever it has been once tried, or wherever its almost universal reputation has extended. In view of these facts it may not be uninteresting to look at some statistics of the trade in its early days, and as it now exists.

"The first lime made in the city, of which we have any record, was manufactured in *Hunterstown* in the year 1815, by Col. Jacob Judy. The manner of its manufacture was in keeping with the primitive style of those early times. It was simply this: Large log heaps were made, and the rock being placed upon them, they were fired, and as the logs burned to ashes the rock was transformed into lime. Lime continued to be made in this way, as occasion and necessity demanded, until 1818, when it was manufactured in kilns. The first kiln was erected in Hunterstown by Maj. C. W. Hunter, who leased it to the Hon. George Smith and Thomas G. Hawley, now of Upper Alton. These gentlemen manufactured lime to a considerable extent, which they were under bonds to sell at not more than 25 cents per bushel. This bond, we understand, is yet in existence, and can probably be seen by the curious.

"The manufacture of lime continued to be carried on with more or less activity until 1847. In this year the barreling and exportation of lime was commenced, and from that day to this the business has prospered and grown, and is yet increasing, day by day. Its present extent can, perhaps, be judged of by a few facts and statistics.

"Since the first of March last, there has been manufactured 121,900 barrels, of which 48,400 barrels have been shipped by railroad in bulk. The balance, 73,500 barrels, have been shipped and sold in barrels, thus affording a large demand for cooperage work. There are twenty kilns now in operation, of which five are patents. These kilns give employment in various ways to not less than four hundred men, aside from the cooperage required by them. Thus we see that this business, though making but little show, and perhaps but little thought of, is yet one of vast importance and benefit. With the kilns now in use, there are ample facilities for the manufacture of about 210,000 barrels of lime per annum, amounting in value to over $200,000. This is the yearly product of the rocky and forbidding bluffs that adorn the river bank in our immediate neighborhood. What other portion of the land, so unprepossessing in appearance, abounding in no hidden deposits of mineral wealth, and of like extent, can yield more, or even as much?"

From that time down to the present there appears to have been a gradual falling off in the lime business at this point, not in consequence of any failure in the supply of the necessary material, but rather from the competition in the manufacture of the article at points nearer than this to the principal markets heretofore supplied from this locality. The supply of material for the manufacture of lime is absolutely inexhaustible in this vicinity, and Alton must always remain a noted locality for this branch of manufacture.

Building Stone.—This useful material, like that for lime, occurs in great abundance, but its outcrop is confined to the vicinity of the river bluffs in the northwest part of the county. The entire thickness of the limestone outcropping in the bluffs between the mouth of the Piasa and Alton is something over three hundred feet, and nearly the whole of it may be made available as a building stone. From the Piasa down to the creek which enters the Mississippi just below the old town of Clifton, the limestones which here form the base of the St. Louis series are more or less magnesian, and some of the beds approach a true dolomite in composition. Where this rock is in heavy beds it makes an excellent material for culverts, abutments, and heavy walls, where strength and durability are the chief requisites. The material for the abutments of the railroad bridge over the Illinois river, at Meredosia, was obtained from the light gray limestone near the top of the bluff, just above Alton, and proves to be a durable stone, not easily affected by atmospheric influences. Some of the beds in the upper part of the group here are susceptible of a fine polish, and may be used as an ornamental stone. The thinner beds make good flag-stones, and have been extensively used, both at Alton and Springfield, for that purpose. The flag-stones around the Capitol Square, in Springfield, were obtained from the upper beds of limestone at Alton.

In the central and eastern portions of the county, the supply of building stone is quite limited. The limestone in the vicinity of Highland, and on Shoal creek, affords a durable stone for rough walls, but as the bed is usually not more than four or five feet in thickness, the supply is limited. There are perhaps some other beds of Coal Measure limestone outcropping in the county that will prove of local value for building purposes. The sandstones of the Coal Measures in this county, so far as they have fallen under my observation, appear to be too soft and incoherent in their structure to be relied on as a desirable building material.

There are but few counties in the State more favored with all the essential elements of wealth and material prosperity than the county of Madison. Possessing a soil of unsurpassed fertility, covering the whole area of the county, with an abundant supply of excellent timber, an inexhaustible supply of coal, building stone, limestone for lime, hydraulic lime and potter's clay, with a favorable position on the Mississippi, which opens up to its products the markets of the world, and with ample railroad facilities connecting it with St. Louis and Cnicago, as well as the cities of the East, it only remains for the citizens to improve the natural advantages so lavishly bestowed, to obtain for this county the reputation it will justly deserve, as one of the most wealthy and populous in the State. To this end, manufactories should be encouraged and built up to consume the surplus of raw material which the soil is capable of producing, and to make available the natural resources, in the way of mineral fuel, which have been so bountifully stowed away beneath the surface.

CHAPTER XII.

HANCOCK COUNTY.

This county is situated on the western border of the State, opposite the dividing line between the States of Iowa and Missouri, and embraces a superficial area of about twenty-one townships, or seven hundred and fifty-six square miles. It is bounded on the north by Henderson county, on the east by Schuyler and McDonough counties, on the south by Adams county, and on the west by the Mississippi river. The face of the country is generally level or gently undulating, except on the borders of the streams, where it becomes broken and hilly. The principal streams in the county are Crooked creek and Bear creek, which traverse the eastern and southern portions of the county.

A large portion of the surface of this county is prairie land, the proportion of prairie and timber being about three of the former to one of the latter. But notwithstanding the great preponderance of the prairie over the timber land, and the fact that the greater portion of the prairie is now occupied and improved, the amount of timber still remaining is probably nearly, or quite, as great as at any period before its settlement by the white race, showing that the annual growth has proved fully adequate to supply the wants of the population for fuel, fencing and building purposes. By the settlement of the county, the fires which annually swept over its surface while in a state of nature, were prevented from spreading over the whole area as before, and the young growth of timber which had previously been destroyed by these annual fires was preserved, and in this way the supply has been fully maintained.

The soil upon the prairie land is usually a deep black loam, with a brown clay sub-soil. On the ridges that skirt the streams the soil is usually a chocolate-brown loamy clay, becoming locally light-brown or yellow, on the slopes of the hills, from the predominant character of the sub-soil. The timber on these ridges consists for the most part of black and white oak and hickory, with an undergrowth of red-bud, sassafras and hazel. On the more level portions of the timbered uplands we find, in addition to these, elm, linden, wild cherry and honey locust. The soil, on the lands where the last named varieties of timber are found, is fully equal, in its productive capacity, to that of the prairies, while that on the oak ridges is comparatively thin. In the southwest portion of the county there is a wide belt of alluvial bottom skirting the Mississippi river, commencing at the city of Warsaw and extending to the south line of the county, with an average width of about three miles. A part of this bottom is prairie, and a part is covered with a heavy growth of timber, consisting of cottonwood, sycamore, red and slippery elm, black and white walnut, ash, hackberry, honey locust, pecan, persimmon, paw-paw, coffee-nut, white maple, red birch, linden and mulberry, and the common varieties of oak, and shell-bark and pignut hickory. The greater portion of this bottom is susceptible of cultivation, and possesses a sandy soil that is not surpassed, in its productive capacities, by any other portion of the county. It is subject to overflow, however, during seasons of extraordinary high water, and those who cultivate these lands must calculate on a partial, if not a total loss of their crops once in about seven years.

Springs are not abundant in this county, but are occasionally found at the base of the river bluffs and in the valleys of the small streams. Some of these are chalybeate, and contain, in addition to the iron, both sulphur and magnesia. Good wells are usually obtained on the uplands at depths varying from twenty to forty feet. The surface deposits of this county comprise the usual sub-divisions of the Quaternary system, and attain an aggregate thickness of about seventy-five feet. All the uplands are covered by accumulations of drift, varying in thickness from twenty to sixty feet or more. This usually consists of a bed of blue clay or hard pan at the bottom, of variable thickness, which is overlaid by brown clays, with gravel and boulders of water-worn rock of various sizes. Sometimes there are thin beds of sand in the brown clays, that present a stratified appearance, and serve as channels to the underground streams of water. A large portion of the material composing the drift deposits has been transported from a distance, and many of the boulders are derived from the metamorphic strata of Lake Superior, several hundred miles from the spot where they are now found. Many of these boulders are of great size and many tons weight, and must have required a mighty force to transplant them to their present position.

One of these may be seen at the foot of the bluffs between Nauvoo and Appanoose, composed of the metamorphic rock of the northwest, which is nearly twenty feet in diameter. The power required to wrench such a mass of rock from its native bed and transport it, for hundreds of miles, with a force sufficient to obliterate all its angles, is inconceivably great; but here is the boulder of granite, nearly five hundred miles, as the crow flies, from the nearest known outcrop of this kind of rock, giving unmistakable evidence that such a result has been accomplished. Several specimens of native copper have been found in the drift deposits of this county, which, from their appearance, leave no doubt that they have been transported from the copper region of Lake Superior.

Specimens of bituminous coal are also frequently met with in the drift clays of this county, and have come from some of the coal seams in the adjacent region. To those who are unacquainted with the manner in which the drift clays and the inclosed boulders and gravel beds have been accumulated, these specimens of coal and copper, or any of the metallic ores that are to be found in them, may be regarded as indications of the near proximity of valuable beds of these minerals, whereas they were perhaps transported for hundreds of miles and then only in isolated specimens, and furnish no evidence whatever of the existence of any deposit of mineral wealth in the vicinity where they occur.

Along the river bluffs the accumulations of drift appear to have been subjected to a partial sifting process, which has given the whole a stratified character, which may be termed *modified drift*. In the section of the river bluff exposed in grading Main street, in the city of Warsaw, a very interesting section of modified drift may be seen, showing the following order of super-position:

Ash colored marly clay, resembling *loess*	10	feet,	0	in
Brown drift clay	10	"	0	"
Brown sands, partly stratified	8	"	0	"
Blue sandy clay	2	"	6	"
Fine gravel and clay	2	"	6	"
Yellow sand	2	"	0	"
Gravel and boulders	8	"	0	"
Blue clay	5	"	0	"

The upper clay bed in the above section resembles the loess in its color and general appearance, but contains no fossils at this locality. In the vicinity of Hamilton there is an exposure of loess, fifteen feet thick, in the railroad cut; and at this point it contains a few fossil shells. It appears to be generally more argillaceous here than at points farther south, and it probably nowhere exceeds, in this county, a thickness of fifteen or twenty feet. Where it forms the sub-soil its porous character allows the water to pass freely through it, affording a more thorough drainage to the surface than that afforded by the clay subsoils of the drift. Along the river bluffs in this county the drift, either in its normal or modified condition, appears everywhere below the loess, while the deposits of the latter are comparatively thin, and restricted to the vicinity of the river bluffs. The drift clays that underlie the central and eastern portion of the county contain fragments of wood, and often the entire trunks of trees of considerable size are met with, in sinking wells in this formation. These woods are coniferous, and appear to belong to a species of cedar. At several points in this county, one of which is on the State road, five miles nearly east of Warsaw, there is, at the base of the drift deposits, a bed of ferruginous conglomerate, exactly resembling the conglomerate of Southern Illinois, which we regard as of Tertiary age. Whether this bed in Hancock county, which appears to be only about two feet in thickness, is really referable to the same age, is a point we have not yet been able to determine; but the fact, alluded to in a previous chapter, of the occurrence of shark's teeth in the alluvial sands of the Mississippi river, in this county, renders it highly probable that beds of this age were really deposited as far north as this; and if so, this band of conglomerate is most probably referable to the same age. As it contains no fossils, its age can only be inferred from its stratigraphical position, which is below the blue clay or "hard pan" that is usually regarded as the base of the drift formation. These superficial deposits, belonging to the *Quaternary*, or most recent of the geological systems, are spread entirely over the surface of the county, except in the valleys of the streams, where they have been carried away by surface agencies. Hence the underlying stratified rocks are only to be seen in the bluffs and valleys of the streams, where the clays and gravel beds have been removed by the agency of water currents.

The stratified rocks that are exposed above the surface, in this county, comprise a limited thickness of the lower Coal Measures, and about one hundred and fifty feet of lower Carboniferous limestone belonging to the St. Louis and Keokuk groups. A vertical section of these rocks would exhibit the following order and thickness of strata:

Coal Measures:		
Sandstone, passing downward into clay shale	30 feet.	
Coal	2 "	
Bituminous and argillaceous shales	9 "	
Coal	1 "	6 in.
Conglomerate sandstone	20 "	

St. Louis Limestone:	
Brecciated and concretionary limestone	10 to 25 feet.
Calcareous grit stones	10 "
Blue clay shales and Archimedes limestone	20 "
Magnesian limestone	8 to 12 "
Keokuk Limestone:	
Geodiferous shales and shaly limestone	30 to 40 feet.
Light, bluish-gray limestones	20 to 30 "
Cherty thin-bedded gray limestones	40 to 50 "

From the above section it will be seen that the aggregate thickness of the Coal Measures in this county is only about sixty-five feet, and they include the horizon of two coal seams, both of which are comparatively thin. The best outcrop of coal in the county is on Williams creek, near Augusta, in the southeast corner of the county. The upper seam, which we regard as perhaps identical with the Colchester seam, is here about two feet thick, sometimes as much as twenty-eight or thirty inches, and affords a fair quality of coal. The roof is usually clay shale, and when worked by drifting it requires a good deal of expense in cribbing, to keep the roof from falling in. Just above the bridge on the Pulaski road, the following strata were exposed at the time we first visited this locality in 1853:

Shaly sandstone	14 feet
Sandy and argillaceous shales	16 "
Coal	2 "
Red shale	1 "
Unexposed slope	7 "
Fire clay	3 "

The sandstone and shale above the coal seam was somewhat ferruginous, and contained nodules of argillaceous iron ore. At another exposure of these beds, not more than fifty yards from Hawley's coal bank, the coal was replaced by a thin band of bituminous shale, and the following section was exposed:

Ferruginous shale and shaly sandstone	32 feet.	
Bituminous shale	0 "	4 in.
Gray shale	9 "	
Bituminous shale	1 "	
Fire clay	3 "	

These two sections were made less than fifty yards apart, and represent exactly parallel strata, and will serve to illustrate the sudden changes that sometimes occur in coal seams, or indeed in any other stratified rock, even in very limited areas. The coal which, in the first section, is two feet thick, is represented in the last by four inches of bituminous shale. The lower seam of bituminous shale represents the horizon of the other coal seam, and at this locality it contains a few fossils, among which were *Discina nitida* and a few scales and spines of fishes. A coal seam—probably the same as the upper one in the foregoing sections—outcrops about one mile southeast of Plymouth, which had not been worked to any extent at the time of my visit to the locality.

In the central and western portions of the county coal has been found at several localities, but it appears to exist only in detached outliers, and probably occupies shallow depressions in the concretionary limestone. On the small creek north of Carthage there are two or three outcrops of coal, one of which is on the lands of A. Simpson, Esq., the northeast quarter of section 11, township 5 north, range 6 west, and another on the northwest quarter of section 9, township 5 north, range 6 west. The coal at these outcrops is only from twelve to eighteen inches thick, and is of little economical value at the present time. On the head waters of Waggoner's creek, which enters the Mississippi one mile above the old town of Montebello, there is an outlier of coal, that was worked to some extent in the early settlement of the county. The coal at this point is from twelve to fourteen inches thick, and strongly impregnated with iron pyrites. On Mr. Miller's place, a little farther north, on the northeast quarter of section 32, township 6 north, range 8 west, there is another exposure of about the same thickness. The coal is here underlaid by about thirty feet of conglomerate sandstone. At Nauvoo this thin outlier of coal was found about a hundred yards south of the "Temple," and was worked, while the city was occupied by the Mormons, by stripping off the overlying drift clays and loess which rested directly upon the coal. It is only about eighteen inches in thickness, and having no roof, could not be profitably worked at the present time. It is probable that this outlier of Coal Measures originally extended continuously from Waggoner's creek to Nauvoo, and it is also found on the opposite side of the river, just below the old town of Nashville, where it is represented by a bed of massive conglomerate sandstone, that caps the bluffs at that point. There are also outcrops of sandstone and bituminous shale extending up the river bluffs nearly to the north line of the county, but up to the present time they have afforded no valuable deposit of coal. On section 13, in the eastern part of township 4 north, range 8 west, on the waters of the north fork of Bear creek, coal was found and worked in the early settlement of the county, but was soon abandoned.

From the fact that all the streams of any considerable size in the county cut down to the limestones that underlie the Coal Measures, it is not probable that any very extensive and valuable deposits of coal will ever be found in this county. Local deposits, however, may exist beneath the heavy drift deposits that are spread over the broad prairies, and may be found by boring through these overlying deposits. It is probable that a boring one hundred feet deep would reach the limestones below the coal at every point in the county, and thus settle definitely the question as to the amount of coal that existed at the point where the boring was made. By referring to the general section of the strata in this county, it will be seen that all the limestones underlie the Coal Measures, and consequently the search for coal either in or below these limestones would be in vain. All the coal in this county lies between the limestones and the drift, and if the drift is found resting directly on the limestone, no coal will be found.

The concretionary or brecciated limestone, which is the upper bed of lower Carboniferous limestone in this county, underlies the Coal Measures throughout this county, and it therefore forms a reliable and easily recognized horizon to guide those who are in search of coal.

Fossils are quite rare in the Coal Measures of this county, but the bituminous shale overlying the lower seam on Waggoner's creek, and near Augusta, has afforded a few marine shells, as well as some fish remains, and the Conglomerate sandstone has afforded a few specimens of plants, such as *Sigillaria*, *Stigmaria*, *Lepidodendron*, etc.

St. Louis Limestone.

Concretionary and Brecciated Limestone.—This division of the St. Louis group is a bluish-gray, sometimes nearly white, limestone, concretionary in structure, and sometimes brecciated, and rarely presents any regular lines of bedding. It contains locally, irregular seams and crevices filled with green marly clay, and also seams and nodules of chert. At some localities the chert forms a stratum a foot or two in thickness at the top of the limestone. This limestone outcrops in the river bluffs throughout the county, and on all the principal streams in the interior. On a branch of Bear creek, in the vicinity of St. Albans, it forms the entire bluff, and also outcrops at several other points in this part of the county. On Crooked creek it was met with as far north as the crossing of the Pontoosuc road west of LaHarpe, and it may be found along this creek as far south as it runs in this county. It is also found on the forks of Brunce's creek, northwest of Plymouth. Its thickness in this county is variable, ranging from ten to thirty feet.

Calcareous Grit-stone.—The concretionary limestone is usually underlaid by about ten feet of grit-stones in regular beds, that are locally calcareous, and vary in thickness from two inches to a foot or more. It is extensively quarried in the vicinity of Warsaw, where it is exposed on all the small streams, as well as in the river bluffs. It is an excellent material for foundation walls, and is very generally used in the vicinity of its outcrop.

Blue Shales and Archimedes Limestones.—Below the grit stones above described, there are a series of blue clay shales, with intercalated beds of coarse granular gray limestone, that attain a thickness of twenty feet or more in this county. They are well exposed at the city of Warsaw, and also in the river bluffs, both above and below. On the southwest quarter of section 24, township 4 north, range 6 west, the beds are well exposed on Brunce's creek, and are twenty feet in thickness. This division of the group is somewhat variable in its lithological characters, and is sometimes composed entirely of blue or gray clay shales, without any intercalations of limestone, and at other localities it becomes a shaly magnesian limestone.

Magnesian Limestone.—The lowest member of the group is a brown or gray magnesian limestone, generally evenly-bedded, is easily dressed, and is an excellent material for caps and sills, and is generally used in the vicinity of Warsaw as a building stone. Its thickness in this county ranges from eight to twelve feet. It is extensively quarried at several points in the river bluffs, from two to three miles below Warsaw, where it attains its maximum thickness, and is quite regularly-bedded, and these quarries afford nearly all the dressed stone used in the city. For evenness of texture and durability, this limestone is not surpassed by any other in the county, but it contains minute crystals of iron pyrites, which oxydize on exposure to the atmosphere, giving origin to patches of rusty brown on the exposed surface of the rock. Zinc blend in crystals, associated with crystals of dolomite and calcite, is occasionally found in pockets in this limestone. It will be found in all the highest points of the river bluffs from Warsaw to Nauvoo, and is also exposed on Brunce's creek and Crooked creek in the east part of the county.

Fossils abound to some extent in all the sub-divisions of the group, but are most abundant in the shales and Archimedes limestones. The *Archimedes Wortheni* is, perhaps, the most abundant and conspicuous fossil in this bed, but there are several other very beautiful forms of *Bryozoa* associated with it, among which are *Coscinium plumosum*, *C. elegans*, *C. sagenella*, *C. Michelinia*, and

Polypora Varsouviensis. Fossil shells are not so abundant, but the following species are to be found at Warsaw: *Spirifer lineatus, Orthis dubia, Productus Altonensis, Rhynchonella subcuneata, Conularia Verneuilii,* and *Lithophaga pertenuis.* The exposures of this bed at Warsaw have also afforded several very beautiful specimens of crinoidea, the most of which are unique. They comprise the following species: *Cyathocrinus Thomæ, Platycrinus Georgii, P. Pumilis, Actinocrinus caroli, Rhodocrinus Varsouviensis, Scaphiocrinus divaricatus, Dichocrinus dichotomus,* and *Pentremites conoideus. Zaphentris spinulifera,* and two or three undetermined corallines, are also quite common at this locality. The calcareous grit-stone and Magnesian limestone, that lie above and below these shales, contain the same species of fossils in a less perfect state of preservation.

The concretionary and brecciated limestone which forms the upper division of the group is characterized by two species of fossil corals, the *Lithostrotion mamillaris* and *L. proliferum,* and an undetermined species of *Aulopora.* The specimens of *Lithostrotion* are almost invariably siliceous, and are found weathered out of the limestone in the *debris* of the streams that cut through it, in masses from a few ounces to forty pounds or more in weight. They are usually of a reddish-brown color on the surface, and a delicate pink or flesh color within, and at once attract the eye even of those who know nothing of their true character as fossils. The *L. mamillaris* is generally known as a *petrified honey-comb* or *hornet's nest.*

Keokuk Group.

Geodiferous Shales.—The upper division of this group consists of blue and brown calcareo-argillaceous shales and shaly limestone, and in this county is from thirty to forty feet in thickness. A good section of these shales, exhibiting the full thickness of the bed, may be seen just above the steamboat landing at Warsaw, and above the railroad grade. It is about forty feet in thickness at this point, and at the bottom is an irregularly-bedded argillaceous limestone, passing upward into a blue clay shale. Running through the bed, near the middle, there is a band of brown, cherty magnesian limestone, about two feet in thickness. Siliceous geodes, the crust of which is composed of chalcedony and crystalline quartz, are disseminated through the entire bed, but at this locality they are most abundant near the base. These geodes are lined with beautiful crystals of limpid quartz, calcite, dolomite, zinc blende, iron pyrites and arragonite, or with botryoidal forms of blue and milk-white chalcedony. In the north part of the county a few have been found that were filled with petroleum and asphaltum. For a detailed description of these geodes the reader is referred to the report of Prof. BRUSH,* of Yale College, in a previous chapter, to whom a collection of them was submitted for examination. This bed outcrops in the river bluffs, from the northern to the southern extremity of the county, and is also exposed on several of the creeks in the interior. Waggoner's creek, above Montebello, and all the smaller streams along the rapids, intersect this bed, and on several of them fine geodes may be obtained. Waggoner's creek has afforded the largest specimens yet found in the county, some of which are from fifteen to eighteen inches in diameter. At some localities the bed affords no good specimens, the geodes all being imperfectly formed, and at others many of the geodes are solid globes of quartz, with no cavity in the centre. Some of them are partly filled with water, which is sometimes quite bitter to the taste, from the mineral substances held in solution. The crystallized minerals contained in these geodes are by far the most attractive specimens in mineralogy to be found in the State.

Keokuk Quarry Rock.—The limestones of this group that are quarried for building stone, are restricted mostly to the middle division, and comprise a thickness of from twenty-five to forty feet in this county. They are mostly of a bluish-gray color, in tolerably regular beds, that vary from four inches to three feet in thickness. Some of the thickest beds are of a light-gray color, and are as completely crinoidal in structure as any portion of the Burlington limestone. The Mormon temple at Nauvoo was built of this limestone; and at Loomis' quarries, just below the city, where a part of the material for the temple was obtained, the beds show the following detailed section:

Thin-bedded, gray limestones	6 feet	0 inches
Argillaceous shale	2 "	0 "
Gray limestone, in two layers	3 "	10 "
Clay shale	1 "	10 "
Light gray limestone (single layer)	3 "	6 "
Dark gray limestone	1 "	10 "
Cherty limestone	3 "	0 "
Light gray limestone	2 "	0 "

This quarry furnished a considerable portion of the material used in building the United States Custom Houses at Galena and Dubuque, and the equivalent strata are generally used as a building stone wherever they are found. It cuts freely, and, when free from chert,

*See page 71.

may be sawed with facility. All the ornamental stone work for the Mormon temple, even the stone oxen on whose backs the baptismal font rested, were carved from this limestone. These quarries will afford an inexhaustible supply of superior building stone for the whole region adjacent to the outcrop. The lightest colored layers are a nearly pure carbonate of lime, and are also valuable for the manufacture of quick-lime. Its outcrop is confined mainly to the river bluffs, and to Crooked creek, and Brunce's creek, in the eastern part of the county.

Fossils.— To the palæontologist this limestone presents a most interesting and varied field for study. It seems to have been deposited in a quiet ocean, where the delicate bryozoa and the beautiful and graceful crinoid flourish in great profusion, and their calcareous skeletons are found attached to the solid surfaces of the limestone, or enclosed in the shaly partings that separate the harder layers, in a most perfect state of preservation. The solid limestone itself is a complete aggregation of the remains of organic beings, including the Mollusk and the Coral, the Crinoid and the Trilobite, associated with the teeth and spines of fishes. A residence of a quarter of a century in the vicinity of some of the most productive localities of fossil organisms ever yet found in this formation, has afforded us an opportunity to study somewhat minutely its palæontological features, and we feel fully warranted in the assertion that, excepting the Burlington limestone, no sub-division of the whole palæozoic series presents, in the same thickness of strata, so rich and varied a series of marine fossils.

Fishes appear to have abounded, both in individuals and species, during the deposit of this limestone, more than at any other period of the lower Carboniferous era. Their remains are not generally distributed through the limestones like those of the Mollusk and the Coral, but are restricted to certain beds, where they are far more abundant than anywhere else. The fishes of the lower Carboniferous period appear to have been entirely cartilaginous, possessing no bony skeleton; yet their teeth and the thorny spines with which they were armed are found, in some layers of the limestone, in great numbers. There are two beds of limestone in the Keokuk group in which these remains are far more abundant than elsewhere, one of which is at the top of the limestones and near their junction with the geodiferous shales, and the other is about twenty-five feet below this, and near the base of the quarry rock. The upper one was first observed in the vicinity of Warsaw, where only the upper beds of limestone appear above the surface; and the other one was found in the bed of the creek that intersects the bluffs just below Hamilton. Neither of these beds are above six inches in thickness, and from the lower one, at the locality above named, we obtained at different times more than a thousand specimens of teeth and spines on a surface not exceeding ten feet square. Forty-eight species from this horizon will be found figured and described in the second volume of the original Report, nearly all of which were obtained from these two localities.

Of the Mollusca and Radiata most common in this limestone, the following species have been found in this connty: *Spirifer striatus. S. Keokuk, S. rostellatus, S. tenuimarginata, S. neglectus, S. lineatus, S. cuspidatus, Productus semireticulatus, P. punctatus, P. Wortheni, Hemipronites crenistria, Agaricocrinus Americanus, A. Wortheni, Actinocrinus pernodosus, A. Nashvillæ, A. Lowei, A. Gouldi, A. Mississippiensis, A. ramulosus, A. Humboldtii, A. spinulosus, A. lobatus, A. steropes, A. unicarinatus, A. jugosus, A. mundulus, A. lagunculus, Forbesiocrinus Wortheni, F. Meeki, F. Norwoodi, Platycrinus Saffordi, Cyathocrinus stellatus, C. bullatus, C. tumidus, C. spurius, C. protuberans, C. intermedius, C. magister, C. angulatus, Poteriocrinus decadactylus, Synbathocrinus Swallovi, Pentremites Wortheni, Granatocrinus granulosus,* and *Archæocidaris Keokuk.* Among the Corals, Sponges and Bryozoa, the most common are *Zaphrentis dalii, Sphenopoterium obtusum, Archimedes Owenana, Coscinium Keyserlingi,* and *Cyclopora discoidea.* These fossils will serve to distinguish this limestone readily from any other division of the lower Carboniferous series, because they are for the most part restricted to this formation, and especially the crinoidea, not a single species of which have yet been found in any other division of the series. The list of fossils given above is by no means a complete one of this group, even in this county, but comprises only some of the most common and well known species.

Cherty Limestone.—At the base of the Keokuk group we find a bed of chert alternating with thin beds of light gray limestone, and attaining a thickness of from forty to sixty feet. The only outcrop of these beds in this county is along the base of the bluffs from a point about two miles above Warsaw to the north line of the county. It not only forms the lower portion of the river bluffs between the points above named, but extends entirely across the bed of the river, forming the serious obstruction to navigation known as the *Lower Rapids.* For economical purposes this rock is of little value, the limestones being generally too thin to be of much value as a building stone. The cherty portion, which constitutes the greatest part of the bed, would make an excellent material to macadamize roads, and for this purpose it would prove of far more value than the limestone.

The following section of the upper portion of these beds, as they appear above the river level, just below Nauvoo, will afford a very correct idea of their general character:

Chert	3	feet.		
Shaly limestone	2	"	6	inches.
Siliceous limestone	2	"	6	"
Limestone	1	"	0	"
Chert	0	"	10	"
Limestone	1	"	0	"
Chert	6	"	0	"
Limestone	0	"	6	"
Chert	2	"	5	"
Limestone	1	"	6	"
Chert	1	"	6	"
Limestone	0	"	9	"
Chert	1	"	2	"
Limestone	0	"	8	"
Chert	0	"	10	"
	26	"	2	"

The limestones in this section are all light gray in color, irregular bedded, and contain more or less chert in nodules and lenticular masses. This chert approaches a true flint in hardness, and was used by the aborigines for arrow heads and other implements. In its fossils, this division presents no marked difference from the limestone above it, except that they are much more rare, and generally not so well preserved as in the higher and more calcareous beds. This is the lowest rock exposed above the surface in this county, and its outcrop is confined to the vicinity of the river bluffs between Warsaw and the north line of the county, and here the lower portion of it is below the river level, so that there is but a partial exposure of the bed even here. Its entire thickness is probably not less than sixty feet, though in this county not more than forty feet is exposed at any locality that we have examined. The only fine examples of *Spirifer striatus* that have been met with in this county, with both valves of the shell together, were found in a band of limestone intercalated in these cherty beds about two miles below Nauvoo.

Economical Geology.

Building Stone.—Hancock county is well supplied with good building stone, and there is perhaps no natural resource of this portion of the State that is so lightly appreciated at the present time in proportion to its intrinsic value as this. In the early settlement of a country, the people are compelled to content themselves with primitive and cheaply constructed dwellings, but as wealth increases, and a taste for more elegant structures is generally disseminated, these cheap primitive dwellings will give place to those of a more substantial character, and many of the quarries, now regarded as of little value, will become a source of wealth to their owners.

The middle division of the Keokuk group will afford the greatest amount as well as the finest quality of building stone, and where this is easily accessible, no better material need be looked for. It is generally even textured, dresses well, and is well adapted for all the ordinary uses to which a building stone is applied. It is also tolerably even bedded, and affords strata thick enough for all the ordinary requirements of architecture. Some of the beds are susceptible of a fine polish, and may be used as an ornamental stone. It outcrops on all the small streams in the western part of the county, as well as in the river bluffs throughout the county, except in the vicinity of Warsaw, and for a distance of five miles below, where, by an undulation of the dip, it is carried below the surface, with the exception of a few feet of the upper layers. It appears again, however, on Rocky run, six miles below Warsaw, forming bluffs on that creek twenty feet or more in height. In the eastern part of the county it outcrops on Brunce's creek, north of Plymouth, and Crooked creek, in the vicinity of St. Marys.

The arenaceous and magnesian beds of the St. Louis group will also furnish a building stone but little inferior in quality, and quite equal in durability, to that afforded by the Keokuk limestone. The Magnesian limestone of this group, especially, affords a most excellent building stone, and it has been very generally used at Warsaw and vicinity for many years, not only for foundation walls, but for the construction of entire buildings of the largest size. At the quarries a mile and a half or two miles below the city of Warsaw, this bed, although only about ten feet in thickness, has afforded the largest portion of the cut stone used in the city and vicinity for the last twenty years. It is even textured, cuts easily when freshly quarried, and hardens on exposure to the atmosphere. It is thick bedded at this locality, and is readily quarried into blocks of suitable size for ordinary use. North of Warsaw its outcrop is generally high up in the bluffs, or on the small streams that intersect them, and in the interior of the county it will be found on all the principal creeks that intersect the limestones immediately below the Coal Measures.

Hydraulic Limestone.—At the top of the geodiferous shales in the vicinity of Warsaw there is a bed of bluish-gray earthy limestone that presents the external characters of a hydraulic rock, and it occupies the same stratigraphical position as the hydraulic beds in Jersey and St. Clair counties. Its thickness is from three to four feet. An analysis* of this rock by Messrs. BLANEY and MARINER, of Chicago, showed a deficiency of lime and magnesia necessary to constitute a good hydraulic limestone, with a superabundance of clay; but an analysis of a single specimen is hardly sufficient to determine its true value for this purpose. It is highly probable that some of the earthy magnesian limestones of this county will be found adapted to this purpose when an increased demand for such material shall require careful practical experiments to fully test the value of those rocks that seem most likely to answer such demand.

Limestone for Lime.—The best rock in this county for the manufacture of quick-lime is the concretionary and brecciated limestone, which immediately underlies the Coal Measures, and outcrops on every stream of any size in the county. Its thickness ranges from ten to twenty-five feet, and it will afford an inexhaustible supply of material for this purpose. At Hamilton, Nauvoo and Niota, lime is manufactured from the Keokuk limestone, and the purest layers, when carefully selected, make a good lime.

Potter's Clay.—The under-clays of the coal seams are almost the only clays in the State used for the manufacture of potters' ware, and are the only ones from which a good article of fire brick has been made. The under-clay below the lower coal seam on William's creek, in the southeast part of the county, is about three feet thick, and appears to be of good quality, suitable either for potter's ware or fire brick. There are probably many localities in the eastern part of the county, where this clay may be found equal in quality and quantity to that at the locality above named. Beds of soft material like this are seldom well exposed by natural causes, and are best seen by artificial cuts through the strata with which they are associated. The coal seams will always serve as a guide to those in search of these clays.

---

* The following is Dr. BLANEY's analysis of this rock:

Carbonate of lime	36.28
Carbonate of magnesia	17.95
Silica, alumina and iron	1.57
Potash and water	9.65
Clay	34.55
	100.00

Iron Ore.—Nodules of carbonate of iron are disseminated through the shale over the lower coal seam, and are found in considerable abundance along the beds of the small creeks that intersect the shale, but no deposit was seen that promised anything like a profitable bed of ore for the manufacture of metallic iron.

Coal.—The supply of bituminous coal in this county is quite limited, and the inhabitants, especially in the western and northern portions of the county, will have to rely mainly upon more highly favored localities, for a supply of this useful mineral. The seam on Williams creek will furnish an ample supply for the southeastern portion of the county, but the area over which it will be found to extend with sufficient thickness to be profitably worked is probably quite limited. A coal seam from twenty-four to thirty inches thick may be profitably worked by the ordinary process of drifting horizontally into the seam, and a thinner one is often successfully worked in open trenches, where there is only a few feet of superficial material above the coal. This seam of coal, where it is worked in the vicinity of Augusta, will probably average about two feet in thickness, and affords a coal of fair quality, and according to the usual mining estimates will afford about three thousand tons of coal to each acre of land, provided all the coal is taken out, and if it should be found to extend uninterruptedly of this thickness over any considerable part of that township, it would afford an ample supply of coal for this portion of the county.

At the other localities where coal has been found in this county, it appears to occur in detached outliers of very limited extent, which afford only a thin seam, from twelve to eighteen inches thick, and the coal itself is generally of an inferior quality. Such deposits are rarely of any considerable economical value.

Soil and Agricultural Products.—The prairie soil which covers fully two-thirds of the entire surface of this country, does not present any very marked difference from its general character and appearance in Central and Western Illinois. It is everywhere productive where the surface is properly drained and thoroughly cultivated. Its deep chocolate-brown or black color shows that it contains a large per cent. of humus, the result of the growth and decay of vegetable and animal matter upon the surface for untold centuries, which were a necessary addition to the finely pulverized mineral matter that constituted the original surface, when it was first drained from the waters in which the drift accumulated, in order to render it fit for the production of the cereals and fruits necessary for the support of man. The subsoil is a brown clay that does not absorb water freely from the surface, and hence, where the surface is level the soil is too wet to be cultivated successfully without artificial draining.

In the vicinity of the streams the surface is more rolling, the soil is lighter colored from the washing away in part of the vegetable humus that would be retained on a level surface, and the lands require no artificial draining. In the immediate vicinity of the river bluffs the soil is more sandy from an admixture of the sandy marls of the loess, which forms a dry calcareous soil that has proved to be admirably adapted to the growth of fruit. The most productive apple orchards in the county are those planted along the bluffs of the Mississippi river, and these lands, which have hitherty been considered the poorest in the county, are now considered the most valuable, and for the use of the fruit grower will command as much per acre as the best prairie lands.

The cultivation of the Catawba grape for wine was undertaken a few years since by the German settlers at Nauvoo, and the marked success which attended the effort at that locality stimulated others to follow their example, and this branch of horticulture has spread to such an extent as to place this county in advance of any other in the State, in the production of pure native wines. The following statistics of vine-growing and fruit culture generally in this county was prepared by N. W. Bliss, Esq., of Warsaw, who is himself personally interested in fruit-growing, and was kindly furnished for insertion in this report:

"Golden Bluff Vineyards,"
Near Warsaw, Hancock County, Ill.,
January 15, 1866.

Prof. A. H. Worthen, State Geologist of Illinois:

Dear Sir: In response to a request that I should prepare, for your forthcoming Report upon the Geology of Illinois, tables of statistics showing the present extent of grape culture upon the bluffs of the Mississippi river, in this county, together with such remarks as I might choose to offer upon the adaptation of the soils and climate of this portion of the State to the culture of the grape, and other fruits, I beg to submit the following statistics and hastily prepared remarks.

And I remain,
Your obedient servant,
N. W. Bliss.

Grape Culture is, at present, attracting a large share of attention among the most active and intelligent of the horticulturists of our country. Its importance to the moral, social and industrial interests of our people is now being so thoroughly and practically brought to their notice, by the many discussions had upon the subject, before our lately formed horticultural societies and in our numerous and widely read agricultural journals, that it bids fair, at no distant day, to become a new and permanent branch of our agriculture, second in importance and money value to no single branch of agricultural pursuits now existing. Embracing within their limits the same degrees of latitude, and possessing throughout their central regions a climate identical, in mean temperature, with that of the wine-producing countries of Europe, it seems strange that a business so wide-spread and universal, in all ages and countries, as that of grape culture, should not have made greater progress in the United States, at the end of two countries and a half after their settlement. It can only be accounted for by the fact that the United States were settled chiefly by emigrants from countries that did not produce wines, and that it is extremely difficult to change the habits of a people.

The cultivation of grapes and the manufacture of wine are among the most ancient and universal arts known to mankind, and have been extensively carried on, at one period or another of their history, in every one of the old countries of the earth, where not absolutely forbidden by severity of climate. Being the only fruit yielding the kind of acid which makes a healthful and true wine, and it being a well ascertained fact that the people of wine producing countries, satisfied with their healthful and harmless wines, do not acquire a taste for those fiery potations that take such fatal hold upon the appetites of people of non-wine producing lands, and are really the soberest people in the world, the culture of grapes and the manufacture of wine assume an importance truly national. The opening of a new branch of industry, of a nature depending so greatly on manual labor that persons with little or no capital can soon, by their own labor, become well-to-do proprietors, adds very much to its importance in a country like this, where the small amount of land needed for a vineyard can be so easily and cheaply obtained.

The antiquity of wine culture is remarkable. We read that Noah, upon the subsidence of the flood, "began to be a husbandman; and he planted a vineyard, and drunk of the wine thereof," etc. Now, it is not to be supposed that these first recorded acts of his agricultural life — the planting of a vineyard and the making of wine — were experiments on his part, but they were unquestionably a result of his ante-diluvian experience and of knowledge coming down to him through many generations. The bible and the most ancient writings abound in allusions to the vine and to the wine; and many different regions of the old countries have been famous for their grapes and wine time out of mind. The culture of the vine is by no means a *new* thing in our own country. The London Company established vineyards in Virginia prior to 1620; and by the year 1630 prospects were so favorable, that they imported several French *vignerons* to attend to the vineyards, who, it was alleged, ruined them by bad management—a result that has occurred so often since, where the attempts have been made to apply the experience, gained in Europe, to vine culture here, under totally different conditions of soil and vine, as to be no longer looked upon with wonder or suspicion on account of its proving a failure. Wine was made in Virginia in 1647, and in 1651 premiums were offered for its production; and on the authority of BEVERLY, who wrote prior to 1722, there were vineyards in that colony producing seven hundred and fifty gallons of wine per annum. In 1634, the yearly rent of Governor's Island, in Boston harbor, was a hogshead of wine, the island having been granted to Gov. WINTHROP on condition that he should plant a vineyard and orchard thereon. It is recorded that in Uvedale (now Delaware) the English settlers, prior to 1648, had vines running upon mulberry and sassafras trees, producing four kinds of grapes, from which they made eight sorts of excellent wine. WILLIAM PENN, in 1683, and ANDREW DORE, in 1685, attempted to establish vineyards near Philadelphia, but neither succeeded. In 1804 a Swiss colony settled at a place on the Ohio river called New Switzerland, now known as Vevay, in Indiana, and planted the grape now known as the Schuylkill Muscadel or Vevay grape, a native grape of Pennsylvania, to which had been given the name of Cape grape, to make its wine sell; and by the year 1810, they had eight acres planted with vines, and produced 2,400 gallons of a rough, red, hard wine. But all attempts to permanently establish wine culture in this country, from one cause or another, failed until, in 1820, Major ADLUM, having found the Catawba grape growing in the garden of a German, in Georgetown, D. C., introduced it to public notice, and sent cuttings of it to N. LONGWORTH, Esq., at Cincinnati, who, by his faith in it, and perseverence in its culture, in despite of all opposition and at enormous expense, made it a success, and for the first time made wine culture a sure and permanent branch of our agriculture—thereby fully entitling himself to the appellation he has received, of "Father of wine culture in the United States." Thus, after a long struggle, wine culture has become established in our country.

The production of wine in the United States has increased from near nothing to 5,000,000 gallons in 1862, and is still increasing rapidly. Those who are, in any degree, acquainted with the statistics of capital invested, labor employed and profit realized from this new branch of business, can fully realize that Major Adlum, when he said that; in introducing the Catawba grape, he was conferring upon the nation a greater favor than if he had paid the national debt, did not speak as a visionary and an enthusiast, as then seemed, but simply stated what is now a proven fact.

The ancients had a proverb that the region yielding corn, wine, oil and salt was a favored land; and surely, since the discovery of petroleum and its uses, and the establishment of wine culture, the United States must be considered as especially blessed! In view of these facts, and many more that might be easily adduced, did time and space permit, it is of very great importance to know what localities of our State are, by climate, soil and position, peculiarly adapted to this new branch of agriculture, as proven by the results of experience therein for a series of years. The county of Hancock lies just north of the fortieth parallel of north latitude, being (curiously) in the same latitude as the city of Erivan, in Armenia, near which the vineyard of Noah is conjectured to have been planted, upon the identical spot of his residence before the flood, and where the vine still flourishes. Lying some ten degrees south of the district of country where the famous Rhein wines are produced, it possesses a warmer climate, a longer season and a more fertile soil. Like Kelley's Island and the shores of Lake Erie, so famous for their success in raising and ripening Catawba grapes, the bluffs of the Mississippi, in this county, lie within what some writer on the subject of grape culture has well termed "the magic circle, influenced by the near presence of a considerable body of water." The geological formations composing the river bluffs in this county, as given by our State Geologist, consist of a base of lower Carboniferous limestone, from sixty to seventy feet in thickness, belonging to the Keokuk and St. Louis groups, overlaid by from forty to sixty feet of modified drift and loess. These bluffs also possess that clay loam soil and clay subsoil so favorable to the production of trees, wheat and vines, and were originally covered with a heavy growth of timber, consisting mainly of white and black oak, and shell-bark and pig-nut hickory, with an undergrowth of red-bud, sassafras and hazel. They present that variety of surface that secures perfect drainage, while the elevation of these bold bluffs above the low and broad river valley secures to those vineyards, located upon them, immunity from frosts, and present locations of the most favorably nature for the planting of vineyards intended to produce first-class wines.

That the only proper location for vineyards, which are expected to produce first-class wines, should be upon the hills, is abundantly shown in Europe, where the hills are planted with the Pineau grape, producing the famed wines of Burgundy, as upon the *Cote d' Or*, or Golden Hills, which stretch from *Châlons sur Saone* to *Dijon*, rising to the height of from two to three hundred feet; or the still more famous Johannisburger and Steinberger, as upon the hills bordering the Rhine; and the plains are planted with the Gamai grape, producing the "*vin ordinaire*," or common wine of the country. So, in this country, the hills produce the best wines, while the rich soil of the prairies and alluvial bottoms give a wine so deficient in saccharine properties, that it will not keep; and the "*must scale*" responds as readily, in degrees, to the differing weights of portions of the must, brought from the hills and from the plains, as the barometer does to the pressure of the atmosphere at different elevations.

Wine culture was first introduced into this county by JOHN SILLAR, a German carpenter, who came from Belleville, Illinois, and settled at Nauvoo in May, 1846. He bought an acre lot on Main street for $425 in gold. A wandering grape-root peddler, from Cincinnati, came along, and SILLAR bought of him thirty-four Catawba grape-roots, at 12½ cents each, and planted them in his Main street lot. The second year he had a bucketful of grapes; the third year more. In 1850 he bought a five-acre lot, but the title proving bad, he bought a lot in Kimball's addition to Nauvoo, upon the hill, and in the spring of 1851 planted 850 roots. The same spring, A. RHEINBERGER planted 500 roots, at 10 cents each, and H. SCHNEIDER planted five cuttings, of which two grew. In 1853, Mr. SILLAR made his first wine—probably the first ever made from grapes in the county—about 80 gallons, which sold for from $2 to $5 per gallon. In the dry year of 1854, he made 160 gallons. In 1855, he made 360 gallons, and planted four acres of vines, six by four feet apart, as he planted his first vines. In 1856, the cold winter killed the buds, as again occurred in 1864, excepting those buds covered by the snow. In 1857, he made 3,500 gallons; in 1858, 80 gallons; in 18 1, 2,800 gallons; in 1862, 2,700 gallons; in 1863, 2,000 gallons; in 18'4 (the frozen year), 500 gallons, of extra quality, and in 1865, 2,000 gallons. He is still enlarging his vineyards, and intends planting 20,000 vines in the spring of 1866.

Mr. John Bauer emigrated to the Mississippi Valley, from Ohio, in 1851. His wife met Mrs. Sillar on a steamer, and learned from her that property was cheap and grapes grew well at Nauvoo. Having been a wine cooper in Germany, he was induced by these facts to settle at Nauvoo; and in the fall of 1851, he bought eight acres of land there, on which was a small house, but no trees or vines. In the spring of 1852, he planted one acre of Catawba and Burgundy cuttings, six by four feet. They did not all grow, by any means, and he has replanted over and again, and the spaces are not all filled yet. In 1859, he planted two acres of Catawba roots, six and one-half by five feet, and made his first wine in 1857—some 160 gallons; in 1858, made 80 gallons, and the same in 1859. In 1860, he made 1,300 gallons, and 1861, 1,000 gallons—*off this one acre.* In 1862 and 1863, he made 3,000 gallons, each year, from about three and one-half acres in vines. In 1864 (the frozen year), his crop was 400 gallons of excellent wine, and in 1865, 1,400 gallons of wine, of unusual strength. Prices of wine have advanced from $1.25 per gallon, in 1860, to $2.50 per gallon, in 1866. The value of Mr. Bauer's crops from three and one-quarter acres, for the years 1862, 1863 and 1865, has not been less than $3,500 each year.

From such small and insignificant beginnings wine culture has grown, till in January, 1866, Nauvoo has 250 and Warsaw 75 vineyards, and there are 700,000 vines growing in the county; and the wine crop of last fall, though partially injured by the extremely wet season, amounted to 47,000 gallons. Owing to different causes, such as careful or careless preparation and after-culture of the ground, closer or wider planting, and the great variety of treatment given to the vines, the yield of wine has not been at all uniform; but there has been *no failure* of crop, from any cause but excessive cold, for the thirteen to fifteen years that Catawba vines have been bearing in the county. We claim that the river bluffs of our county present locations that are, by climate, soil and position, *peculiarly* favorable to the raising and ripening of *Catawba* grapes, and to giving them their full wine-producing qualities; and the value of this fact to our county will be readily appreciated by those whose interest in the subject has led them to investigate it, till they have become convinced that the Catawba is the only grape producing a white wine that has been thoroughly tested in extending vineyard culture in our country, and proven a success. The terrible *Oidium Tuckeri*, or Mildew, that commits such ravages upon the Catawba and other varieties of grapes, in the latitude of Cincinnati, St. Louis and Hermann, has not affected the vines here, until the excessive humidity and heat of the season of 1865 caused a partial loss of crops by mildew, but only partial; and we claim that that loss was owing wholly to the extraordinary season, and not to our soil, or climate, or variety of grape, or age of vines. It cannot have been caused by the soil or climate, for it never occurred before; it cannot have been the variety of grape, for all kinds rotted; nor can it have been the age of the vines, as some would have us suppose, for we have had thirteen crops of grapes in this county; and setting aside the first two crops as good, because the vines were young, we still have, in the remaining crops, just ten times as much evidence that our partial loss of crop in 1865 was *not* owing to the *age* of the vines as we have that it *was*.

The yield of wine per vine has, in some instances, been very large for vineyard yield. Joseph Ochsner, at Warsaw, made, in 1862, 140 gallons of excellent Catawba wine, of unusual body, from 120 bearing vines; and, in 1863, made 315 gallons from 200 vines.

The success of those planting apple orchards upon our bluffs has been very gratifying. I will instance the orchard of Mrs. B. Slattery, adjoining the city of Warsaw, forty trees of which were planted 26 years ago, and have been bearing 21 years without a failure of crop, till the late May frost of unusual severity, in the year 1865, caused a partial loss of crop. The crop in 1864, from 80 bearing trees in this orchard, was 700 bushels. Also, the orchard of Dr. Griswold, four miles east of Warsaw, of some 40 acres, one crop of which a few years ago yielded the magnificent sum of $5,000. Also, the young, vigorous and carefully attended orchard of A. C. Hammond, in the same neighborhood, whose twenty varieties of large and splendid fruits took the premium at our State Horticultural meeting, at Bloomington, for variety and *quality*; and many others might be mentioned. Thus fruit culture has become a permanent pursuit in our county, and the investment of capital in the business to-day cannot be less than $1,250,000 in this county.

Nauvoo has twenty-three and Warsaw four stone-arched wine cellars, while many more are about being built, and many cellars are rendered cool by being doubly ceiled. I enclose tables of carefully collected statistics of vine planting and wine making, in various parts of our county. As to varieties of grapes, on account of our unusual success here with the Catawba, full 90 per cent. of the 700,000 vines planted in the county are of that variety. Mr. Bauer, a year or so ago, stepped in at a wine fair held at Belleville, and found Father Muench, of Missouri, delivering an address upon wine culture, and denouncing the Catawba for its liability to disease, and general unreliability. At the close of his remarks, Mr. Bauer begged leave to give his "experience," and when he had done it, Mr. Muench made the "amende honorable," so far as this region is concerned, by saying, "if you can do that with the Catawba, in Hancock county, don't plant any other variety;" and the people here agree that it was well said, and will vote any new variety of grape, for white wine, that, when fully and extensively tested, equals the Catawba, an aquisition indeed.

I append hereto, a recapitulation, showing the number of vines and trees in gross, in the different localities of our county, and the amount of wines made last year. Of course, those observing the large number of vines growing, and the moderate amount of wine made, will understand that it is owing to the fact that so large a proportion of the vines have been planted within the last three years.

N. W. Bliss.

WARSAW, ILL., VINEYARDS, JANUARY 1, 1866.

Owner's Names.	No. of vines.	Galls. wine, 1865.	Owner's Names.	No. of vines.	Galls. wine, 1865.
C. Albers	9,620	....	J. Lohner	1,500	....
P. Albright	1,000	60	H. Seyhe	1,200	150
Wm. Bauder	1,550	560	Marsh & Bliss	5,000	125
Wm. F. Barnes	1,000	....	C. J. May	4,700	350
——Berg	500	....	—— Miller	1,000	....
Brill & Hoppee	3,850	....	—— Neameyer	1,000	....
A. J. Chittenden	1,500	100	N. Pierrot	4,000	25
W. W. Chittenden	3,600	50	F. Piedrit	2,850	....
G. W. Coster	1,000	....	Wm. Piedrit	1,100	250
Jno. Cammera	500	....	L. Pohl	1,200	....
C. Clingerbeil	2,500	130	Jos. Oehsner	1,100	190
H. Clipper	1,000	110	H. Roth	700	....
—— Dalhousie	1,000	....	Mr. Richards	3,000	69
—— Dross	1,500	....	D. Rinkle	800	30
V. Eichorn	700	196	M. Rinkle	1,000	....
Ch. Eymann	2,600	180	Jno. Rinkle	1,000	50
H. Fuhlen	2,300	....	M. Siller	1,500	80
J. G. Fonda	500	20	Geo. Sauter	1,000	125
—— Gieson	700	150	Jno. Stroh	1,000	60
John Gosch	500	....	Jno. Spitz	600	120
B. G. Grover	1,800	....	Mrs. Sylvester	3,000	20
Jno. Goehrie	2,000	30	Wm. Sehmidt	1,500	150
Jno. Goating	1,400	....	Ch. Schmidt	500	30
S. S. Grover	1,000	....	A. Seygelke	1,000	100
C. Hartmann	2,500	120	—— Schwartz	1,000	....
Jos. Hartmann	1,400	....	Geo. Suter	2,000	....
Chas. Hermann	1,000	80	Geo. Sehott	205	10
Chas. Hay	8,000	420	Dr. Werner	3,000	120
Jno. Hay	2,700	....	C. Wisemann	600	....
F. Herberts	1,575	375	H. Weyshenkel	500	....
Wm. Hoffmann	7,300	100	Wm. Wilke	500	35
C. Hoppee	500	20	A. H. & G. B. Worthen	6,600	680
W. S. Hathway	2,200	25	H. A. Worthen	660	....
J. B. Heylin	3,000	450	——Felz	490	22
Mrs. Jerrard	1,500	150			
John Klopprodt	1,000	....	Totals	135,000	6,100
—— Kinkel	500	....	All others, say	5,000	300
Mrs. Krawshaw	200	33			
H. F. Hoeneke	1,200	....		140,000	6,400

HAMILTON VINEYARD.			BASCO VINEYARD.		
Owners' Names.	No. of vines.	Galls. wine, 1865.	Owners' Names.	No. of vines.	Galls. wine, 1865.
N. Lyons	3,000	50	Jacob Boos	2,000	45
O. Voorhees	6,000	800	Geo. Marlot	7,500	80
D. W. Crockett	3,000	160	J. McAdams	3,000	....
Dr. Griswold	2,000	....	C. H. Steffey	700	....
All others, say	26,000	....	All others, say	1,800	25
Totals	40,000	1,010	Totals	15,000	150
DALLIS VINEYARDS	40,000	2,500	All other localities in the county, say	10,000	840
PONTOOSUC VINEYARDS	30,000	500			

NAUVOO VINEYARDS, JANUARY 1, 1866.

Owners' Names.	No. of vines.	Galls. wine, 1863.	Owners' Names.	No. of vines.	Galls. wine, 1863.
John Amer	2,500	....	J. Aymer	2,000	....
H. Augustine	1,200	208	—— Albrecht	800	70
Ch. August	2,500	....	P. Bechen	2,700	....
F. Argast	2,400	....	Geo. Brugger	1,000	....
Jno. Anton	1,500	....	Andrew Burtin	12,950	700
M. Aeker	2,450	250	John Bauer, Sr	4,850	3,000
U. Bruegger	1,200	....	—— Hummel	2,500	120
C. Bruegger	1,000	....	—— Hemme	2,000	....
P. Bechtold	1,200	22	H. Haas	1,500	....
J. Bierman	800	....	J. Horning	800	....
Geo. Pratz	1,200	250	J. Haas	6,000	350
Emil Baxter	3,250	950	A. Heyberger	3,000	750
Wm. Bertrachi	2,000	....	J. Hohl	1,200	....
H. Bedier & Bro	3,000	....	—— Harnski	1,000	....
Wm. Bartlett	600	....	N. Hall	2,000	....
A. Begar	7,800	1,300	P. Humme	2,000	....
W. K. Burt	750	....	F. Hausman	1,800	....
M. Baumert	500	....	C. Hausman	1,100	....
P. Balfe	1,200	....	John Hobbs	3,100	....
G. Bechtold	3,400	....	G. Herzog	200	30
C. Bohne	3,150	400	M. Hauptman	1,500	....
Berger Bros	1,500	....	J. Hauptman	1,500	....
Jno. Bauer, Jr	1,200	125	G. Hauptman	1,600	....
P. Biesel	2,000	....	M. Huber	4,250	400
F. Becker	500	....	—— Hardenstein	1,000	....
—— Brielbert	2,000	....	H. Helm	500	70
J. Bossler	1,600	....	—— Hornbacker	1,000	....
F. Baum	3,000	....	C. Harsch	2,700	14
Geo. Blum	500	....	G. Hornbacker	1,000	....
—— Bradley	800	....	Thos. Hake	1,250	....
Wm. Boernstein	400	....	A. Jungmeyer	2,075	80
—— Bearersdorf	2,500	....	J. Jungmeyer	2,100	30
L. Bidamon	4,600	50	Wm. Jackson	2,000	....
J. Barrote	500	....	U Jegg	1,200	....
W. Clark	1,500	....	C. Knaust	1,525	....
A. Cambre	1,000	....	F. Knythan	11,600	1,500
E. Cambre	4,200	225	C. Kuhn	2,000	35
—— Cutler	600	....	—— Kursghen	1,500	100
J. Christ	2,000	280	J. Kauffman	2,500	80
—— Dore	750	....	C. Krehmer	700	....
A. Durand	2,150	200	C. Kramer	500	....
J. Durand	2,050	75	A. Korrbel	2,000	....
H. Dioxen	3,000	....	Th. Kelley	2,000	....
K. Dollinger	2,700	....	H. Klingmuller	2,125	180
E. Dorn	700	....	—— Keiterling	300	....
W. Dezeniers	550	....	E. Kerkin	1,000	....
J. Dorman	400	....	D. Koch	3,000	....
A. Dansch	800	....	Mrs. Kuhler	1,100	....
A. Davis	5,000	....	Jos. Kirschboun	550	39
C. Duevel	2,000	....	A. Konantz	425	25
Geo. Diemer	900	....	F. Killian	400	....
P. Diessel	900	....	Mrs. Kraus	1,000	....
John Dornseif	1,400	....	—— Kirshbaum	600	....
Val. Diemer	2,850	250	P. Koechler	1,000	....
J. Deffenday	200	5	—— Kraft	1,000	....
—— Dachroth	300	....	H. Lippert	3,000	1,500

NAUVOO VINEYARDS—Continued.

Owners' Names.	No. of vines.	Galls. wine, 1863.	Owners' Names.	No. of vines.	Galls. wine, 1863.
—— Desbuches	400	......	F. Lecoutx	1,250	......
T. W. Eisenbach	1,750	......	H. Leinhardt	2,400	100
Geo. Edwards	1,000	......	L. & M. Laubensheimer	400	......
Gustavus Eberdt	1,800	......	W. Lange	400	......
A. Enderling	850	......	Wm. Liehtner	1,500	......
—— Engler	2,150	......	J. Meyer	2,000	......
Mrs. Fischer	1,500	300	J. Mittenmeyer	300	......
J. P. Faber	825	......	James Moffatt	2,100	......
Wm. Fritz	500	......	R. W. McKinney	1,000	100
M. Fischer	2,650	......	—— Martin	500	35
—— Frisbie	1,600	......	C. Neusel	600	......
G. Gillhofer	3,300	900	P. Nisel	2,000	......
—— Gottscham	200	......	Jos. Neusel	500	......
—— Grote	800	100	H. Neab	1,000	......
G. Gearheart	1,500	......	A. Newton	450	60
E. Gross	1,100	450	M. Newbrecht	350	......
K. Graunhold	1,700	......	Jos. Ogden	1,500	......
F. Gantee	300	40	—— Ozaman	500	......
D. Glaesner	1,900	......	—— Ordekoren	1,250	......
M. Hummer	4,000	800	—— Prentice	1,200	......
P. Hummel	2,000	......	F. Prosch	1,000	......
—— Hudson	300	......	Jno. Putcher	2,500	200
H. Prentice	400	......	J. Schmidt	200	......
L. Quint	2,000	......	—— Schriber	2,000	......
G. Renschler	3,000	......	—— Tiebe	1,300	350
H. Rouner, Jr	1,050	......	J. Tensler	4,000	......
G. Robertson	850	......	Jno. Tanner	2,150	60
J. Rohm	2,100	400	Geo. Tanner	3,400	150
W. Rheimbold	1,200	45	T. Treiss	850	200
—— Renslaer	2,000	......	—— Tapper	300	......
—— Runyan	1,500	......	P. Thomas	1,550	30
Alex. Ritter	1,625	......	—— Thompson	300	......
Geo. Ritter	5,000	......	F. Thomas	1,500	......
H. Roine	1,780	......	P. Tanner	2,200	70
A. Rheimberger	2,100	400	P. Vallett	3,500	......
—— Reinan	2,000	......	Jno. Wright	1,500	......
Jno. Rogers	1,500	......	Jno. Wimmer	1,400	1,400
B. Rheimbold	1,000	......	E. A. Wasserziehers	5,500	......
B. Rheimbold, Jr	1,350	......	F. White	300	75
Mrs. E. Rheimbold	500	10	A. Wolf	2,000	......
A. Stetzner	825	120	P. Wieman	600	......
—— Stuiz	4,250	250	P. Wolf	600	......
Jno. Sillar	8,200	1,000	J. H. Ward	300	......
H. Schneider	4,000	900	—— Wilkey	2,000	......
M. Strohm	500	......	H. Wiegand	3,200	......
Mrs. Sannmeyer	1,000	80	—— Wilhelmy	2,000	......
Mrs. Stoffels	700	60	F. Walter	7,200	500
J. B. Schmidt	500	......	J. Weisenborn	2,025	100
J. Schmidt	1,500	130	Dr. Weld	600	25
J. Summerhalter	800	......	—— Wiegand	1,000	......
Mrs. Schultz	2,000	......	L. Wolf	2,000	......
S. & M	1,000	......	F. Wolf	2,000	......
H. Schaeffer	3,000	......	M. Waldenmeyer	500	15
M. Schnie	600	40	P. Walter	1,200	......
C. Schilling	1,450	......	C. Walter	1,350	......
G. Stamm	700	......	M. Wetzel	100	20
—— Schleicher	1,050	......	B. Wachman	2,000	45
S. Santo	1,550	100	P. Wahl	1,000	2
F. Schaeffer	1,500	......	—— Zackhuber	4,050	1,150
—— Stibenger	320	50	—— Zulauf	300	......
Adam Swartz	1,400	......	J. Ziegelmeyer	1,100	10
—— Schiff	2,050	350			
P. Swartz	1,500	120		417,950	25,025
P. Schmidt	900	10	All others	7,050	475
—— Slate	1,000	......			
G. Schenck	1,600	......		425,000	25,500

RECAPITULATION.

Hancock County, Illinois.	Vines growing Jan. 1. 1866.	Wine made 1865.	Apple trees, growing Jan. 1, 1866.
Nauvoo region	425,000	25,500	15,300
Warsaw region	140,000	6,400	35,000
Dallas region	40,000	2,500	31,000
Pontoosuc region	30,000	500	
Hamilton region	40,000	1,000	....
Basco region	15,000	100	....
Carthage region	....	....	23,000
Augusta and St. Mary's region	....	....	22,000
Other localities in the county	100,000	1,400	73,700
Totals	790,000	37,400	200,000

CHAPTER XIII.

HARDIN COUNTY.

This report embraces the results of examinations made by the State Geologist and Henry Engelmann, and also includes a report of Dr. J. G. Norwood, on the Rosiclare Lead Mines.*

This county is situated on the southeastern border of the State, and is bounded on the east and south by the Ohio river, on the west by Pope, and on the north by Gallatin and Saline counties. The county embraces the two easternmost tiers of sections in range 7, and ranges 8, 9 and 10 east of the third principal meridian, in townships 11, 12 and 13 south of the base line, as far as they are situated north and west of the Ohio river. It embraces a superficial area of about 176 square miles, all of which was originally covered with a heavy growth of timber. The geological formations exposed at the surface in this county comprise the Conglomerate of the Coal Measures, all the subdivisions of the lower Carboniferous series, except the Burlington limestone, which is not represented in this portion of the State; and the upper part of the Black Slate of the Devonian series.

The surface, over the greater portion of the county, is roughly broken, though it possesses a fair proportion of soil sufficiently level to be susceptible of cultivation. The area occupied by the Conglomerate sandstone, in the northern and northeastern part of the county, is exceedingly broken, and generally arable only on the narrow ridges, while the creeks form deep and narrow rocky gorges. The soil is a yellow, finely sanded loam, and the timber consists principally of white and black oak, together with more or less hickory,

---

* This report on the Rosiclare mines comprises all of Dr. Norwood's manuscript that came into my possession on taking charge of the Survey in 1858. A. H. W.

black walnut, sugar maple, etc. The southern edge of this sandstone generally forms a prominent rocky cliff on the summit of a high ridge with an abrupt southern declivity.

The area occupied by the Chester group is also quite broken, and presents numerous rocky cliffs; but the hills are generally lower, and often slope gently to the northward in consequence of the northern dip of the strata, and the slope of the valleys are less abrupt. The lower sandstone, No. 8 of the Chester series, forms an extensive ridge with a high rocky summit at its southern declivity very similar to that of the Conglomerate. The soil of the district occupied by the Chester group is a yellow loam, and the timber similar to that of the Conglomerate region, but generally somewhat heavier.

The St. Louis and Keokuk limestones occupy a considerable area in the southern part of this county, and embrace the richest agricultural lands in the county, and sustain a heavy growth of timber, embracing the usual varieties of oak and hickory, black and white walnut, sugar maple, ash, elm, linden, etc.

These lands border the Ohio from Rosiclare to Cave-in-Rock, and for the most part are sufficiently level for cultivation, though a portion of this district farther inland is considerably broken. The principal streams in the interior of the county are Harris' creek, Ben's creek, Big creek, Three-mile creek, and the east fork of Grand Pierre creek, and the lower extremity of Saline river. These streams furnish an abundant supply of water, and some of them are never dry.

The Conglomerate enters this county in the extreme northeastern corner, and forms the dividing ridge north of the east fork of Grand Pierre creek, near the north line of the county; from thence it extends round the head of Big creek, forms the ridge between Beaver creek and Harris' creek, crosses the latter, and caps the divide between Cane creek and the Ohio. It covers the whole area north of these points, dipping north and northeast, and ends on the Ohio three-quarters of a mile below Battery Rock.

The Chester group is not quite so heavily developed as in the counties further west, but, according to Mr. Engelmann, who made the principal examinations in the northern portion of the county, it attains an aggregate thickness of from seven to eight hundred feet, and is represented by four or five distinct limestone divisions that are separated from each other by sandstones and shales. Its area is limited, not on account of a smaller development of the strata, but because they dip at a considerable angle, and this is also the cause of their not exercising so marked an effect upon the surface configuration as at some other localities. This division occupies the valley of the east fork of Grand Pierre creek, the country on the upper course of Big creek, part of the valley of Harris' creek, and the valley of Ben's creek. It forms the bluffs of the Ohio for several miles below the south end of Battery Rock ridge.

The lower division comprises the lower sandstones of the group and the intervening limestone, Nos. 8, 9 and 10 of the series, and attains an aggregate thickness of about 250 feet. Its principal outcrops are immediately south of that portion of the county occupied by the upper division of this group, and its southern edge forms a continuous and very prominent exposure along the summit of a high, abrupt ridge, the lower portion of which consists of the St. Louis limestone. It begins on the Ohio, about 3½ miles below Cave-in-Rock, and can be readily traced from thence northwestward, until it divides—one spur continuing northwestward to the Pope county line, covering a narrow strip of territory south of that occupied by the upper division of the Chester series; the other spur running southwestward, and striking the Ohio at the isolated bluff below Rosiclare, and again at the Pope county line, where it covers a surface several miles wide. The dip is not uniform in the southwest part of the county, but the strata dip away from an axis of upheaval, which brings the Devonian slates to the surface in this part of the county.

The St. Louis and Keokuk limestones may be said to form the river bluffs in this county, as far as it runs in an east and west direction. The St. Louis limestone rises from underneath the Chester group, about three miles above Cave-in-Rock, and further west extends several miles inland to the prominent ridge capped by the Chester sandstone before mentioned. From Rosiclare towards the Pope county line it forms the base of the bluffs for a short distance, when it dips below the level of the river. The Keokuk limestone forms the river bluff in the vicinity of Elizabeth, where it forms a low arch, and soon dips below the river level, both in an easterly and westerly direction. These two limestones also occupy nearly the whole area between the two spurs of the Chester sandstone, in the western part of the county, where they have been upheaved, and dip in every direction from the centre of the uplift, which is situate in the southeast corner of township 11, range 7.

Kinderhook Group.—There is a limited exposure of siliceous shales outcropping in this county around the borders of the uplift above named. The outcrop comprises a thickness of from forty to fifty feet of thin-bedded grit-stones, resembling the shales overlying the black slate in the vicinity of Jonesboro, in Union county, and no doubt belong to the Kinderhook group of the general section. No beds were observed in this county that could be identified with the Burlington limestone, and it appears to have no representative in this portion of the State.

Black Slate.—This is the only rock of Devonian age exposed in this county, and it was first observed near the dwelling of Mr. Pleasant Rose, about two and one-half miles northeast of the Illinois Furnace, on section 31, township 11, range 8. The entire exposure does not exceed 20 or 25 feet in thickness, and forms the center of a basin extending about three miles in a northwest by southeast direction, and about two miles in width across its transverse diameter. The slate presents its usual lithological characters here, except that some portions of the bed appear to be partially metamorphosed. These strata do not occupy the entire surface over the above named area, but are seen only at a few points in the beds of the streams near the center of the upheaval—in the south part of section 25, and in section 36, township 11, range 8, and perhaps at some other points; while the higher lands within this area are occupied by the higher limestones. The slate also appears on the west side of the uplift on a branch of Grand Pierre creek, in the north part of section 36 and southwest quarter of section 25, township 11, range 7, where black and argillaceous slates crop out, dipping strongly to the west, and succeeded by the siliceous shales of the Kinderhook group. These two outcrops are the extreme eastern and western points where the slate comes to the surface, and the hills are mainly formed by the overlying limestones.

The limestone immediately overlying the siliceous shales, on the borders of this Devonian basin, is the Keokuk limestone of the general section. It is a thin-bedded gray limestone, very cherty in the lower portion, and it forms a belt of chert hills around the borders of the Devonian basin above described, some of which are more than a hundred feet in height. The chert has been derived from this limestone by the decomposition of the calcareous portions of the mass through atmospheric agencies, leaving the siliceous portion in the form of loose masses of chert. Its entire thickness exposed in this county we have estimated at about 200 feet, though we met with no locality where a complete section could be seen and an accurate measurement made. The characteristic fossils of this limestone are not as abundant in this county as at more northern localities, but we found, in the vicinity of Elizabeth, *Spirifer Keokuk, Hemipronites crenistria,* and some other forms that are characteristic of this horizon. Its outcrop on the Ohio extends from a point half a mile below Elizabeth to within about three miles of Cave-in-Rock, where it dips beneath the river level and is seen no more.

The St. Louis limestone, which succeeds the last named division, in the ascending order, forms an important feature in the geological structure of the county, and is the source from which the ores of lead have been obtained which have made this county somewhat noted for its mineral deposits. The base of the bluff at the village of Rosiclare is formed by the upper fifty feet of this bed, which consists of massive gray limestone, in regular beds, the uppermost having an oolitic structure, and affording strata from two to three feet thick. Tracing the river bluff easterly towards Elizabeth, the lower beds of this limestone come to the surface, and the rock is thin-bedded and siliceous and contains an abundance of chert. This limestone also forms the river bluff at Cave-in-Rock, and for three miles below, and it is here filled with siliceous corals, among which the *Lithostrotion proliferum* is most conspicuous, and often occurs in large masses. At this locality the limestone is dark-colored and bituminous, and emits a fetid odor when struck with a hammer. It also outcrops in the vicinity of the Iron Furnaces in this county, and has been regarded as the source from which the iron was derived. In the vicinity of the Illinois Furnace it is a massive dark-blue fetid limestone, sometimes nearly black in color, and contains *Lithostrotion proliferum, Pentremites conroideus*, and a species of gigantic *Archiæocidaris*. This limestone is noted everywhere for its cavernous character, and in this county caverns and deep vertical fissures are of common occurrence over the surface underlaid by this rock. Along the river bluffs, between Rosiclare and Elizabeth, a small Pentremite, resembling *P. Koninckianus* of Hall, is quite abundant, and several examples have been found with the arms preserved. This locality has also afforded the following species of crinoidea: *Taxocrinus semiovatus, Platycrinus plenus, P. penicillus*, and *Zeacrinus intermedius*.

According to the observations of Mr. Engelmann, this limestone rises from underneath the low water level of the Ohio river not far from the east line of Pope county, and soon attains a considerable altitude. On the east side of section 35, township 12, range 7, a mile east of the county line, only the highest hills are capped by the Chester sandstone, while their main body consists of limestones which extend some distance inland along the creeks, but gradually dip under ground to the northward. Thus, on Three-mile creek the limestone is still in place near the north line of section 31, township 12, range 8, while the sandstone forms prominent cliffs on the west side of the branch, at no great altitude above it. The upper portion of these limestones most probably corresponds to the lower division of the Chester group, while the lower beds belong to the St. Louis group.

The bluff above Rosiclare, near the east line of section 5, township 13, range 8, consists of St. Louis limestone. It has on its top large blocks of sandstone, that appear to belong to bed No. 10 of the Chester group. The upper part of the limestone is generally light colored, whitish or grayish, or bluish-gray; some layers are blue. They are partly crystalline, have mostly a smooth fracture and are rather purely calcareous, while some of the layers contain numerous concretions of flint, which are, however, more numerous in the lower division, which is often dark colored.

The village of *Cave-in-Rock* takes its name from a limestone cavern which opens into the face of the bluff a little above the village, in the southwest quarter of the southeast quarter of section 13, township 12, range 9. The cave is 150 feet deep from the mouth to the rear end, from 36 to 40 feet wide, and 25 feet high, at its mouth. The roof preserves the same altitude through its whole length, while the floor, which is formed of earth that has washed in through a sink hole in the rear, slopes up from the front to the rear end of the cave. The floor of the cave at the entrance is a little below the highest flood mark of the Ohio. The limestone is quite cherty, and the cave has probably been formed by the action of water percolating through the crevices of the rock and by the eroding influences of the atmosphere.

Above this, near the middle of section 18, limestone was formerly quarried and shipped to Memphis. The rock is here tolerably free from chert, and is suitable for making quick-lime. The channel of the river passes close under the bluff, and the facilities for shipping are therefore excellent. The quarry rock overlies the strata of the cave, but more cherty strata from a higher level crop out again farther up the river.

On Big creek this limestone extends to the northwest quarter of section 21, township 12, range 8, but at the saw-mill, near the northwest corner of the section, the bluffs of the creek consist of sandstone, which also appears in the tops of the hills at this point, and belongs to one of the lower beds of Chester sandstone. A little farther up the creek the sandstone forms the entire hills, while near the northwest corner of section 16, a mile from the mill, the limestone rises again from underneath the water level northeastward towards the Devonian upheaval. The limestones in this part of the county are entirely separated from those on the river by the intervening sandstones, although they form the continuation of the same strata.

East of Elizabeth the limestones extend farther north, and the sandstones merely cap the dividing ridge at the head of the creeks which run southward into the Ohio. Thus, Peters creek runs through the limestone formation, while the sandstone caps the high ridge northwest of its upper course, in which most of its branches head, in sections 11 and 1, township 12, range 8, and in sections 6 and 5, township 12, range 9. The *Lead hill*, on the southwest quarter of section 4, township 12, range 9, forms a projecting point of the same ridge. It is capped by about 20 feet of sandstone underlaid by about 150 feet of limestone. Southeast of Lead hill there are several ponds, which appear to be ancient sink-holes, filled with water; and on the southwest quarter of section 2, township 12, range 9, a considerable branch is lost in a series of sink-holes, leading into subterraneous caverns. On this branch the limestone appears to extend nearly to the middle line of section 34, township 11, range 9; but above that point sandstones are exposed in its banks.

The main body of lower Carboniferous limestone that surrounds the Devonian upheaval begins on Big creek, as already stated, near the northwest corner of section 16, township 12, range 8, and thence its boundary extends north of west, crossing the Pope county line on the east side of section 2, township 12, range 7, and, turning northward a short distance west of the county line, recrosses on the east side of section 23, township 11, range 7. Thence it runs northeastward through sections 23 and 13, crosses a branch of Big creek, on the northwest quarter of section 17, township 11, range 8, and Big creek itself near the south line of section 16. From this point it passes southeastward near the head of the eastern branches of Big creek, crosses the Hog-thief branch on the southeast quarter of section 30, township 11, range 9, and then, turning southwestward, runs a short distance south of this branch back to the starting point on Big creek.

The bluff on the Ohio, just below the village of Rosiclare, affords the following section:

1.	Quartzose sandstone, capping the hill	35 feet.
2.	Brown and gray argillaceous limestone	50 "
3.	Shale	10 "
4.	Limestone similar to the bed above	52 "
5.	Sandstone, thin-bedded and highly ferruginous	12 "
6.	Lower St. Louis limestone, gray massive limestone, partly oolitic	52 "
	Total height of bluff	211 feet.

The upper part of this section from No. 1 to 5, inclusive, belongs to the Chester group, and constitutes what Mr. Engelmann calls the lower division of the group. The lower sandstone is quite thin at this locality, and is also thinly-bedded and of a reddish color. The lithological characters of the upper sandstone (No. 8 of the Chester series,) are quite distinct from this. It is more massive, coarser textured, lighter colored, and in its general appearance resembles somewhat the Conglomerate sandstone at the base of the Coal Measures.

In the southeastern part of the county this sandstone No. 8 appears in the bluffs of the Ohio, at the edge of a narrow alluvial bottom on a branch of Ben's creek, not far from its mouth, on the southwest quarter of section 10, township 12, range 10, and rising to the westward it forms a bluff on the north side of the creek, which extends as far as the middle of the north half of section 16, where the lower limestones rise up from beneath it, and the sandstone continues merely as the cap-rock of the ridge, which then recedes from the river in a northwest direction. As already remarked, this sandstone caps the ridge on the Shawneetown road, two miles north of Cave-in-Rock, and crossing the ridge there it may still be seen on the branches of Ben's creek, on section 36, township 11, range 9, and it continues on the main branch westward through the north part of section 35 and into section 26, while the hills on the north side of the creek in sections 26 and 25 are formed by the upper limestones and sandstones of the Chester group. It again appears on the northwest quarter of section 20, on a branch of Harris creek, while the lower limestones crop out on the south side of the ridge on the southeast quarter of section 30.

Mr. Engelmann remarks, in his notes, that on the ridge intervening between these points on sections 27, 28, 29 and 32, the sandstones are exposed in very heavy beds, and present some peculiar features. At some points they are full of quartz pebbles, and include some highly carbonaceous shales which, at some points, change into a thin seam of slaty coal, characters that would lead to the conclusion that these sandstones may belong to the Conglomerate of the Coal Measures, rather than to the Chester group.

In the northeastern corner of the county, near the Pope county line, the successive outcroppings of these strata can be plainly traced along a branch of the east fork of Grand Pierre creek, in sections 2, 11 and 14, township 11, range 7. The high ridge at the head of this branch on the northwest quarter of section ,2 consists of Conglomerate, but the upper bed of Chester limestone, No. 1 of the series, forms the lower part of the hills near Mr. Henry Rose's place, west and north of the centre of section 2. A little lower down the creek the underlying sandstone, No. 2, forms the bed of the creek, with a strong dip to the north or northwest, while still lower down limestone No. 3 reaches the surface, likewise dipping to the northward, and continues for some distance along the creek. Near the north line of section 11, the next sandstone, No. 4, rises from underneath it, also dipping strongly to the northward. Next comes limestone No. 5, with *Archimedes* in abundance, and on the southwest quarter of section 11, the sandstone No. 6 appears, all dipping to the northward. On the east fork, both above and below the mouth of the branch on which the above mentioned outcrops occur, a limestone is seen that appears to be No. 7, while sandstone is strewn profusely over the hillside. Just below the ford on the Shawneetown road, sandstone is again seen in place in the bed of the creek. The dip here seems to be locally reversed to the southwest, and this last named sandstone may be either 6 or 8 of the Chester series. Just above the ford on the Equality and Elizabethtown road, outcrops of the limestone No. 7 again appear, with a decided dip to the northwest, while below the ford, sandstone No. 8 makes its appearance, and also in the sharp bend of Grand Pierre creek, below the mouth of the east fork, and in the hills further east. The valley of the east fork is almost entirely occupied by these Chester strata, while the Conglomerate forms the ridge north of it, near the county line, and at its head in section 3, township 11, range 8. The Conglomerate also forms the ridge at the head of Big creek, on sections 2, 1 and 12, township 11, range 8, between it and the branches of Eagle and Beaver creeks; but at the southern base of this precipitous ridge the Chester strata reach the surface.

Near Mr. Russell's, on the southwest quarter of section 2, the upper limestone, No. 1 of the Chester series, crops out and underlies some low rolling hills. Proceeding thence down Big creek, the sandstone No. 2 outcrops on the southwest quarter of section 2, dipping beneath the limestone, and exposing a thickness of only about 20 feet. Farther down are outcrops of limestone No. 3, and shales, and still below sandstone No. 4, dipping strongly to the northward. It continues through the northwest quarter of section 11, and across the line of section 10. It attains a considerable thickness, and contains some shales, and a thin streak of bituminous and carbonaceous shale which has been mistaken for coal. On the northeast quarter of section 10, the Chester limestone No. 5 rises from beneath the sandstone, dipping strongly to the northward. Sandstone No. 6

appears on the southeast quarter of section 10, and near the southwest corner of section 11, and in the northeast corner of section 14 it forms low bluffs on both sides of the creek, and is underlaid by the next limestone, No. 7, which comes to the surface here, and is well exposed on the creek near the west line of the northwest quarter of section 14, and also on the northeast quarter of section 15, and at the southern bend of the creek, on the northwest quarter of section 15, where it shows a strong northward dip. Tumbling masses of sandstone appear on the southeast quarter of section 16, which probably belong to No. 8, and near the south line of this section, the lower limestones make their appearance, and continue for several miles down the creek.

A few miles farther east, on a branch of Harris creek, on section 20, township 11, range 9, sandstone No. 8 crops out at various points, and on the northwest quarter of section 20 a limestone is seen which overlies the sandstone, and would therefore be No. 7 of the series. Still further northward down the branch, sandstone crops out in the hill sides, and, dipping northward, soon passes below the surface. It overlies the limestone last named, and would therefore be No. 6. On the north side of another branch of the creek, on the northeast quarter of section 17, we find another limestone, probably No. 5, reaching from the water level high up in the hills, and also exposed on the main creek on the other side of the hill, on the northeast quarter of section 17. It also continues eastward in these hills towards the centre of section 16, while the highest points of the ridge are capped by the sandstone No. 4. The sandstone which crops out on Harris creek, on the northeast quarter of section 16, and the northwest quarter of section 15, is also apparently No. 4. The next hill north of this, near the south line of the southwest quarter of section 10, consists of limestone No. 3 capped by sandstone No. 2. The strata dip rapidly northward, so that the high ridge a little further north is capped by the Conglomerate, while the highest Chester limestone underlies the principal portion of the slope below the summit.

Farther east on the upper course of Ben's creek, on the north part of section 36, and the southwest corner of section 25, and in the extreme south part of section 26, township 11, range 9, sandstone No. 8 appears in the bed of the creek, while the limestone No. 7, capped by sandstone No. 6, forms the hills on the north side of the creek, in the south part of sections 25 and 26. Crossing this ridge, and following down the ravine leading north, we find sinkholes, indicating the presence of a limestone, probably No. 5, and on the ridge north of this, another sandstone, No. 4. All the strata in this part of the county have a strong northerly dip. Descending northward along the breaks of Rock creek, we find sandstone No. 4 in place at various points on the north part of section 26. The limestone No. 3 crops out at several points in the low hills, near the south line of section 23, and on the main branch of Rock creek sandstones are exposed at several points on the southeast quarter of section 23, belonging, probably, to No. 2 or 4 of the Chester group. Towards the head of the east branch of this creek the upper limestone No. 1 reaches far up the slope of a precipitous mountain ridge, near the east line of section 24. It is mostly concealed under tumbling masses of conglomerate, which forms a prominent cliff above it, and caps the ridge. These beds continue to outcrop towards the Ohio, along the southwestern slope of this ridge.

On the Ohio river, these beds crop out successively in the big bend at the southeastern extremity of the county, along the edge of a narrow alluvial bottom. As before remarked, the sandstone No. 8 was last seen in the bed of a branch of Ben's creek, in the south part of section 10, township 12, range 10. On the east side of this branch, on the southwest quarter of section 10, the base of the hills consist of limestone No. 7, capped by sandstone No. 6. Soon the limestone disappears below the surface, and the sandstone No. 6 is depressed to form the base of the hills, and limestone No. 5 forms their summits on the southeast quarter of section 10. A little farther up, the sandstone No. 6 disappears below the water level, and the bluff appears to be entirely formed of the limestone No. 5. Around a bend of the bluff, on the northeast quarter of section 10, the sandstone No. 6 is again seen at the foot of the bluff. The valley of Ben's creek here makes a gap in the bluff nearly a mile wide, and on crossing this valley we find the bluff composed mainly of limestone, with sandstone on the higher points. This is probably limestone No. 3, and the sandstone No. 2, Nos. 4 and 5 having been depressed below the water level by the dip in the space now occupied by the valley of the creek. Further up the river the limestone is depressed to the lower portion of the bluff, where it is mostly covered by the detritus at the foot of the bluff, and soon disappears beneath the water level. The sandstone continues to form a prominent cliff along the hillside in the northern part of section 2, and the southwest quarter of section 35, in township 11, range 10. It dips to the northward or northeastward, and does not reach across the small branch which empties into the Ohio in this vicinity. South of this branch it is overlaid by another limestone, probably No. 1 of the Chester group." This limestone is overlaid by the Conglomerate sandstone that forms the base of the Coal Measures, which thence continues in an unbroken bluff to Battery Rock, which is hardly three-quarters of a mile distant.

Conglomerate Sandstone.—In the extreme northwest corner of the county this sandstone forms a high ridge at the head of some branches of the east fork of Grand Pierre creek, and thence extends eastward near the county line, round the valley of the east fork, with the summit of a prominent ridge which it forms mostly north of the county line. In the eastern part of section 4, township 11, range 8, it turns more southeastward round the heads of East Fork and of Big creek, and then forms the dividing ridge between Harris creek and Beaver creek, extending northward far beyond the county line. Although it is largely exposed, and penetrated by numerous deep chasms in which the creeks head on the north and south sides of the ridge, the first coal observed in it was found on the upper course of Beaver creek, on the northeast quarter of section 1, township 11, range 8, at the Billy Black place. In the hillside southwest of the creek, and a little above it, the sandstone is exposed, and below it are blue shales and slates in which the coal is intercalated. The coal was covered by the falling of the roof, but was said to be about fifteen inches thick and of poor quality.

This sandstone caps the ridge north of Harris creek, in the north part of section 10, township 11, range 9, and thence extends towards Saline river. It forms heavy cliffs in the north part of section 3, and southeast of this, on the lower course of Harris creek, the limits between this sandstone and the Chester group are not well defined. On Rock creek, about half a mile from the Saline river, this sandstone is exposed on the northeast quarter of section 13, township 11, range 9, and east from this point it becomes more prominent, forming a high and roughly broken ridge south of the Saline, and eastward to the Ohio, below Battery Rock. The dip of these rocks is uniformly to the northeast. A short distance below the mouth of the Saline, in the south part of section 8, township 11, range 10, the bank of the Ohio shows an outcrop of blue argillaceous shale, capped by sandstone. Still farther down, near Caney creek, in the west part of section 16, an apparently lower sandstone forms the bank, and near the middle of the south half of section 16 another body of shale rises from beneath the sandstone, and at Mr. Seller's place, on the north side of section 21, it has reached an altitude of 30 feet above high-water mark, and is surmounted by heavy cliffs of sandstone. The sandstone in the river bank at the

Battery Rock is apparently still lower in the series, so that the shales in the river bank at Mr. Seller's may correspond to those inclosing the Battery Rock coal.

The *Battery Rock* is situated on the southwest quarter of section 26, township 11, range 10, and its base projects below the level of the Ohio river. The sandstone that forms the lower portion of the bluff is veined with tortuous streaks of ferruginous sand, which, being harder than the intervening surface, withstands the atmospheric agencies, and so forms a raised net-work over its exposed surface. This appearance is not peculiar to this locality, but may be often observed in this sandstone. Above the lower sandstone at Battery Rock there is about 60 feet of shale, then the Battery Rock coal seam, capped by shale and sandstone. The coal seam averages about 20 inches in thickness, of which the lower portion, from 1 to 6 inches thick, is *rash coal*, or slaty, brittle, impure coal, which has to be discarded. This rash coal generally averages from 3 to 4 inches in thickness, so that only about 22 or 23 inches of good coal remains. This coal contains some sulphuret of iron, partly in horizontal streaks, partly in vertical partings; and also some fibrous coal or mineral charcoal, which renders it soft and impairs its solidity. It is distinctly laminated with alternately dull and resinous streaks, and its vertical partings are also strongly marked, so that it generally breaks in rhomboidal pieces. The clay shale under this coal seam is full of vegetable remains, and is sometimes soft and argillaceous, and at other localities hard and siliceous, resembling a siliceous mud-stone more than a clay shale. The roof consists of gray shales, from 6 to 18 inches thick, with the remains of plants and sometimes thin streaks of coal, and above this the shale becomes sandy and passes into a shaly sandstone, which at some localities extends down to the top of the coal. Several drifts have been made in this coal seam in this vicinity, and large quantities of coal are taken from it; and although the seam is a thin one, scarcely averaging 2 feet, yet, as the coal dips strongly towards the mouth of the drifts, the mines are always dry, so that the miners can work in a reclining position without serious inconvenience.

Prof. Lesquereux has expressed the opinion that this coal is not a true Conglomerate coal, but is equivalent to coal No. B of the general section of the coal strata; while Dr. D. D. Owen, who formerly entertained similar views in regard to the age of this coal, is said to have expressed the opinion, shortly before his decease, that it was a lower seam, and belonged in the true Conglomerate sandstone. As Prof. Lesquereux's conclusions are not determined by stratigraphical evidences alone, but have been reached after a careful study of the plants associated with this coal, his opinions are certainly entitled to more consideration than those predicated alone upon a very casual examination of the strata with which the coal is associated.

The shales under the sandstone that forms the bluff at Seller's Landing rise rapidly inland towards the southeast, and inclose, at one point, a band of argillaceous iron ore, about 14 inches thick. This deposit may prove valuable for the production of iron, and should be thoroughly proved. Farther up the ravine, on the northeast quarter of section 21, 4 inches of slaty coal is exposed, inclosed in shales similar to those associated with the Battery Rock coal. Farther up the Ohio, coal has also been found on the southwest quarter of section 11, below the mouth of Caney creek. The exposure is on a ravine at some height above the river, and the coal is also inclosed between shales which appear to hold a higher position than those mentioned near Seller's, and to overlie the sandstone exposed there. Where it is exposed now, the coal is only a few inches thick, but is said to have been opened near by, where it afforded 16 inches of good coal, with about an equal thickness of rash coal.

On the northeast quarter of section 17, coal has been discovered in the face of the bluffs, apparently in the same body of shales above named. It crops out in the lower part of the hill and rests on shales containing *Sigillaria*, and has a roof of sandstone. It is 22 inches thick, and of good quality, and similar in appearance to the other coals of this vicinity. Farther west, on the northwest quarter of section 17, on a steep ravine about 300 yards from the river, it has been found again. It is there underlaid by a considerable thickness of argillaceous shale, and overlaid by shaly sandstone. It is said to be two feet thick and of fair quality. This outcrop is at a much higher level than the one last named, which results from the dip of the strata. Coal has also been found on the southeast quarter of section 7, or the northeast quarter of section 18, with considerable carbonate of iron in the roof shales.

From these remarks it will be seen that there are probably two coal seams in the northeast part of Hardin county, of sufficient thickness to be worked under favorable circumstances, whether they belong to the true Coal Measures or not. The entire thickness of the Conglomerate below the Battery Rock coal, probably does not exceed 150 feet, and the overlying beds, from their shaly character, and from the frequent intercalations of sandy and argillaceous shales, would seem to belong to the true Coal Measures, and not to the Conglomerate proper. There is no well defined line separating this sandstone from the true Coal Measures in this State, and for this reason we have included them together in the general section, as forming but one division of the Carboniferous system.

Economical Geology.

Coal.—From what has been said in the foregoing pages, it will be seen that this county has but a limited supply of coal, to be derived from the two thin seams already described, which underlie only a very limited area in the northeast corner of the county. Nevertheless, owing to the favorable position of these mines, and their proximity to the Ohio river, they have given employment to many miners, and have been worked with pecuniary advantage to the proprietors. Fortunately the county is not dependent on its own resources for a supply of coal, its near proximity to the coal field of Kentucky, and the facilities for cheap transportation afforded by the Ohio river, rendering it easily accessible as a market for the coal of that more highly favored region. For smelting the iron ores of this county, charcoal has been heretofore used exclusively; and the dense forests that originally covered the entire surface of the county can still supply a large amount of charcoal, for this purpose, at a moderate expense.

Iron Ores.—This county has long been noted for its iron ores, and it is the only county in the State where furnaces for the smelting of iron from the ore have been erected. There are several varieties of iron ore in the county; that may be referred to different geological positions. The carbonate of iron, in concretions commonly known as "Kidney ore," is found in the shaly beds of the Conglomerate and Coal Measures, and this ore is a profitable one for the manufacture of metallic iron, wherever the deposits are sufficiently developed to justify the erection of iron furnaces. These deposits have not yet been thoroughly proved, and have scarcely attracted the attention they merit. At one locality, near Sellers' Landing, we observed about fourteen inches in thickness of ore disseminated through about four feet of shale, and another similar deposit above the coal seam below the mouth of the Saline river.

The hydrous oxide of iron, or limonite, occurs in irregular accumulations in the crevices of the St. Louis limestone, and in the surface deposits of this county, over a considerable area, and also in an irregular bed near the base of the Conglomerate. A bed of this kind of ore occurs in the extreme northwestern corner of the county, near Mr. H. Rose's, on the north half of section 2, township 11, range 7. The ore is partly in small pieces, sometimes in large masses, embedded in a clay shale or "soap-stone," or resting directly on the underlying limestone. It forms quite a heavy body of ore, though somewhat irregularly developed, and in some places is several feet thick. Part of it is quite pure, while other portions contain sand and flint, and occasionally masses of carbonate of iron were found mixed with the limonite. On the whole, it appears to be a deposit of considerable value, but its extent and richness have to be proved by excavations before a well founded opinion can be formed of its value for the manufacture of metallic iron.

The limonite of the St. Louis limestone is the only ore hitherto used in this county for the manufacture of iron, and it has been obtained mainly from a belt of country immediately outside of the rim of chert hills surrounding the Devonian basin already described. The chert has been derived from the decomposition of the limestone strata of the Keokuk and St. Louis groups. The last named group is everywhere noted for its cavernous character, and here, as well as elsewhere, it abounds in fissures and caverns, the result in part of the shrinkage of the strata, and in part of erosive agencies operating upon the surface. The cherty portion of this limestone is highly ferruginous, and probably may have been the source, in part at least, from which these ores of iron have been derived. Water, charged with organic matters permeating ferruginous strata, would dissolve the peroxide of iron contained in the strata, and on reaching the surface would absorb oxygen from the atmosphere, and becoming insoluble in consequence, the metal would be precipitated in the form of a hydrous oxide of iron or limonite.

In this way ores of this kind may have been derived from the ferruginous chert of these limestones, or it may have resulted from chalybeate waters issuing to the surface through the fissures of the limestone from subordinate beds of ferruginous material. Much of this ore occurs in stalactitic forms or "pipe-ore," especially in the limestone crevices. The ore is indiscriminately intermingled with the surface deposits, consisting of sand, clay and pebbles of chert, and this intermingled mass often covers the limestone to the depth of thirty or forty feet, and also fills the crevices of the limestone. The ore is also very irregularly distributed through this mass, and hence the difficulty of making any satisfactory estimate of the quantity of ore that may be obtained from a given locality; and the iron master can never rely entirely upon surface indications, however promising, for a supply of ore. This iron deposit corresponds, in a degree, to what, in the lead mines of the West, is called "float mineral;" and a locality of iron ore of this kind can only be considered to be exhausted when the entire surface deposits have been worked over, and the limestone crevices thoroughly explored to the bottom. Other deposits of iron ore no doubt exist, hidden in the superficial material or in the limestone crevices, quite equal in value to any hitherto discovered, but no definite directions can be given for their discovery.

The following are some of the principal localities where iron ore has been found in this county: On the northwest side of Big creek, on the southwest quarter of section 4, township 12, range 8; also, on the opposite side of the creek, on the southwest quarter of section 4, and at several points northeast of this on the same hills; on the southwest quarter and the northeast quarter of section 3, and the northwest quarter of section 2, in the same township. At all these points the ore has been obtained from open cuts in the hillsides and from irregular openings in the limestone. The ore is partly compact limonite and partly pipe ore. Much of the ore for the supply of the Martha furnace has come from the Jack Moore mine, on the northeast (?) quarter of section 34, township 11, range 8. Some of the ore from this locality is sandy, but it has also afforded much good ore. The ore has also been obtained at McCoy's diggings, on the northwest (?) quarter of the same section, where it is found between walls of limestone.

Several miles north of the Illinois Furnace, a considerable quantity of ore has been obtained near the centre of section 17, township 11, range 8, in the superficial material above the limestone.

Farther west, on section 13, township 11, range 7, large masses of iron ore have been found, though only a few shallow holes have been dug there. The ore is also found strewn along a branch of Grand Pierre creek, near the Pope county line, especially on the northwest quarter of section 26, township 11, range 7. West of Peters creek, on section 17, township 12, range 9, examinations have been made in the superficial material near the surface, and small quantities of ore found.

Two furnaces have been in operation in this county, both smelting the limonite ores above described with charcoal, of which the heavily timbered lands of the adjacent region have furnished an abundant supply. The Illinois Furnace is situated on section 4, township 12, range 8, near Big creek. It was built about the year 1837, and rebuilt and enlarged 1856, and continued operations until the beginning of the rebellion in 1861, when it was stopped. It is 32 feet in height; the hearth and inner walls are built of the sandstones of the Chester group, and the outer walls of limestone. The blast entered the hearth on one side, while the iron was drawn from the opposite side and the slag from a third, while the fourth was closed. The blast was furnished by two horizontal double-acting cylinders, driven by steam power. and could be applied either hot or cold. The flame at the top of the furnace was conducted under a steam boiler, and then round a heating apparatus for the blast, and escaped thence through a chimney. The ore was first burned on log-heaps, to expel the water and prepare it for the furnace. Two hundred bushels of charcoal, from oak and other hard woods, were consumed in the production of a ton of pig iron, and this furnace is said to have yielded nine tons of pig metal every twenty-four hours. It was usually run from six to nine months in the year, according to the facility with which the ore was obtained. The metal produced was of excellent quality, and always commanded the highest market price.

The Martha Furnace is situated on Hog Thief branch, on the northeast corner of section 2, township 12, range 8. It is smaller than the Illinois Furnace, was built in 1848 and stopped in 1857, and is now in a dilapidated condition. It usually run about eight months in the year. The ore for these furnaces usually cost from one and three-quarters to two dollars per ton, at the furnace, and the charcoal four cents per bushel. Although many of the local deposits of ore first discovered in this county are apparently exhausted, there are no doubt others equally rich, yet hidden beneath the superficial deposits and in the crevices of the limestone, which, under the auspices of an active manager and close observer, with the necessary capital at his command, would be brought to light. For an analysis of the iron ore of this county, see Dr. Blaney's report, in a previous chapter.

Lead.—Sulphuret of lead, or galena, is found in this county associated with fluor spar and sulphuret of zinc or blende, in veins, traversing the St. Louis limestone. The only lead mines that have been worked to any considerable extent, in Southern Illinois, are located near the village of Rosiclare, on the Ohio river, in this county. They are below the middle of the lower Carboniferous series, and in the St. Louis limestone, with the whole of the Chester series, at least six or seven hundred feet thick, overlying the lead bearing strata and separating them from the Coal Measures. The veins in which the ores occur are probably *gash veins*, and formed by the shrinkage of the strata, and consequently are confined to the group or set of strata in which they appear; but as this group may be as much as three or four hundred feet thick in this county, it affords an ample field for mining operations.

The mines at Rosiclare are located on different veins, running nearly parallel, and have been owned and operated by different parties. They are known as Barbour's mines and Pell's mines, the former on section 5, township 13, range 8, and the latter on section 32, township 12, rage 8, and the Blue diggings on the southwest quarter of the same section. Part of the ore raised from these mines was crystalline and part granular. The principal *gangue* appears to be fluor spar, which contains lead so universally disseminated through it that, with proper appliances, all the piles of refuse material that have accumulated around the old shafts could be profitably worked up by crushing and washing; and, without such apparatus, a large part of the profits of mining in these veins would be lost. The fluor spar will command a ready sale for the manufacture hydro-fluoric acid, and is also valuable as a flux for the smelting of ores, especially where the sulphuret of zinc occurs with the galena, rendering smelting operations more difficult. Copper pyrites is also associated with the galena, but only in small quantities. The galena from this portion of the State is also argentiferous, the silver, according to an analysis by Prof. J. D. Whitney, amounting to as much as nine ounces to the ton of ore. These mines, however, have never been worked with the capital and skill necessary to prove their real value, and they have been entirely abandoned for about ten years.

The following report on the Barbour mines was made by Dr. Norwood to Capt. James T. Barbour, of Rosiclare, shortly after the work on the mines was suspended, and it embodies all the historical and statistical information relating thereto which is now accessible; and as the examinations were in part made while the mining engineer and some of the miners were still there, it contains data that could not now be obtained:

Dr. J. G. Norwood's Report on the Rosiclare Lead Mines.

History.—The first discovery of lead ore near Rosiclare was made in the fall of 1839, in sinking a well near the river, on the farm of Mr. James Anderson, about one mile below the above named village. In this well the now so-called "Well lode" was met with. No attempts, however, were made for its exploration. In a second well, dug on the same place, in 1841, not far from the first one, the lode was again found; but, as in the first instance, no particular attention was paid to it.

In the early part of the year 1842, Mr. William Pell discovered spar and galena about three-quarters of a mile back of Rosiclare, on his own land, at the place now known as "Harrison's diggings." In consequence of this discovery, Marshall & White took a lease of Mr. Pell, and commenced mining. Shortly afterwards, a company from Alton, Illinois, composed of Dr. Lathy, Mr. Hibbard Capt. Kittinger, and others, purchased this lease, and continued the work until late in the fall of 1843, when they suspended operations. The next year (1844) Gen. Harrison leased a part of the ground covering the shaft of the "Alton company," and in the year following (1845) a company from St. Louis and Mine LaMotte, under the firm of Geo. Anson & Co., leased a portion of the lode south of Harrison's diggings, commenced working it, and prosecuted the work for about eighteen months, at which time Anson died, and the lease fell into the hands of Anthony Vanlier and John Stacker, of Tennessee.

In the meantime, Mr. Valle, of St. Louis, became interested with Gen. Harrison, and finally bought him out. Subsequently Mr. Valle united his interest with that of Stacker & Vanlier, and they continued operations together until the winter of 1849-'50, when their works were suspended.

In the year 1843, James T. Barbour leased of James Anderson a part of his tract of land, and commenced mining at what is called the "Blue diggings," situated about three hundred and fifty yards west of Harrison's works. In the year 1844, Capt. Barbour made a new lease with Mr. Anderson, embracing more ground, and covering the lode now known as the "Good Hope," on which it was supposed Harrison's first explorations were made, and the outcrop of which he had then discovered. He commenced mining there in the spring of 1845, and continued the work up to April, 1851. From 1845 to 1847, he sunk several shafts from forty to eighty feet in depth, within a distance of 200 yards, running south on the vein. He abandoned them, however, in the year 1847, and commenced sinking the "Good Hope Engine Shaft," which was carried to the depth of one hundred and thirty feet. Throughout this whole depth, galena, in a gangue of fluor spar, was met with, the galena becoming more abundant as the shaft descended. However, circumstances, not necessary to be mentioned here, prevented him from a further prosecution of the work, which, as before stated, was suspended in 1851. Since that time nothing of importance has been done.

Geological Formation.

The veins traverse that division of the Carboniferous series generally known as the Mountain limestone, in this country and in Europe.

This is, in our country, a very unusual position for workable veins of lead ore. Indeed, I know of no country in which lead is worked to advantage in the Carboniferous series, except a portion of Derbyshire, England. In the districts of "Galena," "Mineral Point" and "Dubuque" the ore occurs in Silurian rocks—not, however, in regular veins, but occupying joints, fissures and caverns; and is occasionally met with between the strata, in beds or layers of limited extent.

In Devonshire, the experience of the miners, after centuries of observation, has led to the conclusion that the profitable lead lodes occupy a particular horizon, or, as they call it, "zone." Burat, in speaking of these mines, says: "The upper beds have always been recognized as richer than the inferior ones." The inference, therefore, is—first, that there is an upper limit of richness, which is indicated by the arenaceous bed, termed millstone grit, which is found at a mean depth of from nine hundred and eighteen to nine hundred and eighty-four feet. Between these two limits, there exists a horizontal metalliferous zone, having a mean thickness of five hundred and ninety feet. In certain mines, these veins were worked to a much lower depth, in a manner to demonstrate, satisfactorily, that, notwithstanding this apparent concentration, they continue to a greater depth; which is in accordance with the general law of veins, so far as their vertical extent is concerned. The horizontal beds constitute no exception to this rule, and ought to be considered as a spreading out or ramification of the veins between the planes of the beds which they traverse.

There is good reason to believe that a similar metalliferous zone exists in the lead-bearing rocks of this country. If so, judging from its place in Iowa, Wisconsin, Northern Illinois and Missouri, it is far below the deepest workings yet made at Rosiclare.

The Veins.—On the tract occupied by Capt. James T. Barbour, four veins have been discovered, up to the present time, and are generally designated as—first, the "Good Hope vein;" second, "Blue lode;" third, "The Cross vein;" and fourth, "Anderson's Wel lode."

The "Blue lode" bears north 29° east.
The "Good Hope vein" bears north 21° east.
The "Cross vein" bears north 35° east.
The "Anderson Well lode" bears north 3° east.

In the immediate neighborhood of these veins, on the land of Mr. William Pell, is a good lead lode, which has been worked to some extent, and bears north 3° 45′ east. No report, however, will be made at present on this lode, and it is only mentioned here to enable the practical miner to see, at a glance, the entire association of veins in the mining ground of Rosiclare.

Barbour's mines are situated on an elevated ridge, somewhat detached from the main body of hills which form the principal features of that section of country. This ridge terminates in high rocky bluffs on the Ohio river, immediately below the village of Rosiclare. It is about half a mile in width, but presents a rather broken outline in consequence of being intersected by several streamlets and numerous small ravines, due to the erosive action of running water. The slopes on the eastern and western sides are at angles varying from ten to thirty degrees.

Of the lodes mentioned, the "Good Hope" is the principal one, at least it is the only one, that has been proved to any extent. Upon this vein five shafts have been sunk, besides one or two holes not deserving notice.

The "Good Hope" lode varies from eight to eighteen feet in width, and hades from eighty to eighty-five degrees to the northwest. The wall rocks are limestone. The gangue is chiefly fluor spar, carrying galena and zinc blende. It may also be well to state that sulphuret of copper is occasionally met with in specks and small lumps. For the measurements and results, given in the following statement, I am principally indebted to Mr. W. F. Haslett, who was cognizant of every material fact brought to light during the time they were worked. The workings were also entered and examined by Mr. A. Varner, assistant in the State Geological Survey, while they were in full operation, and his statement not only confirms that of Mr. Haslett, but he adds many observations going to prove the valuable nature of the lode, so far as his observations could enable him to form an opinion.

Good Hope Engine Shaft.—The size of this shaft is seven by seven and a half feet. For the first thirty feet down, fluor spar is sparsely intermixed with specks of galena. From this depth there is a general increase of galena, disseminated in lumps through the fluor spar, to the depth of ninety-five feet, the bottom of the drift, which runs in the vein, northerly, one hundred and forty feet. Occasionally, at regular distances, rich spots or bunches of galena were met with, varying in quantity from one to five or six thousand pounds, increasing in richness as the workings progressed in depth, while the intermediate or poorer parts of the lode became constantly more loaded with ore.

The next five feet, which extends down to the cavern, is very rich in galena, which is disseminated through the fluor spar. On the west side sulphuret of zinc (black-jack) is met with. Out of this cavity there was raised some 20,000 pounds of galena. The 140 feet drift spoken of above is from four to five feet in width, and from five to eight feet in height. It runs along the east wall rock, with a sheet of soft, slaty, argillaceous material, from two to eight inches thick, dividing it from the fluor spar and galena, with occasional lumps of zinc blende. Pockets, or small openings, were frequently met with, which contained, generally, ochreous clay, with some carbonate of lead. Immediately around these pockets there is generally an increase of lead ore. Seams of pure galena are frequently found running through the soft, slaty material on the side of the vein, and lumps are found disseminated in the hard wall rock, to the depth of three or four inches from its face. The metalliferous character of the drift resembles very much the shaft leading to it, as respects the rich and poor places, and would, on the whole, afford a profit on the expenses of working it. The "Cavern" is from ten to twelve feet in width, about thirty feet in length, and extends along the vein northerly. It is about twenty feet in depth. The sides and top are incrusted with fluor spar, intermixed with galena in lumps. For one-half of its depth it is open, the remainder being filled with decomposing spar, ochreous clay, and loose masses of galena, occasionally reaching from 50 to 100 pounds in weight. Opposite this cavern is a drift running southerly, twenty feet in length. This was rich in bunches of large cubes of galena, extending for some ten or twelve feet. From this gallery more than 20,000 pounds of ore was taken. The lode then became leaner, more fluor spar being intermixed with the galena, while on the west side "black-jack" was found in the seam which divides the lode. Many pockets of galena, however, were still found in this seam. The lower ten feet of the shaft is composed, for the first five feet, mostly of decomposing fluor spar, intermixed with galena, of which there are many pockets. The spar then becomes more compact, and the ore increases in quantity to the bottom of the shaft, where it will pay for working.

Barbour's Whim Shaft.—This shaft was started on the east side of the lode, but very near to it, and sunk perpendicularly forty-seven feet, through an ochreous clay, loose fragments of limestone and masses of fluor spar. A cross-cut was then made westerly, about five feet in width and six in height, which passes, for four feet, through clay, loose rock and decomposing spar. The lode then begins to make its appearance, composed entirely of a yellowish-colored, decomposing fluor spar, very rich in galena. Passing through this portion of the lode, the spar becomes more compact, and occasional pockets, containing ochreous clay and carbonate of lead, are met with, for the depth of six feet, when the main seam is reached, which passes vertically through the lode. This seam is sometimes very much contracted, but its sides, which are sometimes composed of compact, yellow fluor spar, and again of the same material in a state of decomposition, with pockets or openings, never coalesce.

This seam contains many openings or pockets, through which all the water of the lode passes. On the west side of this seam a thin sheet of "black-jack" is frequently found, varying from one to two or three inches in width.

Adjoining this seam the surface of the fluor spar is smooth, and resembles what is generally termed, in mining language, "slicken sides." Passing this seam about three feet, through a hard, fine-grained, bluish fluor spar, interspersed with occasional lumps of steel-grained galena, a vertical seam of coarse-grained sulphuret of lead is met with, in small lumps, varying in diameter from one to four inches. The lumps of galena are separated by thin septæ of fluor spar. About three feet westerly, on the cross-cut, after passing through a soft and brash white and yellow fluor spar, another seam, of about the same size and character, is met with, intermixed with lumps of coarse-grained ore. From this point to the west wall rock, some four or five feet, the character of the vein remains the same. A thin sheet of argillite lays between the fluor spar and the wall rock. On the east side of the seam which divides the vein, a shaft, between five and six feet square, is continued down from the cross-cut to the depth of ten feet. Through this whole depth it is represented as being rich in coarse-grained galena, embedded in decomposing fluor spar. Much of this part of the lode was worked with a pick without blasting. During the last ten hours it was worked, not less than a thousand pounds of the best quality of galena is said to have been taken out.

Another shaft was sunk on this lode about one hundred feet north of the "Whim Shaft," and to nearly the same depth, which corresponded, in almost every particular, with the one described.

Blue Lode.—Two shafts have been sunk on this vein, each about thirty feet in depth. It is about six feet wide at the surface, and hades to the east, or in direct opposition to the pitch of the Good Hope vein, and about the same angle. About twenty feet below the surface a cross-cut was made, which showed the vein to be eleven feet at that depth. The gangue is violet-colored fluor spar. The "Cross vein" shows itself about one hundred yards westerly from the shafts just mentioned, and is about three feet in width. Like the other, it is composed of fluor spar, carrying galena.

Anderson's Well Lode.—This vein, as before stated, was discovered by the sinking of a well. This well caved in, and another was sunk about twenty feet from it, also on the vein. By this its course or bearing was ascertained. At the bottom of the first well the vein is represented as having been very rich in galena. This lode, if it continues its direction after connecting with the Good Hope vein, will strike the Blue lode a little north of the old workings. Its course is nearly, if not precisely, parallel to the workable lode on Pell's mining ground.

In relation to the further prosecution of the work on Baurbour's premises, I can only repeat what was said in the "Report of Progress," made to the Legislature of Illinois at its last session. When speaking of the large sums of money which have been expended there without any adequate returns, the report says:

"I am satisfied that this has resulted more from the injudicious manner in which the mining operations were carried on, than from the absolute poverty of the veins that have been opened. They have never yet been proved. This can only be done by the drill and the pick, and the proprietors have, in my opinion, stopped far short of the proper point."

The uniform width of the veins, the character of the gangue and the nature of the wall rock (limestone), are all favorable indications of a valuable lode. The character of the ore varies somewhat at different shafts and at different depths. It is mostly cubical galena, with patches of granular ore on the west side of the seam dividing the vein. One specimen (the only one I cupelled) yielded a bead of silver of such size as to impress me with the opinion that certain portions, at least, of the vein might be considered "argentiferous," in the proper sense of the term. No quantitative analysis of this ore, however, has yet been made. You must, therefore, attach no undue weight to this opinion.

It may also be well to state that these mines are very favorably located. They are within half a mile of the Ohio river, which, being navigable for the greatest part of the year, affords the requisite facilities for carrying off the products of the mines, as well as for procuring all the materials necessary for building up and carrying on the works. Stone coal, of excellent quality, is found in Illinois, near the mouth of Saline river, twenty-five miles above Rosiclare, and also at Tradewater, in Kentucky, about eighteen miles above the lead mines. This can be boated down, at a small expense, from either place, and will furnish an inexhaustible fund of fuel for running the necessary machinery. Another important advantage is that the country is densely wooded; and an abundant supply of the finest timber, suitable for smelting or building purposes, is found on the premises.

In conclusion I can only say, that I would advise the prosecution of the work, provided a sufficient amount of capital can be invested to insure the veins being worked in a proper manner. If this cannot be done, they had better be abandoned altogether. Two of the present shafts can, in my opinion, now be worked to advantage; that is, they would yield a constant profit to the owner, if the operations were conducted judiciously and with a due regard to economy.

There are various other points in this county where lead bearing veins have been discovered, though their value has not yet been proved. Three miles northeast of Rosiclare, at the base of the hills, on the west side of Big creek, on the southwest quarter of section 21, township 12, range 8, fluor spar and galena have been found in the same horizon, and a shallow pit has been sunk that is known as the McAllen diggings. In the rubbish that had been thrown out we found calc. spar, white and violet colored fluor spar, and galena. On the bank of the Ohio, just below the mouth of Big creek, near the south line of section 27, several veins of calc. spar occur in the limestone, one of which measures three feet or more in thickness. This was nearly vertical, and had been drifted into a short distance; but no other minerals appear to have been found. Outside of the vein some particles of blue fluor spar were seen.

Six miles northeast of Elizabethtown some galena occurs at the locality known as the Lead Hill, on the southwest quarter of section 4, township 12, range 9. This hill is capped with the lower sandstone of the Chester series, and the galena occurs about 60 feet below, in the oolitic beds of the St. Louis limestone. Numerous shallow holes have been sunk on the western slope of the hill, some of which were carried down to the depth of 30 or 40 feet. The rubbish thrown out consisted of partly decomposed limestone, fluor spar and calc. spar, with some galena. The fluor spar at this locality is white, rose-colored and deep violet, and is frequently met with in fine cubes. When freshly broken it has a bituminous odor. The diggings which were made about the year 1850 are now partially filled by the caving in of the sides and the wash from the surface; but enough remains to show that there were irregular openings in the limestone, which seem to have had a general direction. Both the fluor spar and the galena appear to have been more sparingly developed here than at Rosiclare. Without a systematic excavation at this locality, carried to a considerable depth, no definite opinion could be formed of the probable value of this mine.

Further east, on a branch of the east fork, are the Stickney diggings, on the southwest quarter of section 7, township 11, range 8. A considerable quantity of white and violet colored fluor spar, with some galena, have been obtained here, but the prospect seems not to have been sufficiently promising to induce a continuance of the work. No regular vein appears to have been found here, but the ore and associated minerals were obtained from pockets in the limestone. Several holes were also dug on Big creek, on section 20, township 11, range 8, from which calc. spar was obtained, but no galena. On the high sandstone ridge on section 28, township 11, range 9, a hole was sunk to a considerable depth in search of mineral, but none was found. This place is known as the Moulton or Mountain diggings. These are all the points in the county, that have been ascertained, where any attempts at lead mining have been made.

Mineral Springs.—There are several chalybeate springs in this county, the waters of which are charged mainly with the sulphate of iron, derived from the decomposition of iron pyrites contained in the Chester group and the Conglomerate, through which the waters percolate. One of these is on Rock creek, in the southwest quarter of section 29, township 11, range 9; and another is found at the foot of the bluff on Saline river, about a mile above its mouth. No surface indications of brine springs or valuable saline deposits have been discovered in this county; and the Conglomerate and Chester group, which afford the saline waters of the adjoining county, are so thoroughly drained here, from their elevation above the surface and being intersected by deep ravines, that they have been entirely exhausted of whatever saline properties they may have originally possessed. All the stratified rocks of this State were originally deposited beneath the ocean, and may still retain saline matters in small quantities; but it is only where the conditions were such as to cause the precipitation of chloride of sodium, in considerable abundance, during the accumulation of these sediments, and their subsequent retention in the strata, that they afford valuable deposits of brine.

Building Materials.—This county abounds in building materials of excellent quality. The St. Louis limestone outcrops over a considerable portion of its area, and furnishes an excellent building stone, as well as a superior limestone for the manufacture of quick-lime. The oolitic beds of this group in the vicinity of Rosiclare, and elsewhere, may be easily cut into any desirable form, are susceptible of a high polish, and make a very handsome ornamental stone. At some localities this rock is beautifully veined with white calcareous spar. An analysis of this limestone from the vicinity of Rosiclare, by the late Mr. HENRY PRATTEN, a former assistant and chemist in this Survey, gave the following result in per cent. :

Carbonate of lime	90.86
Carbonate of magnesia	3.18
Peroxyd of iron and alumina	1.06
Insoluble matter, sand, etc	2.72
Moisture	0.15
Loss	2.03
	100.00

In other portions of the county the Chester group, in alternating beds of limestone and sandstone, is exposed, affording an abundant supply of material for foundation walls; and some of the limestones make a very good quick-lime, though generally inferior to that afforded by the St. Louis limestone. The sandstones of this group afford excellent building stone and flag-stones, and have also supplied the hearthstones required for the iron furnaces. A rock, suitable for this purpose, must be capable of withstanding the highest degree of heat, and also great changes of temperature, without cracking—even in contact with melted iron and scoria, which often shows a tendency to take up from the hearth substances with which it is not saturated at the existing high temperature. Some beds of the lower sandstone of the Chester group have been found well adapted to this purpose. They consist of nearly white quartzose sand cemented with a siliceous paste. The coarse varieties of this sandstone are preferred for hearthstones, because they withstand best the extreme changes of temperature to which they are necessarily subjected.

Loam and sand, suitable for making brick, are common in various portions of the county.

Agricultural resources.—The surface of this county is generally roughly broken, especially that portion of it underlaid by the Chester group and the Conglomerate. Along the Ohio river, where the St. Louis limestone is the prevailing formation, a considerable extent of surface is only moderately rolling, with a rich soil, which was originally covered with a heavy growth of the finest timber, consisting of the common varieties of oak and hickory, with sugar maple, elm, linden, black walnut, persimmon, paw-paw, mulberry, sassafras, etc. These lands are among the most productive in Southern Illinois, and produce excellent crops of corn, tobacco, and all the cereals usually grown in this latitute. The bottom lands on the rivers and smaller streams are also very productive, and produce several varieties of timber not before mentioned, among which are the sweet-gum, white ash, horn beam, honey locust, soft maple, slippery elm, sycamore, cottonwood, Spanish and water oak, white walnut, etc. In the northern and western portions of the county, where the formations are principally arenaceous, and consist of the Chester group and the Conglomerate, the surface is very broken, and the arable land is restricted to the tops of the ridges, and the narrow belts of bottom land along the streams. But all these broken lands may be successfully cultivated in fruit; the peach rarely fails to produce a full crop in this county, and many varieties of the grape might be successfully cultivated. These lands are in no respect inferior for fruit-growing to the best fruit lands in Union and Jackson counties, and, with equal market facilities, would soon be covered with orchards and vineyards.

CHAPTER XIV.

JOHNSON COUNTY.

BY HENRY ENGELMANN.

Johnson county is bounded by Union county on the west, by Williamson county on the north, by Pope county on the east, and by Massac and Pulaski counties on the south. It embraces a little over nine townships, or about 335 square miles of surface, all of which is finely timbered. The dividing ridge between the waters of Cache and Bay rivers, tributaries of the Ohio, running south, and those of the Big Muddy and Saline rivers, running northward, stretches from west to east through the northern portion of the county. The southern part of the county is lower, but mostly still broken, and reaches to the low cypress swamps which extend from Bay river to Cache river, or I should, perhaps, say from the Ohio above the *Black bend* to the Mississippi, across the south end of the State. The geological formations are restricted to the superficial deposits and the lower part of the coal formation, and a part of the lower Carboniferous limestone. The regular Coal Measures, or principal coal bearing strata, do not extend into Johnson county; but we have at several points outcrops of a minor coal seam, of variable thickness, in connection with the Conglomerate sandstone, and traces of coal, not, however, of any practical importance, in lower strata. Other valuable minerals have not been discovered, nor is there any prospect of future discoveries of that kind. The soil is, however, of a superior quality, and all the county needs is an easier communication with the great marts, when its fine agricultural resources will be fairly developed. Wheat, corn and tobacco have been the great staples for years past. Cotton thrives well, but has only been raised for home consumption. For fruit trees of all kinds no better situations could well be found, and especially for grape culture, the prospects appear to be flattering.

Surface Configuration.

The surface configuration of Johnson county depends upon its geological formations. The rocks consist of alternations of softer and harder bodies of sandstones, limestones and shales, which have been heaved up, and exhibit a general dip to the northward. This, in connection with the small elevation of the southern part, and the high elevation of the dividing ridge in the northern part of the county, causes this district to be rather broken. We frequently find high and rocky escarpments facing towards the south, and capped by one of the harder ledges. Then, continuing northward, we descend over a more or less gradual slope, which conforms to the dip of the strata, until we reach the base of a second declivity, formed by a series of higher strata which overlap the first ones. From this summit we descend again northward, and we find it thus repeated several times. This regularity is modified considerably by the course of the streams and their eroding action. They intersect the formation in various directions, continue for considerable distances parallel to the trend of the strata, along the same ledges, then turn abrubtly and break through them. A careful observer, however, cannot fail to recognize this feature. One of the most prominent examples of it is presented by the main dividing ridge in the north part of the county, the highest summit of which coincides with the southern limit of the Conglomerate sandstone. It falls off abruptly to the south, and slopes down gradually northward. In the district occupied by the Conglomerate, which comprises the whole county north of the dividing ridge or bluffs, as its southern declivity is frequently called, and extends thence more or less south, along the upper course of the creeks, so that it embraces four-ninths of the whole county, the country is very roughly broken, the creeks run through rocky chasms, and have seldom any arable bottom lands. The hill sides are steep and rocky, and frequently exhibit prominent cliffs; but the ridges are mostly rather level, and of sufficient width to make fine farms, so that this district includes some very fine settlements, and a good growth of white oak, black oak, hickory, etc., with a warm, sandy soil.

South of this the formations consist of alternations of sandstones, limestones and shales. The two latter disintegrate more readily than the sandstones, and the hills are, therefore, generally more sloping, outcrops of rocks are wider apart, the creeks form wider

—21

bottoms, the ridges more rolling, but there are also many roughly broken portions, and bold and rugged cliffs. The soil of this region is similar to that of the northern part of the county, especially where sandstones prevail. At other points the limestones and shales have naturally added to it by their disintegration, and a change of the soil can be recognized by a somewhat changed growth of timber, especially by the presence of the yellow poplar (*Liriodendron tulipiferum*). In the lower part of the county, towards the edge of the swamp lands, the soil is of surprising fertility, and withal warm and easily tilled. In the lower part of the county, especially on Cache and Bay rivers, there is so little fall that the bottoms are frequently overflowed, or perpetually wet. These bottoms and adjoining stretches of low land assume the character of cypress swamps.

Geological Formation.

I have stated above that the rocks of Johnson county all belong to the lower division of the great Carboniferous formation, which underlies the upper division or regular Coal Measures.

The strata dip towards the north, trending from east to west. The dip is not quite uniform; for miles it appears to be slight, then all of a sudden it is sometimes very strong, and changes again close by; but these are only local irregularities. In passing over the county from north to south, we therefore advance successively from the lower to the higher or more recent deposits.

The formations in Johnson county are the following, in descending order:

1. The Conglomerate, consisting of quartzose micaceous sandstones, with some intercalations of shales, several hundred feet in thickness.

2. The Chester group, which is largely developed, and consists of ten principal divisions, composed mainly of limestones, shales and sandstones. The aggregate thickness of this formation amounts to about 1,000 feet.

3. The St. Louis group, consisting of various limestones, part of which are oolitic. It is not exposed to a greater thickness than 120 feet, but it apparently continues downward, and its aggregate thickness is much greater.

The St. Louis Group.—This group occupies only a small area in the southwestern corner of the county, forming the base of the hills along the Cache river flats, from the west line of the county to the east end of the Indian Point bluffs. It cannot everywhere be readily distinguished from the very lowest Chester strata. Near the Union county line, on the southwest quarter of section 31, township 13, range 3, at the edge of the Cache river and Cypress creek bottom flats, I observed several outcrops of this limestone, as well at the foot of the hills as higher up, partly in connection with sink-holes. The rock is mostly gray, partly crystalline and siliceous, partly close textured, sub-crystalline, and sub-conchoidal or splintery in fracture, partly oolitic. The highest sub-conchoidal ledges appear to be very pure, and would probably make superior quick-lime, and a fine building material. Traces of fossils are numerous, but no well preserved specimens could be obtained here. On the summit of the hill the limestone is directly overlaid with several feet of quartzose sandstone, which is thinly but not evenly stratified. In the northwest quarter of the same section 31, in a ravine, I observed some sandstone which, although it appears to be in place, is probably a large tumbling mass, and higher up some pieces of limestone, and towards the summit of the hill some argillaceous shales were noticed, but the whole is little exposed. The sandstone is either the sandstone No. 8 (in which case the lowest divisions of the Chester formation appear to be wanting here), or else it represents the lowest Chester division, No. 10, and the above shales, perhaps No. 9. In the northwest part of section 31, I found numerous sink-holes, which unmistakably indicate the presence of limestones. The hills there fall off gradually to the northward, according to the general rule which I have before explained.

Continuing eastward along the hills, we find more outcrops of the St. Louis limestone, and overlying sandstone. The most prominent one is the Cedar bluff, so called on account of some cedar trees growing on its top, in the south part of the southwest quarter of section 5, township 14, range 2. The slope at the base of this bluff reaches not more than twenty feet above the low bottom of Cypress creek, then the limestone rises in a vertical cliff 95 feet high, and is capped by 8 or 10 feet of sandstone, the same which formed the summit of the before mentioned hills. The limestones are mostly of light grayish color, hard, siliceous, and close-textured. Some of the uppermost ledges are sub-crystalline, sub-conchoidal in fracture, and apparently siliceous and very hard. Some of the lower strata are white, oolitic, soft, can be easily dressed, and might readily be burned into lime.

East of this, for some miles, the country is low, with only a few protruding ledges of the limestone. The nearest ones are found in two outcrops near the centre of the south half of section 4, near Mr. Jackson Axley's; also, at the edge of the flat. They are about 25 feet high, and the rock is partly oolitic, and makes good lime. Then, in the southwest quarter of section 2, the limestone is found tumbling at the edge of the flat, but must be *in situ* in the low adjoining hill, and more is found near the middle of the south half of section 2.

The low, undulating land north of the cedar bluff, in the southwest part of section 29, north part of section 32, south part of section 33, and farther on, is evidently also underlaid with limestone, but I am not fully satisfied whether this is throughout the St. Louis limestone or partly the lowest strata of the Chester group. Close to the west line of Johnson county, where it is crossed by the Dongola and Metropolis road, near the northwest corner of section 30, township 13, range 2, I have observed limestones and shales, forming division No. 9 of the Chester series, underneath the sandstone No. 8. This sandstone can be traced thence eastward, by Gray's mill, to Indian Point. There I observed, again, Nos. 9 and 10 of the Chester series; but I am not fully satisfied whether they are developed continuously between these points, or whether at some places the sandstone No. 8 rests directly upon the St. Louis limestone. The upper part of the high hills in the west and southeast part of section 29, and in the southwest quarter of section 28, township 13, range 2, is formed of this sandstone; but in the ravines at the southern foot of these hills a few pieces of limestone are found, and their base is probably formed of No. 9 of the Chester series.

Considerable outcrops of rocks were observed, in the continuation of the same range of hills, near Gray's mill, near the middle of the north half of section 2, township 14, range 2, and thence on towards Cache river, in the north part of section 1. The sandstone No. 8 caps these hills; but limestones, interstratified perhaps with other strata, reach high up towards the summit. The base of these hills consists of St. Louis limestone, which is mostly light gray, close-textured, and splintery or crystalline, but the upper part below the sandstone contains the lowest Chester divisions. Northward these strata dip rapidly underground, but continuing eastward across Cache river bottom, we find them again, at the Indian point, a precipitous cliff, which extends from Cache river, in the northwest quarter of section 5, township 14, range 3, eastward along the edge of the swamps. Where it is highest, in the south part of section 33, township 13, range 3, only a short distance north of the Massac county line, I obtained a section of the formation, partly by measurement, partly by a close estimate. It shows 40 feet of sandstone, the eighth division of the Chester formation; 54 feet of Archimedes limestone and shale, No. 9 of the Chester series; 12 feet of sandstone, No. 10 of the Chester series; and 10 feet exposed and 34 feet concealed of St. Louis limestone.

Section of the strata at Indian Point, in Johnson county, in the southeast quarter of southwest quarter of section 33, township 13, range 3.

1.	Cliff of sandstone, forming the highest summit of the bluff; white quartzose, of middle grain, partly quite friable inside, partly tolerable hard, of the sandstone No. 8 of the Chester group; estimated at	40 feet
2	Steep slope, the upper portion of which is covered with heavy tumbling masses of sand-rock. It is underlaid altogether or in part with shales, alternating with seams of limestone, some of which is highly siliceous and full of Archimedes, pentremites, etc. It is the lowest limestone division of the Chester group; estimated at	54 "
3.	A heavy ledge of a finely grained hard sand-rock, unlike the upper sand-rock, and apparently an irregular deposit of impure material. It is the very lowest (tenth) division of the Chester series	12 "
4.	Limestone; gray, siliceous, close-textured or crystalline; of the St. Louis limestone formation	10 "
5.	Slope to the edge of Cypress pond, undoubtedly underlaid with more limestones of the St. Louis group	34 "

A mile further east, on the county line, in the middle of the south line of section 34, another section of the strata was obtained by measurement. It still shows the sandstone No. 8 forming the summit, then 62 feet of the ninth division of the Chester group, and 12 feet of the St. Louis limestone, which continues downward. The tenth Chester division is not represented.

From this point eastward the bluffs continue high and mostly rocky, round the northeastern extremity of the swamp. I observed much of the close-textured St. Louis limestone, and other ledges of the same formation, which were full of fossils and so coarsely crystalline that they possessed little firmness; but I noticed only traces of an oolitic structure. A quarter of a mile south of the Johnson county line, and half a mile from the last one, in the northeast quarter of section 3, township 14, range 3, I measured the following section:

1.	Slope to the summit of the hill, underlaid with sandstone	10 feet
2.	Cliff of sandstone—No. 8	15 "
3.	Limestone	2 "
4.	Shales	10 "
5.	Limestone, with Archimedes, pentremites, etc	4½ "
6.	Slope, apparently underlaid with shales	6 "
7.	Cliff of limestone	18 "
8.	Steep slope to a terrace, formed by a ledge of rock, which is, however, not exposed	35 "
9.	Slope to the level of the bottom flat	40 "

Nos. 1 and 2 are the sandstone No. 8; Nos. 3 and 6 correspond, undoubtedly, to No. 9 of the Chester group, which probably includes, also, No. 8 of this section. Of this I am, however, not certain.

Section of the strata taken on the Johnson and Massac county line, near the middle of the south line of section 34, township 13, range 3.

1.	High slope to the summit of the ridge, strewn and evidently underlaid with sandstones; the sandstone No. 8 of the Chester group	(?)
2.	Sandstone in thin, irregular ledges	6 feet
3.	Gentle slope, strewn with sandstone, probably underlaid with shaly rocks of the ninth Chester division	20 "
4.	Slope, underlaid with argillaceous shales and some seams or Archimedes limestone	14 "
5.	A ledge of highly fossiliferous Archimedes limestone	1 "
6.	Alternations of argillaceous shales and siliceous crystalline limestone, the former prevailing. Probably still a member of the ninth division of the Chester series	27 "
7.	Limestone of gray color, sub-conchoidal fracture, close textured, between finely granular and splintery in texture; of the St. Louis limestone formation	12 "
8.	Slope to the edge of the Cypress flat; no exposures, but undoubtedly underlaid with limestones of the St. Louis formation	20 "

The only other point where some limestone was observed underneath the sandstone No. 8 is north of Indian Point, at the edge of the Cache river bottom, in the northwest quarter of section 33, township 13, range 3. It must correspond to No. 9 of the Chester series, and can not well be St. Louis limestone.

The Chester Group.—I have stated above that the Chester group is largely developed in Johnson county, and may be divided into ten principal divisions, each one composed mainly of limestone and shales, or of sandstone and shales: and its aggregate thickness amounts to about 1,000 feet. It occupies the whole southern half of the county, with the exception of the small area occupied by the St. Louis group, and extends into the northern half, especially on the west side of the county. The general trend of the strata is very little south of east, and the dip to the northward, and not quite uniform. It is slight at many points, but at others locally quite strong.

The Lower Chester strata.—In the remarks on the St. Louis limestone, I have already had occasion to speak of the eighth division of the Chester formation, because it caps many of the hills at the base of which that limestone has been observed. I have also mentioned, in the same connection, all the outcrops of limestone, shales and sandstone which form the two lowest divisions, Nos. 9 and 10 of the Chester group, in the hills extending from the Union county line near the northwest corner of section 30, township 13, range 2, to the Massac county line, near the southeast corner of section 34, township 13, range 3. We have, then, seen that the thickness of the Chester sandstone No. 10, at the only point where it was undoubtedly and well exposed, amounted only to 10 feet; that that of the Chester limestone and shales No. 8 reached some 60 feet, and we left it undecided whether the sandstone on top of the hills in the southwest corner of the county, in section 36, township 13, range 2, and at the Cedar bluff, in section 5, township 14, range 2, was the sandstone No. 10 or No. 8 of the Chester series.

The sandstone No. 8 caps the hills on the Union county line near the southwest corner of section 19, township 13, range 2, and its southern outcrops can easily be traced by the high hills in the middle of the west half of section 29, southwest quarter of section 28, and so on, to those in the southeast quarter of section 35; thence through the northeast quarter of section 2 and west part of section 1, township 14, range 2, to Cache river; and beyond that stream, by Indian Point, from the northwest quarter of section 5, township 14, range 3, through the southeast quarter of section 32, township 13, range 3, south of section 33, and south of section 34. Thence eastward it underlies the uplands along the Massac county line to George's creek, dipping under ground on that creek near the southeast corner of section 33, township 13, range 4. On Cypress creek this rock was observed to dip underground half a mile west of the west line of Johnson county, at the south line of section 7, township 13, range 2. Its uppermost ledges descend underneath the water level of Cache river, near the northwest corner of section 23, and in the southwest quarter of section 24, township 13, range 2, north of the bridge on the road from Gray's mill to Vienna, in the southwest quarter of section 19, township 13, range 3, and farther east near the mouth of Cave creek, in the northwest quarter of section 28. In consequence of an irregularity of the dip, the formation extends up Cave creek to near the middle of the west side of section 23, and up Clifty creek to above the crossing of the road from Vienna to Columbia, into the southeast quarter of the northeast quarter of section 25, township 13, range 2, and the southwest quarter of the northwest quarter of the adjoining section 30, township 13, range 4; but on the intermediate upland the higher formations reach farther south.

This sandstone is quartzose, rather finely-grained and whitish, but on the exposed surface it is mostly gray or light-brownish. It mostly shows a massive structure, and is rather soft when freshly quarried, but hardens in the course of time. Some of it is thinly and evenly stratified, and forms fine slabs and thin, brown, highly cemented ledges. Its thickness in Johnson county must reach at least 150 feet, perhaps more.

Some of the most conspicuous outcrops of this sandstone, between its southern and northern limits, were observed along a slough of Cache river, on the north side of which, near the southeast corner of section 20, township 13, range 2, it forms a prominent cliff, and continues northeastward, nearly without interruption, for two miles. Near the centre of section 21 it reaches from the water's edge to a height of 60 feet, and at its extreme, in the northwest quarter of the northeast quarter of section 22, it is still 25 or 30 feet high. It forms lesser bluffs on the opposite side of this slough in the west part of section 22, and on another branch of it in the northeast corner of section 26 and the northwest corner of section 25.

On Cache river itself, in the northeast quarter of section 1, township 14, range 2, it begins 100 feet above the water level, and is exposed to a thickness of 20 feet. Near the middle of the east line of section 36, township 13, range 2, it appears to reach to the water's edge. A quarter of a mile below the mouth of Dutchman creek it is prominently exposed on the river in the southeast quarter of section 30, township 13, range 3, and continues northward to the sharp bend in the southwest quarter of section 19, where the beds of transition between it and the next higher division of the Chester group form the bank of the stream. On the east side of the Cache river bottom I noticed it in some low bluffs in the southwest quarter of section 28. On Clifty creek I noticed, also, numerous rugged outcrops of this sandstone.

The Higher Divisions of the Chester Group.—Although I have been able to trace the succession of the different divisions of the Chester group, with great precision, in some parts of the county, I have not succeeded in doing so with sufficient accuracy at other points, owing to the scarcity of outcrops, the similarity of the lithological character of the different divisions, and the limited time which I would have been justified to spend upon this subject. I will describe them, therefore, more with a view to their geographical than geological succession, which are, however, closely connected.

The limestone No. 7 is well exposed on Cache river, at the sharp bend on the southwest quarter of section 19, township 13, range 3, 156 feet thick, and extends thence east and westward. It consists of mostly gray, siliceous, crystalline, a close-textured, partly magnesian limestone, inter-stratified with shales. At the last named point they present the following section:

Section of the Chester strata next above the Sandstone No. 8, in Johnson county, on Cache river, the north part of the southwest quarter of section 19, township 13, range 3 east.*

1.	Short slope to the summit of the hill, underlaid with soil, and probably some sandstone	20	feet
2.	Quartzose sandstone, belonging to the Chester group No. 6	5	"
3.	Limestone, with some partings of shale in the lower part. The rock is all of gray color, compact, hard, mostly semi-crystalline; some of it is crystalline. It is all more or less siliceous. The highest layers of the 7th division of the Chester series	44	"
4.	Argillaceous shales, probably with some thin seams of limestone	29	"
5.	Limestone, dark gray, semi-crystalline and siliceous, with some shale partings	7½	"
6.	Steep slope, the upper portion underlaid with shales, the lower apparently with alternations of shales and limestones	24	"
7.	A bed of hard, gray, siliceous, more or less crystalline limestone	5	"
8.	Slope, covered with fragments of limestone. Probably the upper portion is underlaid with alternating layers of shales and limestones, the lower entirely with shales	40	"
9.	Gray argillaceous shales	5	"
10.	A bed of semi-crystalline limestone, with Archimedes, corals and other fossils, inclosing numerous flint pebbles, the lowest layer of the 7th Chester division	1⅓	"
11.	Arenaceous shales, with shells of hard, finely-grained sand-rock, forming the beds of passage to sandstone No. 8	7	"
12.	Bed of Cache river.		

The total height of the bluff is 187 feet 10 inches. The same strata continue to form the bluffs on the northeast side of Cache river, to near the bridge in south part of section 10, township 13, range 2, and a short distance above that bridge on the south side; also the hill southwest of the bridge, in the northwest corner of section 15, which is capped by the same sandstone, No. 6. Then these strata appear to dip suddenly under ground to the northward, for north of the bridge, near the centre of section 10, the same sandstone, No. 6, forms a low bluff at the edge of the creek bottom, and nothing more of it was discovered higher up Cache creek. Over a mile further northwest, in the northeast quarter of section 4, we find some ledges of apparently the next higher limestone, No. 5, of the Chester series, in the bank of the Cache river, and the sandstone No. 4 higher up in the hills. A short distance farther north, this sandstone has dipped down to the water's edge, and forms a long bluff along the stream in the west part of the northeast quarter of section 4, reaching, in places, a vertical height of 30 feet. It is

* All the vertical sections in this volume are given in their natural, or descending order.
A. H. W.

thus exposed at several points near the bridge and mill, in the north part of section 4, and, rising rapidly, caps the sharp hills in the west part of section 4, and the ridge west from there, in sections 5 and 6, north part of section 8, and farther north. It also crops out at the next bridge, in the northwest quarter of the southwest quarter of section 33, township 12, range 2, not far above the water's edge, and at numerous points along the branch in the south part of section 32, and up to the southeast corner of section 31, near its head, partly forming fine even ledges, well adapted for building purposes, partly hard, thinly stratified and ripple-marked. Of its thickness we cannot say more than that it is not, in any single place, exposed over 40 feet, but probably considerably greater in the aggregate. Underneath this sandstone, No. 4, I noticed, at numerous points, the limestone No. 5. They may be seen a few feet thick at the base of the hills on the west side of the river bottom, near the northwest corner of section 4. Near the middle of the west line of section 4 they reach to a height of fifty feet above the bottom, and still farther south, in the northeast quarter of section 8, and in the south and west parts of section 6, they reach nearly to the highest summit of the ridge, as may be recognized from numerous sink-holes. They, too, are partly crystalline, partly close-textured, and mostly of impure grayish colors. The sandstone No. 4 was further observed on another branch farther north, on the road from Vienna to Anna, in the southeast quarter of section 30 (?), township 12, range 2; but the country about there, and east from there, is mostly rolling, with very few outcrops of rocks of any kind.

In the north part of the southwest quarter of section 28, the higher limestones, No. 3 of the Chester series, were first noticed at the foot of the gently sloping hills, near the edge of the Cache bottom. The same were also observed at the edge of the bottom near the northwest corner of section 28, and in the southwest quarter of section 21. They underlie the hills over most of section 28, and in the southwest quarter of section 27, and form the lower part of the higher ridge in the northwest quarter of section 27. They, too, are partly crystalline, but mostly semi-crystalline and close-textured. They are the same formation which had been observed in Union county, in the bed of Cache river, close to the Johnson county line, and which, a little farther northwest, reached to a height of at least 30 feet, capped by cliffs of the sandstone No. 2. In the northwest part of section 20 this sandstone apparently forms the foot of the hills, but with it I also noticed tumbling slabs of a slaty limestone, which crops out in turn in the low hills in the south part of section

17, inter-stratified with shales, and capped by more sandstone. This last limestone is partly blue and compact, brittle, sub-conchoidal or uneven in fracture, partly slaty. It appears to be a local formation, which I have noticed farther east and west, but nowhere as prominently developed as here. I have, however, not distinguished it as a separate division of the Chester series. In the northwest quarter of section 17 the sandstone No. 2 crops out in the bed of Lick creek and on the west side of that creek, in the southeast quarter of section 7, this sandstone forms conspicuous cliffs, as well at the foot of the hills as toward their summit, showing an intercalation of the blue, slaty limestone which we find once more on Lick creek, close to the county line. Through sections 6 and 5 the upper part of the sandstone No. 2 forms numerous outcrops along the low hills on the south side of the creek, while the next higher limestones form the hills on the north side, capped on their highest summits by the Conglomerate.

A section of this highest division of the Chester series was obtained at the edge of the Lick creek bottom, near the big bend of the creek, in the southwest quarter of section 4, township 12, range 2. It is mostly composed of compact, siliceous, partly flinty limestones, of impure grayish color, varying between close textured and crystalline, and of shales.

Section of the highest Chester strata capped by the Conglomerate, in the northwest part of Johnson county, near the bend of Lick creek, in the southeast quarter of the southwest quarter of section 4, township 12, range 2.

1.	Gentle slope to the summit, apparently underlaid with sandstone of the Conglomerate, about	50 feet
2.	Slope, strewed with sandstone, and apparently underlaid with it	25 "
3.	Slope, heavily strewn with sand-rock and some limestone, apparently underlaid with limestones, and perhaps shales of the Chester group	15 "
4.	Limestones, siliceous, in heavy outcrops, forming precipitous bluffs around the hill	21 "
5.	Slope, without outcrops, strewn with limestone and sandstone. It is apparently underlaid with shales and limestones, the former probably predominating	24 "
6.	Limestone, hard, siliceous, forming a prominent ledge	8 "
7.	Gentle slope, apparently underlaid with shales, and perhaps some limestones	12 "
8.	Limestones, outcropping in rugged ledges. The rock is mostly very hard, brittle, siliceous, uncrystalline, with conchoidal fracture	30 "
9.	Slope, with some outcropping ledges of limestone, perhaps altogether underlaid with limestones, perhaps with an alternation of limestones and slates	22 "
10.	Limestones, hard and siliceous	12 "
11.	Slope, strewn and probably underlaid with limestones	6 "
12.	From the foot of the hill to the bed of Lick creek, covered with soil, about	12 "

The total altitude of the hill is about 237 feet. Of these, 144 feet are undoubtedly the upper Chester limestone. The sandstone No. 2 of the Chester series reaches at this point probably just to the water level of Lick creek. In this case we have to add 18 feet to the thickness of the limestone division, which would make its aggregate thickness 162 feet.

This formation continues northward, variously exposed. I observed it, especially, again, in the hills north of Lick creek, in the northwest quarter of section 5, and on Clifty branch, in the northeast quarter of section 32, township 11, range 2, and in the south part of section 29, in the lower part of the lofty dividing ridge, the so-called "*bluffs*," which are capped by the Conglomerate.

Returning to the mouth of Dutchman creek, we find there, in the northeast quarter of section 30, and in the southwest quarter of section 28, township 13, range 3, the upper strata of the sandstone No. 8. Farther north, the bluffs in the east part of section 19, in section 20, in the north part of section 28, and in section 21, are composed of the next higher Chester divisions, the limestone No. 7, and the sandstone No. 6. Near the mouth of Cave creek, near the middle of the north half of section 28, the limestone No. 7 is exposed to a thickness of considerably over 100 feet, capped by only a few feet of sandstone, and it continues about two miles up Cave creek on the north side. On the eastern bend of Dutchman creek, in the northeast quarter of section 21, the limestone No. 7 appears to pass underground, soon followed by the sandstone No. 6, and a short distance farther north, on the northeastern part of the bend, in the southeast quarter of section 16, the limestone No. 5 forms the bluff on the northeast side of the creek, capped by the sandstone No. 4. The limestones and shales No. 5 are here at least 68 feet thick, as will be seen from the section which has been measured here:

Section of strata of the fourth and fifth divisions of the Chester formation, on Dutchman creek, in Johnson county, in the southeast quarter of section 16, township 13, range 3.

1. Cliffs of sandstone, to the summit of the hill. The rock is whitish, quartzose, of a middling fine grain. No. 4 of the Chester series	28	feet
2. Steep slope, apparently underlaid with sandstone, which, near by, can be seen immediately to overlie the limestone	8	"
3. Cliffs of compact siliceous limestone No. 5 of the Chester series	14½	"
4. Slope, strewn with limestones, and apparently underlaid with limestones, probably with some shales. At the base of a ledge of limestone	28	"
5. Steep slope, strewn with limestones and sandstones. It is probably underlaid with limestone at the upper end, and principally with shales and slates lower down, which still belong to No. 5 of the Chester series	25	"

6. Slope, apparently with a solid ledge at its upper end, perhaps partly underlaid with the Chester sandstone. No. 6 of the Chester series.......................20 feet
7. Level of the bottom lands...

Continuing up stream southward, round the bend, we soon find on the south side of the stream the lower sandstones rising in the bluffs, and below them the lower Chester limestones No. 7. Near the southwest corner of the bend, in the southwest quarter of section 16, the lower 50 feet, from the water up, are strewn with the limestone and sandstone, evidently underlaid with the former. The 23 feet following are apparently underlaid with the sandstone, which then forms a prominent cliff 20 feet high. North from there, on the next bend, in the southwest quarter of section 16, this sandstone, No. 6, has dipped much lower down, is prominently exposed 25 feet above the water level, and probably reaches down to it. It partly forms fine smooth ledges of convenient thickness for building purposes, is soft when newly quarried, and hardens on exposure.

This sandstone, No. 6, continues up the stream at the base of the hills on the southwest side of Dutchman creek, through section 17, and into the northeast quarter of section 18. We find it, for example, at the bridge two miles south of Vienna, while further south and southwest, on Cache river, it capped the bluffs. Here the upper part of the hills is formed by the limestone division No. 5, which has here a thickness of some 68 feet, and is capped by the sandstone No. 4.

The following section of the strata, taken near the bend in the northeast quarter of section 18, township 13, range 2, shows that part of the sandstone No. 6, which is there exposed to a thickness of 72 feet, is shaly, and that it contains a thin streak of coal near its upper end, a few feet below the higher limestone. It also shows that the limestone division No. 5 contains a considerable thickness of shales, which accounts for the few exposures which were observed of it, and that the sandstone No. 4 immediately rests upon solid ledges of the limestone No. 5, without intervening beds of passage, as we have observed already, two miles further east:

Section from the middle of the Chester formation in Johnson county, taken on Dutchman creek, two miles below Vienna, in the northeast quarter of section 18, township 13, range 3 east.

1. Slope of considerable height to the top of the hills, apparently underlaid with sandstone, No. 4 of the Chester series...2 feet
2. Sandstone, the 4th division of the Chester formation...................................20 "
3. Limestone, the 5th division of the Chester formation.................................... 5 "
4. Slope, strewn with sandstones from the ledge No. 2, but partly underlaid with shales, partly with limestones...45 "

5. Chester limestone, mostly gray and coarsely crystalline; some of it semi-crystalline and compact .... 8 feet
6. Argillaceous shales with shells of limestone at the base a ledge of limestone, the lowest stratum of the fifth Chester division .... 10 "
7. Sandstone, arenaceous slate, and shaly, arenaceous ledges. The highest of the sixth division of the Chester series .... 8 "
8. Coal, a thin streak.
9. Sandstone, with shaly partings, overlaid with arenaceous slate and shaly ledges. 25 "
10. Shaly sandstone and arenaceous shale .... 14 "
11. Sandstone, white, quartzose, rather finely grained, in thin even slabs, No. 6 of the Chester series. It may reach lower under ground .... 25 "
12. Level of bottom lands.

I will state that no section could be obtained by one continuous measurement, but that the one presented was compiled from two measurements, taken a few rods apart.

Continuing northward up the creek, the upper shaly portion of the sandstone No. 6 and the limestone No. 5 prevail. Outcrops are therefore few and far apart. A short distance above the mouth of Town creek, on the east side of the latter stream, in the north part of the southwest quarter of section 8, township 13, range 3, I noticed an outcrop of some limestone belonging to this fifth division at the foot of the bluffs, and the sandstone No. 4 higher up. The latter reaches to the water level in the north part of the section, round the bend in the northeast quarter of section 8, and forms the banks of the creek at Vienna, in the southeast quarter of section 5, or in the west part of section 4, to a height of 10 feet, consisting there of thinly but mostly unevenly stratified, partly ripple-marked sandstone of a brown color. The low hill on which the town is situated contains some shales and limestone above the sandstone, which forms part of the third division of the Chester series. On the main Dutchman creek the limestone No. 5 crops out at the western edge of the bottom only at a spring in the center of the northwest quarter of section 7, and at a cave a little farther south. It is capped there also by the sandstones No. 4. Apparently the same formations were observed on the upland, a mile farther west, in the northwest quarter of section 12 (?), township 13, range 2; but I could not trace their limits farther up the creek, where the hills are gently sloping. Only near the Vienna and Jonesboro road, on the west side of the creek, I noticed some of the sandstone at the foot of the hills, near the middle of the east line of section 35, township 12, range 2. Farther north, then, follows a few outcrops of limestone, forming the third division of the Chester series, in the northwest quarter of section 36 and in the south part of section 25, and also on the low upland in the west part of section 31, township 12, range 3. In the southeast quarter of section 25, township 12, range 2, a few feet of these limestones are exposed at the water's edge, and a few feet higher sandstones crop out—No. 2 of the Chester series. These, then, form the hills in the northwest quarter of section 25, and form low bluffs near the creek in the northwest quarter of section 30, and in the northeast quarter of section 30, township 12, range 3, and appear to continue near the water's edge to the northeast quarter of section 19. At the upper end of the low bluff, in the northeast quarter of section 30, I observed some limestones of the Chester formation in the lower part of the hill. They are not prominently exposed, compact, siliceous, partly close-textured, partly coarsely crystalline. I am somewhat doubtful whether this corresponds to the intercalated slaty calcareous layers on Lick creek, or whether it is a part of the highest Chester limestone No. 1, which is not impossible on account of the disturbed stratification in this part of the county. The higher hills in section 19 are mostly formed of this limestone formation, and capped by Conglomerate. Near the southwest corner of section 17 this limestone reaches undoubtedly to the water's edge, and extends up the creek for several miles to the south line of section 1, township 12, range 2, and farther west up Grasshopper branch to the northwest corner of section 11, or even farther. It attains a very considerable thickness, at least of 150 feet, perhaps much more, and forms numerous precipitous cliffs. It is similar in appearance to the same formation on Lick creek, and also contains numerous seams of very brittle brown or blue flint. A section was obtained near the center of section 18, township 12, range 3. The bluff is there 269 feet high, from the bed of the creek; its lower part, to a height of at least 144 feet, consists mainly of alternations of limestones and shales, the uppermost and Chester limestone; and the upper part consists of Conglomerate, which is at least 68 feet thick. The 57 intervening feet may be underlaid with either of these formations, or by both in part.

It forms the following section:

1.	Slope to the summit, underlaid with the Conglomerate	57 feet.
2.	Cliff of sandstone (Conglomerate)	8 "
3.	Slope, with tumbling sandstone, underlaid probably with limestone and shales, perhaps with sandstone	57 "
4.	Slope, with heavy masses of tumbling limestone, apparently underlaid with limestones and shales	40 "
5.	Limestone, exceedingly siliceous, with seams of dark, brittle flint. The rock is blue or gray, very hard, close-textured, and sub-conchoidal in its fracture	22 "
6.	Steep slope, apparently underlaid with shales, and perhaps limestones; ends on a ledge of limestone	20 "
7.	Slope, apparently underlaid with shales	20 "
8.	Limestone, forming a prominent cliff. The rock is partly dark bluish-gray, close-textured, partly lighter gray, and more or less crystalline	18 "

9. Heavy outcrops of similar limestone, apparently alternating with shales, down to the creek. This is supposed to be near the base of the upper division of the Chester series........24 feet.

From the south line of section 1, township 12, range 2, upward, Dutchman creek runs entirely through the Conglomerate, either in consequence of the Chester strata passing rapidly underground to the northward, or perhaps because the Conglomerate may at this point fill a basin eroded in the Chester formation. This sandstone, as I have stated before, caps the ridge south of Grasshopper branch, in section 10, south part of sections 11 and 12, township 12, range 2, and farther on, and extends as far south as the northeast part of section 24 and the northwest part of the adjoining section 19, township 12, range 3; but the sandstones on the summit of the steep hills in the northwest quarter of section 27, township 12, range 2, and farther northwest and east, are the highest sandstone division of the Chester series No. 2. They contain, in their lower part, a faint streak of stone coal, such as we have seen before in the upper part of the sandstone No. 6.

Near the southeast corner of section 14, I noticed, in a branch, thinly stratified ripple-marked sandstones, and a few feet higher some limestones, shales, and blue, highly calcareous slate. This limestone undoubtedly belongs to the first division of the Chester series, but I am not satisfied whether the sandstone forms the top of the second division or is a local intercalation in the first limestone division.

On Town creek, just below Vienna, we have found the sandstone No. 4 of the Chester series, and above it, underlying the town, limestones of the third division. While the sandstones are exposed at various points southeast of town, these same limestones form a bluff on the bend of Town creek, a mile and a quarter above Vienna, in the northwest quarter of section 3, township 13, range 3. They were also observed half a mile farther south, and especially on the branch near Scott's mill, in the middle and north part of section 3, and appear to extend up that branch through the northwest quarter of section 2, and through section 35, township 12, range 3, to its northeast corner. A short distance farther up the main creek, in the southwest quarter of section 34, sandstone forms a bluff, on the bank, with an aggregate thickness of at least 30 or 40 feet. To all appearance, it overlies the limestone, and is the lowest of the second Chester division. It also caps the ridge east of the creek, in the north part of section 3, in section 34, the northwest quarter of section 35, section 26, and east part of section 27, and we find it again on the Town creek in the northeast quarter of section 27, and at the ford in the southwest quarter of section 22. At this latter point, the upper ledges of this formation are exposed, consisting of some hard, ripple-marked, thinly stratified sandstones, gray, argillaceous shales, and some shaly sandstones. Overlying this sandstone, follows the first limestone division of the Chester series, which reaches on the creek from the ford to near the north line of section 21, when it is succeeded by the Conglomerate sandstones. It is not much exposed on the creek, but can well be traced. It also underlies the slopes west of the creek, in the southeast quarter of section 21, and the northeast quarter of section 28, but is more conspicuous on the east side of the creek, in the northwest quarter of section 23, where it is again characterized by the seams of dark colored brittle flint, and extends thence eastward, at the base of the high sandstone ridge through the east part of section 22, the southeast corner of section 15, sections 23 and 24, to Mack creek, in section 19, township 12, range 4.

The country north of Vienna, between Town creek and Dutchman creek, is rolling, with low hills, and shows various outcrops of limestone at low points in the north part of section 32, the southwest quarter of section 29, etc. The higher hills in the southwest quarter of section 28, and the north part of section 29, appear to be capped with sandstones; and in section 21 we reach the Conglomerate. In this vicinity, the uppermost Chester strata change their trend from southeast to east, and the outcrops are too few to trace the single sub-divisions with accuracy. They may, possibly, not be all developed at this point.

We have seen that east of Cache river, the limestone No. 7, capped by the sandstones No. 6, form the hills on the north side of Cave creek, from its mouth to the meeting house in the north part of section 23, township 13, range 3. There the limestones dip under ground, and the sandstones No. 6 continue up the creek to the Vienna and Metropolis road, in the south part of section 14, where they are themselves capped by limestones belonging to the fifth division of the Chester series, while the top of the ridge to the northward consists of sandstones No. 4. The formations, Nos. 4, 5 and 6, continue in the same relative position eastward along the old Metropolis road. The limestone No. 5 was there observed in the southeast corner of section 13, and Nos. 4 and 6 above and below it. Prominent outcrops of No. 5 were also noticed near the crossing of a branch of Johnson's creek, in the northeast quarter of section 19, township 13, range 4, overlaid by the sandstone No. 4, while the bed of the branch consists of sandstones belonging to No. 6. They extend to Bay river, near the southeast corner of the county.

The limestones and shales of the seventh division are exposed east of Cave creek, in the breaks of Clifty creek, in the north part of section 25, township 13, range 3, and in the northwest quarter of section 30, township 13, range 4, above the crossing of the Vienna and Metropolis road, while the sandstones of the sixth division cap the ridge to northward to a considerable thickness. Both were also observed on and near George's creek, from the Massac county line upwards. The highest strata of the sandstone No. 8, as we have stated before, crop out in the bed of that creek, close to the county line, in the southwest corner of section 34 and the southeast corner of section 35, township 13, range 4, and rise southward, and then form the bluffs at the edge of the swamps. Farther up the creek, which here has a strong fall, the limestone formation No. 7 crops out in the banks in the southwest quarter and the northwest quarter of section 34, and underlies the slope of the precipitous ridge in the south part of section 33. This ridge is capped by 40 or 50 feet of the sandstone No. 6, which, likewise dipping northward, forms the banks of the creek in the northwest quarter of section 34, southwest quarter of section 27 and the southeast quarter of section 28. Near the centre of section 28 it is succeeded by the overlying limestones and shales of the fifth division of the Chester series, which is, however, only very sparingly exposed. This formation underlies the southern slope of the ridge north of George's creek, in the east part of section 28, and extends at the same altitude farther southeast through the southwest quarter of section 27, and so on, into section 35, overlaid by the sandstone formation No. 4, which forms the summit of this whole ridge. At the point where the county line strikes the Bay river swamps, near the southeast corner of section 35, the limestone division No. 7 forms the base of the hills, and continues in this position to Bay river, in the north part of section 36, although it is little exposed.

On Bay river, near the southeast corner of the county, the seventh Chester division, the next one above sandstone No. 8, forms the base of the hills west of the stream. Thence upward there is a wide bottom between the river and hills, and only sandstones are exposed for some distance in the upper part of the hills, which are very high. These sandstones are No. 6, and at the highest points probably No. 4. The strata appear to be nearly horizontal. Near the south line of the southeast quarter of section 23 I observed some of these limestones in the low hills, capped by the sandstone No. 6;

and more of both formations was seen farther northwest, especially in the southeast quarter of section 22, on a branch slough, and farther west at the edge of the principal bottom north of the centre of section 22. Near the south line of section 15, on the west side of the section, where Johnson creek enters the Bay bottom, I found about 25 feet of the limestone formation exposed, capped by about 70 feet of the sandstones No. 6. These reach the water's edge at the bend of Bay river, in the southeast quarter of section 15, and form the bed of the stream at the bridge in the northwest corner of section 15; but then they, too, dip underground and are succeeded by the limestones No. 5. They are much more prominently exposed on the east side of Bay river, from near the centre of section 14, southeastward. Near the southeast corner of section 14 they form bold cliffs, from near the water's level to an altitude of fully 100 feet, and they cap the hills on the Pope county line in the east part of section 24, probably underlaid, at the edge of the Bay bottom, with the formation No. 7.

The limestone of the fifth division of the Chester series crops out on Bay river, north of the crossing of the lower Vienna and Golconda road, on the west side of the stream, near the south line of section 10, and on the east side in the southwest quarter of section 11, and in the northwest quarter of section 11, township 13, range 4, and it extends apparently a short distance farther north, near the water's edge, concealed by the detritus and soil. I also noticed it at the northwest edge of the Cypress pond, east of Bay river, near the middle of the north line of section 11. Wherever I saw it exposed, I found it overlaid with the sandstone No. 4. These extend northward along Bay river to the ford near the centre of section 3, forming numerous rocky bluffs. I noticed them especially on a branch not far from the edge of the Bay bottom, on the Columbia and Reynoldsburg road, in the northeast quarter of section 5, where they are capped by the limestone No. 3, and lower down on the same branch in the northwest quarter of section 4; also, on a rocky ravine in the southeast quarter of section 4, and thence eastward to the river and at the edge of the bottom in the south part of section 3, and all through section 10. They are at no one point exposed to a greater thickness than 40 feet, but their aggregate thickness must be fully double that much. Some of this rock is finely-grained, of a pleasing yellowish-white color, forms heavy ledges, can be easily dressed, and is sufficiently firm; so that it forms a superior material for stone-cutters' work. Blocks of any desired size might be obtained. East of Bay river, besides the points already mentioned, I observed it in the lower half of the hills north of Cypress pond, in the southeast quarter of section 2, where it is capped by the limestone No. 3, and the sandstone No. 2, and on the Pope county line in the hills along the east line of section 12.

Proceeding northward, we enter the district of the limestones forming the third division of the Chester series. They form the hills to both sides of the Bay creek bottom, in the northeast quarter of section 3 and north part of section 5, township 12, range 4, and on the southwest part of section 32, and in most of section 33 and section 34, township 12, range 4, extending on the Big Bay to the northwest quarter of section 35, and on its tributary, Cedar creek, to within a short distance below the mouth of Mack creek to the southwest quarter of section 27, overlaid near their northern edge by the sandstones No. 2. They were observed, also, on the upper part of the precipitous southern slope of the high ridge in the south part of section 2, and in the hills on the Pope county line, in the southeast quarter of section 1, township 13, range 4.

The second division of the Chester series, which, as we have seen, consists mainly of sandstones, is largely developed in this portion of Johnson county. On Bay river it extends from the northwest corner of section 35 to the point where this stream first enters the county on the east line of section 21, forming the bed of the creek at the bridge just across the line in Pope county, east of the centre of section 24. Thence southward, gradually ascending, it underlies the uplands in sections 25, 26, 36, 35 and farther to the south of the centre of sections 1 and 2, township 13, range 4. It crowns the bluffs in the forks between Bay and Cedar creeks, and is conspicuously exposed along a ravine on the east side of section 27. It forms the bed of Mack creek, a short distance above its junction with Cedar creek, near the east line of section 28, reaches northward along Cedar creek to near the south line of section 15, and westward up Mack creek far into the southeast quarter of section 19. It forms within these limits many prominent cliffs on the north side of Mack creek, and extends south of the creek to the centre of section 32, and farther eastward. This sandstone formation consists of alternating harder and more yielding ledges of well cemented sandstones and shaly sandstones or arenaceous shales. The sandstones are partly ripple-marked, and most of them rather irregularly stratified. Many of them are brown, and contain marks of Lepidodendron and of many other plants. Near the base of this formation a thin streak of coal was discovered by Mr. H. P. Sharp, in digging a well in the southwest quarter of section 29, township 12, range 4. It will be remembered that a similar streak was found at the base of the same formation, east of Cache river, in the northwest quarter of section 27, township 12, range 2. There is no prospect that it might anywhere attain a sufficient thickness to be of importance as fuel. In the upper part of the sandstone formation some blue slaty limestones were observed on the east side of Mack creek, at the crossing of the old Vienna and Golconda road, in the southeast quarter of section 19, which resembles the development of these rocks on Lick creek, near the west line of the county. The aggregate thickness of this sandstone formation is over 120 feet, as may be seen in the southeast quarter of section 27, and probably about 150 feet.

The Chester limestone No. 1 is exposed on Mack creek first, near the middle of the east half of section 19, township 12, range 4, and extends northward towards the center of section 18, where the overlying sandstone reaches the water level. It is siliceous, partly close-textured, from uneven to conchoidal in fracture, partly crystalline, of bluish and grayish colors. Contains the same seams of brittle flint which have been observed in this formation further west, alternates with shales and rises considerably to the southward, so that, although the outcrops along the banks of the creek extend a little over a mile, they attain a thickness of more than 100 feet. East of Mack creek it occupies the upland from the summit of the sandstone bluffs in the south part of sections 20 and 21, to the foot of the higher ridge of Conglomerate, the extreme southern point of which is on the west part of the south line of section 17. On Cedar creek this first Chester division extends from near the south line of section 15 through sections 15 and 10 into 3 and 2. The last points where it is exposed are near the schoolhouse, in the southeast quarter of section 3, and on the branch not far from the center of the southwest quarter of section 2. Then the Conglomerate follows, which reaches in the hills east of Cedar creek as far south as the high summit near the middle of the east half of section 23. The slope underneath it is there formed of the limestone No. 1, which crosses the Pope county line in the northeast quarter of section 24 and the southeast quarter of section 13, township 12, range 4.

On Johnson creek, where it enters Bay river bottom, in the southeast quarter of section 15, and in the north part of section 22, township 13, range 4, we find the upper ledges of the limestones No. 7, overlaid with sandstones of the sixth division, as I have stated above. These limestones extend up the creek to near the crossing of the Marion and Metropolis road, near the middle of the south half of section 16, and up the southern branch into the southeast quarter of section 17. The sandstones No. 6 extend farther up the branch through section 17, and on the main creek several miles. In the southeast quarter of section 8, their highest ledges only form the bed of the creek, while the overlying limestones, No. 5, crop out in the low bluffs north of the creek, capped by the sandstone No. 4; but on the west side of section 8, and in the northeast quarter of section 7, they are more conspicuously developed. In the northwest quarter of section 7, township 13, range 4, and through the north part of section 12, and in the northeast corner of section 11, township 13, range 3, they are again mainly confined to the bank of the creek. These sandstones, No. 6, include in their upper ledges some feet of argillaceous shales, and a thin seam of coal, of which we have found indications farther west, on Dutchman creek, southeast of Vienna, in the northeast quarter of section 18, township 13, range 2. This stone coal was observed on Johnson creek, in the northwest quarter of section 12, in the bed of the creek, underlaid with a little slate, and then with dark argillaceous shales, and covered with soil. It is there 6 inches thick and quite impure. Many persons have supposed that where this coal had a solid roof i might be thicker, perhaps sufficiently so to be worked, but I am fully satisfied, by a careful consideration of all the circumstances, that such hopes will not be realized. The same coal seam was observed in the bank of the creek, a mile farther east, in the northwest quarter of section 7, where it consists of three inches of very impure coal, intercalated in dark colored clay shales, within a few feet of the overlying limestone No. 5. Near Mr. Dednam's, a mile and a half farther southeast, near the center of the northwest quarter of section 17, it has again been noticed, higher up in the hills, on a ravine of the south fork. I saw the sandstones and overlying limestones, but the coal was not exposed at the time. Its thickness there is variously stated at between 1 and 8 inches.

The next higher limestone division, No. 5 of the Chester series, is first exposed in the bluffs of the creek near the west line of section 9, south part, thence northwest through section 8; also in the south part of section 5, mostly capped by the sandstone No. 4. It underlies the low rolling uplands in the south part of section 6, and in the south part of the adjoining section 1, township 13, range 3, and was observed in the northeast quarter of section 11. The limestone at the branch south of the creek, near the center of the southwest quarter of section 12, is also supposed to belong to this formation, which must underlie part of the slopes on the south side of Johnson creek, in this vicinity, although it is nowhere else exposed. It further caps the hills near Mr. Dednam's, in section 17. The sandstones on the higher ridges, both north and south of Johnson creek, belong to the fourth division of the Chester series. This and the third limestone division are not so prominently exposed, and cannot be traced in detail farther north, but I have already stated that the sandstone No. 2, and the limestone No. 1, form conspicuous bands of outcrops between Town creek and Mack creek.

From the foregoing enumeration and description of the principal outcrops of the Chester formation in Johnson county, we may deduce the following numbers as representing, approximately, the thickness of the different divisions of the Chester series in this county:

1st division—limestone, etc	144 to 170	feet
2d division—sandstones, etc	120 to 150	"
3d division—limestone, etc	60	"
4th division—sandstones, etc	50 to 80	"
5th division—limestones, etc	68	"
6th division—sandstones, etc	72 to 100	"
7th division—limestones, etc	156	"
8th division—sandstone	150 to 250	"
9th division—limestones, etc	62	"
10th division—sandstone	12	"

The aggregate thickness of this formation would be, accordingly, from 894 to 1,108 feet.

Conglomerate.—This formation occupies the northern part to Johnson county. On the Union county line it extends south of the vicinity of Lick creek; is then intersected by the valley of Clifty branch, along which the Chester formation crops out; occupies the summit of the ridge southeast from there, terminating in the northeast part of section 24, township 12, range 2; is then intersected by the valleys of Dutchman creek and Grasshopper branch; crosses Dutchman creek in the southeast quarter of section 1, township 12, range 2; extends again southeastward on its east side; crosses Town creek in the north part of section 21, township 12, range 3; forms the summit of the high, precipitous ridge, which extends thence eastward; crosses Mack creek south of the centre of section 19, township 12, range 4, and Cedar creek near the middle of the east line of section 3, township 12, range 4; then extends southward again on its east side, terminating in the high knob in the northeast quarter of section 23, and strikes the Pope county line on the east side of section 13.

It consists mainly of quartzose, micaceous, seldom conglomerate, mostly whitish, and only slightly cemented sandstones of great thickness, with intercalations of shales, and forms two principal divisions, separated by a seam of stone-coal, the lowest one in the geological series of our strata, which at some points attains a workable thickness. Both divisions are largely developed in this county; but as the coal is exposed at a few points only, we are not able to trace their limits throughout. I am not certain whether the upper division exists in the extreme northwestern part of the county, but in the northeastern part it is the prevailing formation.

At the west end of the *bluffs*, as the high cliffs of sandstone are called, which form the southern rim of the dividing ridge, extending from west to east, through the north part of the county, towards the head of Clifty branch of Lick creek, this sandstone forms high vertical cliffs, and reaches a thickness of some 150 or 200 feet, to the summit of the ridge. The scenery there is very grand. On the ridge, at the edge of the northern breaks, I was astonished at the sight of a curious knob of sandstone, with bare sides, which rises from the descending ground, in places 60 feet, to the full height of the most elevated points of the ridge, with which it is connected to the eastward by a narrow neck, while it stands isolated as a promontory in all other directions. This is in the east part of section 20 (or in section 21), township 11, range 2. Heavy outcrops of sandstone occur at numerous points all over the ridge, and along the creeks flowing northward from it, as well on the branches running towards Crab Orchard, as on those of Saline river. Some shales were also noticed on these creeks, and I may as well mention here that on Clifty branch of Saline river, in the southeast quarter of section 9, township 11, range 2, I found some boulders of granite, the southernmost representative of the great drift formation, of which I had observed similar signs farther west, in the south part of Jackson county. On that same branch, near the centre of section 2, I observed a few feet of argillaceous and arenaceous shales intercalated in the sandstones, and with the shales traces of coal, forming a thin but rather pure streak, partly mixed with shale. I am not fully satisfied whether this is the representative of the coal seam between the upper and lower divisions of the formation here reduced to almost nothing, but I consider it likely. Two and a-half miles farther north, in Williamson county, a thicker stratum of coal is said to have been found. In section 12, on Dry Fork, some slate crops out, perhaps containing a faint streak of carbonaceous matter, but no limestones, as I had been told. Over three miles of the upper course of Dutchman creek are through this sandstone formation, which, if we consider the height of the bluffs at the head of the creek, and farther, that the general dip of the strata is to the northward, although they may be horizontal in places, while the creek runs southward, gives us an idea of the great thickness of the formation. The same may be said, with still greater force, of Town creek, which runs five and one-half miles in a straight line, due south, through this sandstone. On the ridge between the two creeks, close to the Vienna and Marion road, in the southwest quarter of section 32, township 11, range 3, at Mr. Campbell's, the intervening coal seam crops out at the head of a ravine. It is fifteen inches thick, rests on a few feet of shales, and is capped by sixteen inches of clay shales, which are succeeded by shaly sandstone, and then by massive sandstone. The coal appears to be fair, but not superior. It is rather soft, splits in cuboidal lumps, and crumbles after having been exposed some time. It seems not to contain a great deal of sulphuret of iron. The coal could probably be traced easily round the adjoining hills, and might perhaps be worked profitably by stripping along its outcrops. This outcrop at Mr. Campbell's gives us a basis from which to judge the extent of the upper part of the sandstone in this county. Its southern limit probably extends northwest and east of this point, making an allowance for the depression of the creek valleys. In the district thus marked off the upper part of this sandstone caps most of the ridges. The next point farther north where the coal has been observed, is about four and one-half miles farther on the Vienna and Marion road, near the middle of the north line of section 16, township 11, range 3, rather low down on a ravine running towards Wagon creek. At the time of my visit the coal was covered with rubbish, but I noticed in the ravine arenaceous shales, and higher up sandstones apparently of the upper division. Fragments of the coal were strewn about. I could not ascertain the thickness of the seam, which appears to be small, much thinner even than at Campbell's. Farther down the branch to the main creek, through the west part of section 9, the arenaceous shales accompanying the coal seem to prevail along the base of the hills. A little south of west of the last named outcrop, we find the coal again on the main branch of Wagon creek, at the water level, in the northeast quarter of section 15. The coal seam has a slight northern dip conformable to the general dip of the formation, is about twelve inches thick, and resembles that at Campbell's. Above it I observed fifteen feet of bluish-gray argillaceous shale, overlaid by shelly sand-rock, below it slate; heavier masses of the sandstone are exposed in the higher hills. This coal has been used to some extent by blacksmiths. It is known as Mr. Whitehead's coal-bank, and might certainly be followed up considerably farther. The strata appear to continue in, approximately, the same relative position to the creek, for a considerable distance downward. The same shale was observed half a mile farther southeast on another branch of the creek, in the southwest quarter of section 14, and if proper search was made, the coal would undoubtedly be discovered there also.

Reynoldsburg is situated in the southwest quarter of section 33, township 11, range 4, just below the summit of the bluff ridge, on its south side, on the breaks of Cedar creek. In that vicinity the coal seam has been discovered at various points. The town, and also the mill, three-quarters of a mile farther west, near the middle of the south half of section 32, are both situated just on the uppermost ledges of the lower Conglomerate. Descending thence about 112 feet, we reach the point where the town branch and mill branch unite. These upper 112 feet of the lower Conglomerate are there all quartzose, partly quite pure, partly slightly tinged with iron. Most of the rock consists of fine limpid grains of quartz, with rounded edges, which are scarcely cemented together, so that the stone is friable underneath a thin outer shell, hardened by the atmospheric agencies. It forms partly massive layers, partly heavy ledges with false stratification and ferruginous seams, partly thin even ledges, and partly it contains more iron and is strongly cemented into a hard rock. Few of the strata contain quartzose pebbles. It extends at least a mile lower down along this rapidly descending branch, and must therefore attain a very considerable thickness. The horizon of the town and of the mill is that of the coal seam, while the upper Conglomerate forms the higher summits. At the town the coal is not exposed, and has never been dug after, but it is known to exist at several points near the mill. A few rods north of the mill, south of the centre of section 32, Mr. Woodside has opened it and found it only covered with a few feet of sand and gravel. It is said to have been 30 inches thick, and underlaid with shale. To judge from the weathered fragments it must have been of good quality, but it appears to have contained more sulphur than is desirable for the use of blacksmiths. Large quantities of coal might here be obtained by stripping a quarter of a mile farther west, up the branch, near the centre of the southwest quarter of section 32. Mr. John May has opened the same stratum. It is there 24 inches thick, overlaid with 8 feet of laminated blue slate. From the bottom of the coal to the lower sandstone is only a few feet. Farther on, in one of the ravines of the same branch, at Mr. Elisha Bushing's, in the southeast quarter of section 31, coal has also been found, and is reported as 18 inches thick. It is not now exposed. Sandstone crops out a short distance above and below it. It is situated higher than the before mentioned outcrops, and if it is the same stratum, as I have good reason to believe, the dip of the formation must here be locally slightly to the eastward.

A mile north of the mill, across the main ridge, the coal was again discovered on a branch of Sugar creek, near Mr. Dean Harper's place, in the southwest quarter of section 27, township 11, range 4. It is here 24 inches thick. The roof consists of gray argillaceous shale, capped with sandstone. The strata below the coal bed are not exposed. Nothing was seen of the blue slate. If search was made the coal would be discovered all around these hills. Even if it was not of the very best quality, it would make a valuable fuel for all ordinary heating purposes, especially for making steam. A mile and a half farther north, on another branch of Sugar creek, at a much lower level, at the ford on the Reynoldsburg and Marian road, south of the centre of section 19, I saw in the bank about 25 feet of bluish-shaly slate, capped with sandstone. The general configuration of the formations led me to believe that this might be the slate above the coal, and that the coal would perhaps be found just below the water level. I was afterwards assured by Mr. Woodside, of Reynoldsburg, that such was actually the case, and that at the season of low water about 20 bushels of coal had once been taken out there. Still my information on this subject is quite vague, and I can only state what I had heard. Westward, up that branch, the sandstones continue prominently exposed in the hillsides. Towards the head of one of its prongs, in the southeast quarter of section 24, township 11, range 3, near Mr. Casey's, I observed a heavy outcrop of bluish arenaceous slates, capped by sandstones. The slates are penetrated by numerous fissures, and show a marked dip to the east and north. Some crystals of calcareous spar, found in these fissures, have given rise to the idea, with those not acquainted with the occurrence of mineral veins, that there was a mine of some valuable metal, probably silver; and considerable labor has been expended in digging into these slates, of course with no beneficial result whatever. Notwithstanding the dip there and in the adjoining sections is strong to the northeastward, still I hardly consider these slates as identical with those of section 19; nor can I tell whether the argillaceous slates on the branch near the middle of the north half of section 17 are those which accompany the coal, although I believe they are. Farther down Sugar creek higher sandstones form the banks of the creek, in consequence of their northern dip, especially in the west part of section 6, township 11, range 4; and the same is the case a mile farther west, on Maple branch, in the west part of section 1, township 11, range 3. They must belong to the upper part of the Conglomerate.

The uplands east of Sugar creek, in the northernmost sections of the county, are all underlaid with the upper Conglomerate, and coal has been observed there at several points. There have been some doubts in my mind whether this coal was the same stratum as the one at Reynoldsburg, at the junction between the upper and lower Conglomerate, or a higher stratum intercalated in the upper part of the sandstone. It is found on ravines and creeks considerably below the level of the ridge, which is itself not high in this vicinity; and a slight undulation only of the strata would be sufficient to account for its being the lower one. I found it thus on a branch in the southeast quarter of section 5, accompanied by gray slaty shale; but it was not sufficiently exposed here to learn more about it. Near Mr. Elijah Henderson's, in the northwest quarter of section 4, it was again observed in a ravine, hardly more than 14 inches thick, but of very fair quality. The roof consists of bluish-gray indurated argillaceous shales, of which 5 feet are exposed; and 20 feet above the coal follows a prominent ledge of sandstone. I could not see the strata next below the coal, but I noticed more sandstones a little farther down. The stratification at this point is irregular; the strata are bent. It cannot surprise us, therefore, to find a different condition in the next ravine, only a few rods distant. There we have again the lower sandstone, then light colored plastic clay, gray indurated shale, then the coal capped with slaty shale. The thickness of the coal is, however, greater, although variable within the space of a few feet. At one point I observed 18 inches of good coal, overlaid with 12 inches of very slaty coal; at another, from 12 to 24 inches of shale were intercalated between the lower coal and a few inches of upper coal; at a third place, close by, the coal was from 4 to 5 feet thick and apparently of fair quality, but not well exposed, and perhaps slaty. Blacksmiths have thus far confined themselves to the coal of the 14 inch point, although it contains some lumps of sulphuret of iron.

On Pond creek, a little over a mile further southeast, I noticed the same coal seam first on the east side of the northeast quarter of section 9. It is there only from 6 to 8 inches thick, directly overlaid with a heavy ledge of sand-rock, and rests on gray argillaceous shales, underneath which more sandstones follows. Farther down the creek the thickness of the shales evidently expands. Near the northwest corner of section 10 the bank of the creek consists, to a height of 10 feet, of argillaceous laminated slate and shale, which is capped by shaly sandstone. The coal is here apparently underneath the water level. A short distance farther down, at Mr. W. Phillips', in the southwest quarter of section 3, coal has been dug up in a ravine a few rods distant from, and a few feet elevated above the creek. It is only covered with soil, and large quantities might be obtained by stripping. The thickness of the stratum is variable. In one hole it was found as much as four feet thick, and it may be still thicker where it has a solid roof. Part of it has a dense texture, but the lamination can be recognized throughout; another portion is slaty, and streaks of slate are found between the coal. It is evidently the same bed as the one at Henderson's, and it appears that wherever it increases in thickness slate becomes mixed with the coal. It is also said to have contained large lumps of sulphuret of iron. A quarter of a mile farther down Pond creek, I observed the lower sandstone at the water's edge, and above it the argillaceous strata which contain the coal. The latter was not exposed at the time of my visit, but had been opened some years before, and was reported to have been found 18 inches thick. The slope is there steep and rather high, and partly underlaid with shaly, laminated and thinly stratified sandstone. The prominent ledges of sandstone are many feet higher, above this coal seam, than at Mr. Henderson's. Only a few feet below these ledges, I observed a considerable thickness of arenaceous slate, then some feet of argillaceous bluish and gray slates, and underneath them a thin streak of coal, not more than a few inches thick. The distance between the two coal seams is probably 50 feet. Here the sandstones corresponding to those at Henderson's are either hidden under the slope or else the slaty division is here far more developed. I understood that some traces of the coal had also been discovered a mile farther southeast, in the hills on Little Saline, but I could not obtain satisfactory information in relation to it. Nothing else is known of coal in the northeast corner of the county. The ridges in section one are still composed of the upper part of the sandstone.

On Little Saline creek, about half a mile from the Pope county line, in the southeast quarter of section 12, township 11, range 4, we find the lower part of this sandstone dipping underneath the water level to the eastward. Higher up, it forms the foot of the hills, while the higher beds form their summits. I traveled southward up Clifty branch of Little Saline, along which this same relative position of the strata prevails. The lower part of the sandstone forms nearly continuous cliffs along it, through the southwest quarter of section 12, west of section 13 and west of section 24; then the cliffs are more scattering, and the increased fall of the creek brings us finally up to the upper sandstone, which I traced far to northward on the east side of the creek, and which here, also, contains much brown hydrous oxide of iron. The coal has thus far not been discovered on Clifty branch, nor has any search been made for it. I suppose it could be found by digging down to the strata which separate the upper and lower sandstones. Not far from the head of the creek, near the southwest corner of section 25, I observed some ledges of sandstone in the bank, which evidently belong to the lower division. In the breaks above there, in the southeast quarter of section 26, I noticed, above this sandstone, blue slate and some thinly-stratified shaly sandstone; and higher up still more slate, capped by heavy ledges of upper sandstone. It seems that these slates are those separating the two principal divisions of the Conglomerate, and that the Reynoldsburg coal, if it continues eastward, might be found here by denuding a few feet of the slope where it is covered with soil and rubbish.

Thence southeastward, beyond a narrow intervening ridge, I struck a branch of Cedar creek, and found on its banks heavy cliffs of sandstone, which continue up and down the creek, especially downward, and exhibit a strong dip northward. Near the middle of the southeast quarter of section 35 this lower sandstone is exposed on the creek with an uninterrupted thickness of 140 feet, and it reaches much farther down the creek, where lower strata of this formation rise to the surface one after the other. Near the head of the middle branch of Cedar creek, in the northwest quarter (?) of section 27, I observed an outcrop of gray and bluish shales, which apparently correspond to a portion of the beforementioned slate formation, and are half way between them and the Reynoldsburg coal. No traces of the coal were, however, discovered at this point.

The lower Conglomerate extends considerably farther south over the roughly broken ridge into township 12, east and west of Cedar creek, but the coal and upper sandstone are not supposed to extend far in that direction beyond the town line.

Economical Geology.

Coal.—Coal has been observed in Johnson county in the Chester group and in the Conglomerate, but the regular Coal Measures do not extend quite so far south. In the Chester group, it is confined to a few thin streaks, the thickest of which has at one single point been found to reach a thickness of 6 inches. This coal has only a scientific interest, inasmuch as it shows that the conditions under which coal could be formed began to exist during the Chester era, before the Coal Measure period; but these seams of coal cannot be presumed to have anywhere attained a sufficient thickness for being worked.

The conditions in the Conglomerate, which succeeded the Chester era, were more favorable to the development of stone coal, and we find one coal seam at the junction of the lower and upper divisions of this formation in Johnson county, and perhaps a second one higher up in the upper beds. This coal does not differ materially from the coal of the Coal Measures, but it is mostly thin, varying between 12 and 24 inches in thickness, and where it increases to 4 feet or more, this increase appears to be partly due to an admixture of shales, which impairs the quality of the coal. It is, nevertheless, of considerable local importance, because in this broken country it can be worked by stripping along its outcrops, which might undoubtedly be traced round most of the hills in the northwestern part of the county, especially in township 11, range 4, and in township 11, range 3. The coal is bituminous, but not strongly; its quality appears to be fair in general, only it contains, in places, considerable sulphur in connection with iron, which makes it necessary to pick the coal well.

In the foregoing pages, I have described all the points where any signs of coal have been discovered in the Conglomerate. I will, therefore, confine myself here to the enumeration of them again, in a tabular form.

Outcrops of Coal in the Conglomerate of Johnson County.

Number....	Name.	Township.	Range....	Section....	Quarter.	Thickness of the coal *Inches.*	Remarks.
1	Woodside's........	11	4	32	S.. of center....	30	Near Reynoldsburg Mills,
2	John May's........	11	4	32	S.W............	24	" " "
3	E. Rushing's	11	4	31	N.W. of S.E....	18	" " "
4	Dean Harper's....	11	4	29	S.W. of S. W....	24	At the head of Sugar Creek.
5	Elij. Henderson's.	11	4	4	N. of N.W......	14	Different outcrops of the same
6	Elij. Henderson's.	11	4	4	N. of N.W.......	30 to 60	bed.
7	....	11	4	5	S.E. of S.E.....	?	Branch of Sugar Creek.
8	....	11	4	9	E. of N.E.......	6 to 8	On Pond Creek.
9	W. Phillips'	11	4	3	S.W. of S.W....	48	" " "
10	....	11	4	3	S.E. of S.W....	18?	On Pond Creek, the same as No.
11	....	11	4	3	Center of S.W..	Thin	9, 50 feet above No. 10.
12	....	11	4	11	N.W(?)	?	Near Little Saline creek.
13	Whitehead's	11	3	15	E. of N.E......	12	On Wagon Creek.
14	....	11	3	16	Mi'dle of N. line	?	Branch of Wagon creek.
15	Campbell's........	11	3	32	S.W............	15	....
16	....	11	2	2	Center	Thin	On Clifty branch of Saline.

Outcrops of shales or slates, supposed to be those which accompany the coal, were further found at the following points: In the southeast quarter of section 26, the northwest quarter of section 27, middle of the north part of section 17, south of the center of section 19, township 11, range 4, northeast quarter of the southwest quarter of section 14, township 11, range 3, and at other places.

Minerals.—Ores of the valuable metals are not found in Johnson county, with the exception of the brown hematite iron ore, the hydrous oxide of iron. This is distributed in small quantities through many of the sandstones, and is present in considerable quantity in the upper Conglomerate. It does not appear to form any regular veins or strata, but it is mixed, in smaller or larger quantity, into the sandstone. Thus we find all degrees of transition, between a slightly ferruginous sandstone, an iron ore mixed with some sand, and a pure iron ore. No excavations have ever been made to ascertain the quantity of the iron ore in any one place. I think it doubtful whether it occurs anywhere in sufficient quantity, and of sufficient purity, to warrant the erection of smelting works. The sand with which it is so profusely mixed is a very undesirable admixture, because it is apt, under the influence of a smelting heat, to enter into chemical combination with the iron, and to form slag with it. It takes a high heat and a large quantity of lime, as flux, to prevent this.

The following localities are amongst those at which the iron ore has been observed most profusely: Two miles northwest of Reynoldsburg, between the forks of Sugar creek, on the northeast quarter of section 30, and farther northwest near the range line west of section 19, township 11, range 4; also near Clifty branch of Little Saline, in the northwest quarter of section 13, township 11, range 4, and thence southeastward. One of the richest localities is just beyond the county line in Pope county, in the northwest corner of section 30, township 11, range 5, at the southern edge of the crest of the main dividing ridge.

Saltpetre has in former years been obtained in small quantities from under some overhanging cliffs of Conglomerate sandstone; but the small quantity which can thus be obtained, and the present low price of the article, prevents its exploration being any longer remunerative.

Mineral Springs.—The only mineral springs at present known in Johnson county are springs containing sulphate of iron, copperas springs, not sulphur springs, as they are also sometimes erroneously called, which name is generally used for springs containing sulphureted hydrogen. Weak springs of this kind are very numerous, and ooze out of nearly every layer of shales in the Conglomerate. The two most noted ones are the one northeast of Reynoldsburg, on a branch of Cedar creek, in the northwest quarter of section 34, township 11, range 4, and the other half a mile west of the Pope county line, south of the center of section 12, township 12, range 4, on a small branch of Little Bay creek. This latter spring used to be a noted watering place in former times, when the country was thinly settled. People congregated there from far and near lived there in log houses, the remains of which may still be seen, or camped around, drank the water, and amused themselves with hunting, horse-racing, gambling, dancing, and in having a good time in general. Sulphate of iron appears to be its principal, and perhaps only, mineral constituent. Its hygienic properties are, therefore, of at least doubtful value. As a cure for intermittent fever, people sometimes drink as much of it as they can possibly swallow during an hour, and then exercise violently in order to produce perspiration. This treatment might, however, be modified advantageously by substituting an artificial compound instead of the spring water. Its continued use exercises an unfavorable influence upon the digestive organs, while the favorable effect of the iron upon the system would be far better produced by some other combination of it.

Building Materials.—Johnson county is rich in the ordinary materials for building. Sandstone may be obtained at numerous points from the sandstones composing the eighth, sixth fourth and second divisions of the Chester series, and the Conglomerate. The sixth Chester division contains fine even slabs of sandstone, which were especially noticed in the center of section 10, township 13, range 2; in the southwest quarter of section 16, and the northeast quarter of section 18, township 13, range 3; south of the center of section 33, township 13, range 4; and in the west part of section 8, township 13, range 4. The fourth division contains similar slabs in the southeast quarter of section 31, township 12, range 2; and a very superior sandstone for stone-cutters' work, on Bay river, near the southwest corner of section 3, township 13, range 4. The sandstone No. 2 contains mostly only rocks for ordinary walls, and the Conglomerate, although most of it is not fit for building purposes, contains good quarries at various points; for example, near the Vienna and Marion road, in the southwest quarter of section 3, and in the southeast quarter of section 29, township 12, range 3; in section 4, township 12, range 3; in the northeast quarter of section 1, township 11, range 3, and at other places.

Limestones of good quality as building rock may also be obtained in the St. Louis and Chester groups. It may also be burnt into lime at numerous points, although much of it is too siliceous and too full of other impurities for this purpose.

Sand, for making mortar, is of common occurrence, and clay for brick may be dug up nearly everywhere.

Agriculture.

In the preceding pages I have discussed the general surface configuration of the county. I will add some details, especially in relation to the width of the creek bottoms and the growth of timber. I have already stated that in the northern part of the county, in the district occupied by the Conglomerate, the county is very roughly broken; that the creeks run there through rocky chasms, and have seldom any arable bottom lands; that the hillsides are mostly steep and rocky, and frequently exhibit prominent cliffs, but that the ridges, where they are of sufficient width, make fine farms.

On Wagon creek, Maple branch, Sugar creek aud Pond creek, there are some bottom lands near the county line, mostly in detached patches. On them I find much white oak (*Quercus alba*), swamp white oak (*Q. bicolor*), scarlet oak (*Q. coccinea*), a few laurel oak (*Q. imbricaria*), and pin oak (water rock, *Q. pallustris*); also, sugar maple (*Acer saccharinum*), white walnut (*Juglans cineria*), black walnut (*J. nigra*), elm (*Ulmus spc?*), mulberry (*Morus rubra*), scaly bark hickory (*Carya alba*), pignut hickory (*C. glabra*), a few yellow poplar (*Liriodendron tulipiferum*), red-bud (*Cercis Canadensis*), box elder (*Negundo aceroides*), sycamore (*Platanus occidentalis*), then pawpaw (*Asmina triloba*), hazel (*Corylus Americana*), and other smaller trees; but at some points, also, where sandstones form the bank of the creek, with scarcely any soil upon them, the red birch (*Betula nigra*).

Higher up on these and on other creeks of the Conglomerate district, the bottoms are generally not more than a few yards wide, and overflow after every heavy shower. We find there principally the various oaks, some walnut, sugar maple, some yellow poplar, but only a few beech. On the branches running southward, which have also the same character, I observed, before they reached the Chester formation, more beech (*Fagus ferruginea*), maple (*Acer dasycarpum*), and sweet gum (*Liquidamber styraciflua*), with the oak timber.

On the ridges of the Conglomerate formation the principal timber is a fine growth of white oak, with black oak (*Quercus tinctoria*), black gum (*Nyssa multiflora*), barren hickory (*Carya tomentosa*), pignut, some scalybark hickory, sassafras, hazel, etc. Where the soil is shallow, and the ridges very dry, the growth becomes more stunted, and post oak (*Q. obtusiloba*), and black-jack (*Q. nigra*) make their appearance, and also the winged elm (*Ulmus alata*). On bald sandstone bluffs, of the Conglomerate and of the Chester sandstones, only the red cedar (*Juniperus Virginiana*) will thrive. Towards the north line of the county the growth on the ridges begins to change somewhat, and to become more similar to that of the lower Coal Measures. The white oak becomes smaller; post oak becomes plenty. Besides, there is especially black oak, barren Spanish oak (*Q. falcata-triloba*), some black-jack, barren hickory, some laurel oak, and water oak, hazel, sassafras, sumac, etc.

On the ridges, which are directly underlaid with Chester sandstones, the growth of timber is nearly the same as on the Conglomerate. It consists principally of white oak, black oak, some barren Spanish oak, scarlet oak, black gum, barren hickory and pig-nut hickory, either of which trees is more or less frequent, according to local circumstances. At very dry points we find the winged elm; but the post oak and laurel oak were observed only at a few localities. Where shales and limestones have participated in the formation of the soils, the growth of timber is more luxuriant, and with abundant white and scarlet oak, and some others of the above trees, are profusely mixed the sugar maple, black walnut, scaly-bark hickory, yellow poplar, sweet gum, and others.

The timber of the creek bottoms in the district of the Chester formation, above the points where they begin to form wet low bottoms with cypress growth, and lower down, at such points where the bottoms are not swampy, consists mainly of the swamp white oak and the sugar maple, together with the white oak, a few burr oak, sweet gum, elm, ash, walnut, scaly-bark and other hickories, and maple.

In those creek bottoms, including the Cache river bottom along the lower course of that river, which are swampy during the larger part of the year, the growth consists prevailingly of the bald cypress (*Taxodium distichum*) and tupelo gum (*Nyssa uniflora*, at the lowest points, then of sweet gum, white ash (*Fraxinus Americano*), hornbeam (*Carpinus Americano*), sycamore, locust, slippery elm (*Ulmus flava*), maple, water oak, swamp white oak, Spanish oak, shell-bark hickory and bottom hickory (a variety of the barren hickory (*C. tomentara var*). On the higher ground around the foot of the hills at the edge of the bottom, we find there principally white oak, red oak, yellow poplar, black and white walnut, black gum, sugar maple, pig-nut hickory, besides red-bud (*Cercis Canadensis*), paw-paw (*Asmina triloba*), sassafras, hazel, etc. The whole is densely interwoven with cane, where the latter has not been destroyed by cattle.

In relation to the bottom lands along the different creeks, I have further to state that the bottom of Lick creek varies from a quarter to a half mile in width in Johnson county. On the Cache river we find the first cypress swamp just west of the Union county line, but then the bottom is again higher and dryer, and its width, which is quite variable, may average half a mile through township 12. In the north part of section 4, township 13, range 2, it has scarcely any bottom; in section 9 it connects with an extensive cypress swamp. Through the south part of section 11, sections 15 and 14, and the north part of section 23, the bottom contains much cypress timber, is fully a mile wide, and spreads even farther into branch bottoms. In the north part of section 23 it connects again with extensive ponds, which reach thence several miles to the west and southward. In the west part of section 24 the bottom is once more narrow, and ledges of sandstone form the bed of the stream, which is here clear and runs swiftly. Below this point it is more stagnant, with brown-colored water, and full of drifted logs. The bottom lands then average three-quarters of a mile to near the mouth of Dutchman creek, when they spread out to nearly two miles; and at the Massac county line Cache river enters the main swamp region, which at numerous points measures several miles in width.

The lower two miles of the Dutchman creek bottom are very wide, but then it is hemmed in by bluffs which reduce its width to a quarter of a mile at an average. From the mouth of Town creek upwards it is again considerably wider for some miles, in places over a mile wide. On the upper course of the creek, in the Chester formation, and further upwards in the Conglomerate, there are no bottom lands, or only small detached and mostly overflowed patches. Town creek has some wide bottoms above Vienna, but principally finely sloping low side hills, up to the point where it leaves the Conglomerate formation. Mack creek, after it leaves the Conglomerate, soon begins to form considerable bottom, which, thence to its mouth, averages half a mile in width, and is, in places, a mile wide. The same is the case with Cedar creek to its junction with Mack creek. Thence downward, its bottom unites with that of Bay river. The bottom of Little Bay creek, at the Pope county line, is a quarter of a mile wide, and has low, finely sloping uplands adjoining it. It soon unites with Big Bay river. The bottom of the latter, a short distance from the county line, begins to form wide, low, wet bottoms, and cypress swamps. They appear to average fully one mile, and are in some places two miles wide, while at others they are much narrower. Near the southeast corner of the county, Bay river enters the main swamp region.

In conclusion, I have to allude to a small but interesting tract of land at the extreme southern end of the county. In the east part of section 4 and in section 3, township 14, range 2, I observed an extensive body of post oak timber under very unusual circumstances, at the edge of the Cache river flats, and only a few feet elevated above these bottom lands, far away from any other post oak lands. The post oak thrives best on the white, extremely fine arenaceous soil of the Coal Measures of Southern Illinois, especially in flat districts with an imperfect surface drainage, and also on the flats with a similar soil, which are formed by the fine Tertiary sands near the Ohio, in Massac county. At the above named point we find a similar white, extremely fine, siliceous soil, over a nearly level area, and I can not but think that it must be derived from the Tertiary formations which underlie the uplands south of Cache river. Together with the post oak we find here some white oak, black oak, etc., and, at a lower point, the swamp white oak, scaly-bark hickory, and some laurel oak, locust, etc.

CHAPTER XV.

PULASKI COUNTY.

By Henry Engelmann.

Pulaski county is bounded on the south by the Ohio river, on the west by Alexander county, on the north by Union and Johnson counties, and on the east by Massac county. It embraces an area of 192 square miles, of which nearly 115 are more or less elevated upland, and the remainder low alluvial bottom and swamp land, mostly situated along Cache river. All of the county is timbered, the bottom lands very heavily.

Surface Configuration.

The surface configuration and growth of timber are by no means uniform over the whole county, but they vary considerably with the geological formations and with the proximity of the main water courses—the Ohio and Cache rivers. A new feature, not found in the counties heretofore described, is presented by the yellow loam region of the oak barrens, in the central part of the county.

The lower Carboniferous limestone formation extends into the northern and northwestern part of Pulaski county, and forms gently-sloping low hills, with a fertile soil, a rich arenaceous loam. These hills are covered with heavy timber, consisting principally of white oak, black oak, pignut hickory, scaly-bark hickory, yellow poplar, black gum, black walnut and dogwood. They slope off to southward to the Cache river bottoms. Cache river runs from east to west, through the northern part of the county, before it turns southward at its west side. Along the river we generally find a wide, wet and overflowed bottom, and it forms numerous pounds, sloughs and swamps. Scattered through this low land are ridges or swells, only a few feet higher, but above the overflow; and north and south of the main bottom there are other ponds and swamps, generally connected with the river by a depression of the surface, and often situated below the flood level. The back-water from the Ohio reaches up Cache river hardly as far as Ullin, at the crossing of the Illinois Central Railroad, and the floods above are more immediately caused by the headwater of the stream when its discharge is impeded by the back-water. The bottoms are heavily timbered throughout, and at some points the timber attains a prodigious size. It consists, in low places on the river, and on sloughs, and in ponds, of the swamp cypress and tupulo germ; and, on a little dryer ground, sweet gum, swamp white oak, Spanish oak, red oak, white oak, yellow poplar, black walnut, sugar maple, black gum, pignut hickory, scaly-bark hickory, a few pecan, maple, white ash, elm, dogwood, pawpaw, redbud, and others. The branches and small streams emptying into Cache river from the south and east have mostly wide wet bottoms, in which, except in close proximity to the Cache river bottoms, the water oak and the swamp white oak prevail, together with sweet gum, ash, locust, and locally, also, burr oak, laurel oak, bitter oak, and other trees. The bottom ridges have a growth of white oak and yellow poplar, mixed with other trees such as thrive in the dryer parts of the bottom. They have a warm, light, sandy soil of inexhaustible richness, but the principal drawback to their more extensive cultivation is the malaria arising from the adjoining swamps and the difficulty of getting pure water. The extensive lumbering operations on Cache river will gradually exercise a beneficial influence in thinning out the heavy timber of this district.

The limestone formation extends southward beyond Cache river, and underlays the opposite hills, which are gently sloping and heavily timbered. The growth of trees is similar to that north of the swamps, consisting of white oak, black oak, yellow poplar, hickory, etc., but the mixture of the soil with materials from the adjoining barren region is manifested by the presence of maple, sweet gum, and some other trees which are not common on the limestone hills farther north.

The main body of the upland in Pulaski county, between Cache and Obio rivers, is underlaid with Tertiary strata, and may be designated as oak barrens. They consist of alternations of gently sloping, more or less sharply rolling or broken ridges. Their soil is a yellow, finely-arenaceous loam, and reaches to a considerable depth. The growth in the central portion, and extending nearly through the whole width of the county, is characterized by an abundance of small, brushy bitter oak, an upland variety of the Spanish oak, a tree which is hardly found anywhere farther north and replaces the black oak and black jack, which diminish in numbers and soon disappear, when the bitter oak begins to prevail. The bitter oak usually forms a dense under-brush, together with an abundance of hazel, sassafras and sumac, and is more or less interspersed with large bitter oak, together with some post oak, white oak, black oak, barren hickory, pig-nut hickory, black gum, in some places small yellow poplar, in others a few winged elm; at some points, also, with the laurel oak and the scaly-bark hickory. These oak barrens are sparingly cultivated at present, but are susceptible of a high state of cultivation. Their soil is strong, and has all the elements of fertility in a considerable degree.

Near the western edge of the oak barrens, towards Pulaski, the species of timber remain nearly the same, but white oak prevails over the others, and black gum and yellow poplar are, also, more numerous. South of Boar creek, west and southwest of Villa-ridge, the hills extend farther west, close on to Cache river. Although the geological formation remains unchanged, and the yellow loam soil continues, the timber in this district is different; hickories prevail, with walnut and sweet gum, and the barren oak has all but disappeared. I noticed on the hills, and on the slopes especially, white oak, swamp white oak, blue bark oak, a variety of the red oak, scaly-bark hickory, pig-nut hickory, barren hickory, black gum, sweet gum, ash, black walnut, white walnut, yellow poplar, sugar maple, dog wood, red bud, sassafras, and a few beech. Farther east, towards the Ohio and Caledonia, this forest growth continues, gradually admitting more and more of the oak barren growth, while the swamp white oak is not found any more. On the hills and ridges near the Ohio, above Caledonia, the barren growth is found to a considerable extent; still the white oak generally prevails, together with black oak and hickories. The sweet gum is confined there to the foot of the hills. In the extreme southeastern corner of the county the limestone formation once more crops out at the base of the river bluffs, and consequently the same timber is found there which covered the slopes south of the swamps.

The extreme southwest corner of the upland consists of steep rugged hills, which are remarkable for being covered exclusively with beech timber, probably in consequence of their geological formation, in which a heavy body of imperfectly cemented flint-gravel and sand appears to predominate. The beech timber extends on the slopes of the bluff hills a short distance east of the Illinois

Central Railroad, and also southward into the bottom, where it is mainly mixed with white oak, yellow poplar, scaly-bark hickory, and sugar maple.

The bottom lands on the lower Ohio river, up to within a few miles of Caledonia, may be considered as belonging to the Mississippi bottom. The Ohio, farther up in Pulaski county, has generally no bottom, or only a narrow strip. These bottoms are subject to frequent overflows, and cannot be cultivated. Their principal growth is willow, pecan, sycamore, maple, cottonwood, ash and box elder.

Geological Formations.

In the northern part of the county the St. Louis limestone is largely developed. It extends also south of the Cache river swamps, forming a narrow band along the foot of the uplands, and crops out once more near the head of the *Grand Chain Rapids*, on the bank of the Ohio river, in the southeastern corner of the county; so that it would seem as if these strata were continuous all underneath the eastern part of the county, reaching little above the low-water level of the Ohio and Cache rivers, and covered between these rivers by the Tertiary strata of the oak barren region. Where the Cache river bluffs approach Mill creek, north of Ullin, these limestones rise considerably, and another formation, probably the Kinderhook group, appears to form the base of the bluffs; but it has nowhere been exposed sufficiently to be identified. At one other point only have I observed a small outcrop of an older formation. On Boar creek, not far from Cache river, north of west of Villa-ridge, the lower Devonian or Clear creek limestone may be recognized, nearly concealed by Tertiary deposits. It forms high hills in Alexander county a few miles west of this point, and where now the bottom lands intervene there stretched evidently, at some former time, a barrier of Devonian hills. The whole of the uplands of Pulaski county, south of Cache river, are underlaid with the continuation of those strata which, in Alexander county, forms the southern extremity of the Mississippi river bluffs. They appear to be of the Tertiary age, and may date partly from a still later period. They form all the outcrops at the edge of the uplands east of the Cache river below Ullin, the bluffs of the Ohio river from below Caledonia to the Massac county line, and underlay the oak barren region generally, extending to and beyond the eastern boundary line of the county. The geological formations of Pulaski county are, therefore, the following in descending order:

1. *The Tertiary formation,* which consists principally of clay and very fine micaceous sand, together with coarser sand, which is more or less indurated, and irregularly permeated and cemented with oxyd of iron. Then there are large masses of rounded siliceous pebbles, which are at many points formed into a ferruginous conglomerate, popularly called cement rock. This formation contains traces of lignitic coal, which are, however, of no practical importance. The aggregate thickness of the formation is estimated at from 200 to 300 feet; it could not be determined more closely. Some of these strata have probably been broken up and re-deposited at a later period, and others may originally belong to a later epoch, but the uniformity of the material made it impossible to make nicer discriminations of their age. The Tertiary formation overlies the older rocks unconformably.

2. *The St. Louis Limestone.*—This formation in Pulaski county consists of limestones of gray, bluish and white colors, crystalline, sub-crystalline, or semi-crystalline, and partly highly siliceous, and full of concretions of flint. The thickness of this formation could not be ascertained because the outcrops are far apart, and none of them exhibits more than a few feet of strata. The aggregate thickness must, nevertheless, be considerable.

3. *Kinderhook Group, Black Slate and Devonian Limestone.*—These groups were nowhere identified in this county, although the overlying and underlying beds were recognized, and this outcrop is probably now hidden by the Quaternary and Tertiary formations. But as there is a hiatus of several miles in extent between the outcrop of St. Louis limestone and the lower Devonian or Clear creek limestone, it is probable that it was originally occupied by these groups. If these Devonian strata extend into Pulaski county, however, they have either been so far destroyed by denudition that they do not reach above the bottom level, or else they are entirely covered up now by Tertiary and Quaternary deposits.

4. *Clear Creek Limestone.*—This formation crops out only at a single point, in a bluff a few feet wide and high, on Boar creek, half a mile east of Cache river, in the east part of section 30, township 15, range 1 west. This outcrop consists of some thin ledges of white flint rock, with partings of white clay, and might, by its lithological character alone, at once be identified. It contains, however, some casts of fossils of this formation. It will not be necessary to refer to it again in the following pages.

The St. Louis Limestone.

I have stated before that the most prominent exposures of this period correspond to its lowest sub-division, which is a whitish, semi-crystalline limestone, with an earthy, uneven fracture, relieved by numerous crystalline particles, partly siliceous. We find this formation in the Cache river bluffs east of Mill creek, and on the south side of Cache river, for some miles east and southeast of Ullin, which indicates the undisturbed continuation of the southeastern trend which it has in Union county.

A mile and a quarter south of Wetaug, a short distance west of the Illinois Central Railroad, in the northwestern corner of section 14, township 14, range 1 west, we find at the upper edge of the low bluff hills an outcrop of a few feet of gray crystalline, apparently magnesian limestone, in heavy layers and of a uniform texture, full of indistinct fossils. These appear to be the lowest strata of the middle division. A quarter of a mile farther southwest the lower beds crop out with their usual characters. They have been quarried extensively, and are a superior building material. The white rock is ten feet thick, underlaid with as many more feet of a more compact, gray and cherty limestone, below which the slope is fifteen feet high to the river bottom. Thence southwestward through section 14, the white limestone forms nearly continuous cliffs, with an exposed thickness of from twenty-five to thirty feet, rising, gradually, higher above the bottom. On the southwest quarter of section 14 (?), it appears to begin at a height of fifty feet. Toward the west line of the section the bluffs are lower, and at the base of the white rock gray and cherty ledges are exposed. The wet character of the creek bottom seems to be caused by the presence of the shales of the Black Slate formation, which, however, are not exposed. Thence up Mill creek we find no outcrops for some distance, but in the roughly broken hills the gray and bluish siliceous limestones of the middle division of the St. Louis group prevails. I noticed them especially near the northeast corner of the northwest quarter of section 14, on a branch not far from Mill creek, in the south part of the southeast quarter of section 3, and at other points; and towards Wetaug I observed several sink-holes, which are evidently connected with this formation. The big spring near Wetaug owes its origin to these sink-holes and subterranean caverns in the limestone.

South of Cache river the lower beds of this group are exposed in the low bluff bank near the middle of the west half of section 19, township 14, range 1 east, and has been found at various points in digging through a few feet of soil for about three-quarters of a mile up the stream. Again, two miles further east, in the north part of section 28, in a well dug on the low upland, limestone was struck at a depth of sixteen feet, which partly resembles these lower beds, but is a little more bluish. Above it loose pieces of chert were found, which are derived from the higher ledges of this formation. In the southwest quarter of the adjoining section 21, more limestone was struck in a well. That, too, was partly close-textured, cherty and blue, partly corresponded to the lower beds, so that it appears as if these wells were at the junction of the lower and middle sub-divisions of this limestone formation. The limestone was also struck near the Cache bridge in the northeast quarter of section 20.

A short distance below the outcrop of the limestone, in section 19, near the west line of that section, slate is said to have been found in the bank of Cache river. It was covered by the water at the time of my visit, so that I could not ascertain its true character; but as it had been dug into some years ago, with the expectation of finding coal, I suppose that it must be the Black Slate of the Devonian formation. Farther south and southwest other traces of limestone have been found; a sink-hole in the southwest quarter of section 30, township 14, range 1 east; then the rock itself in a well on the low upland, a little distance farther west, just across the range line, in range 1 west; and lastly, in the southwest quarter of section 25, in the low bluffs at the edge of the bottom, limestones have come up in large masses with the roots of fallen trees, and have near by been found in solid ledges in a well. All these rocks are siliceous, cherty and sub-crystalline. I hardly think that they can correspond to the middle division of the St. Louis limestone, but rather that they may belong to the siliceous limestone below.

The middle division of this limestone occupies the partly broken and gently sloping uplands between Mill creek and Wetaug, north of the bluff hills; it forms the bluff hills themselves between Wetaug and Big creek, and farther on to Cypress creek, and can be traced on the south side of Cache river, to and across the Massac county line, although it is little exposed. The prominent bluff which it forms on the opposite side of the Cache bottoms in Johnson county have been described in the report on that county.

I have mentioned above that the lowest strata of this division are found in the bluffs a short distance west of the railroad. A mile east of it, southeast of Wetaug, in the west part of section 7, township 14, range 1 east, the gray and bluish crystalline, or sub-crystalline and siliceous rocks of this formation, form a considerable outcrop at the bottom's edge, and crop out of the cultivated slope farther east. We then find them again in the banks of Big creek, in the northwest quarter of section 8, southeast corner of section 6, and near the county line in the north part of section 6. The only outcrops farther east are also along the Cache river bluffs, if the low banks at the edge of the upland can be so called. The first and most prominent one is near the east line of section 8, where some rock has been quarried, although it is cherty and of indifferent quality. Another one is in the southwest quarter of section 10, and several in the southwest and southeast quarters of section 2. In the south part of the northeast quarter of section 2, close to the banks of Cypress creek, I observed a layer of gray, siliceous, fetid limestone and a limestone spring; but close by, scarcely lower down, a soft-water spring and fragments of a hard sand-rock. Should this sandstone be in place, capping the limestone, it must be an outlier of sandstone No. 8, or No. 10, of the Chester series. Possibly the sandstone might be an outlier of the Tertiary formation. A mile farther northeast, in Johnson county, the St. Louis limestone reaches high up in the hills.

We have seen that the lowest ledges of the middle division cap this limestone in the north part of section 28 and the southwest quarter of section 21, township 14, range 1 east. Thence eastward in the northwest quarter of section 22, a bluish-gray, semi-crystalline, silico-magnesian, fetid limestone, evidently a member of the middle division, crops out a few feet thick at the bank of a slough of Cache river. Two miles farther east, in section 13, the bluff hills rise again a little bolder, and fragments of similar limestones are strewn over their slopes, indicating that these hills are formed by the same formation which is also exposed at the edge of the bottom in the southwest quarter, and in the northeast quarter of the adjoining section 18, township 14, range 2 east. Thence eastward, outcrops are entirely wanting on the south side of Cache river, but in a well on a low hill, near the centre of section 24, such limestone is in place at the bottom, and was found tumbling higher up, which proves that this formation continues, but is covered up by superficial deposits, and perhaps locally removed by denudation. Farther on, in Massac county, it is again prominently exposed, and it also reaches the surface three and one-half miles south of the last named point, on the banks of the Ohio.

There the limestone protrudes along the gravelly beach in detached masses, extending altogether about 1½ miles along the river, from a quarter of a mile west of the Massac line, downward through the north part of section 12, and near the south line of section 2, township 15, range 2 east. Its highest exposures reach hardly 10 feet above low-water mark, and it is therefore during a part of the year concealed from view. The statement made to me that the bed of the river in this vicinity also consisted of this limestone, seems to be well founded, and it is undoubtedly this rock which causes the shallows and rapids known as the "Grand Chain" of the Ohio, which begin near the Massac county line, and extend some distance down the river. Of course only the hardest and most compact ledges have withstood the eroding power of the river, and the exposed masses are therefore exceedingly hard, and full of chert in nodules and seams. Fossils are abundant, especially bryozoa. The hills which reach close to the river bank consist of Tertiary deposits, and the regular bluffs near the limestone exhibit outcrops of Tertiary strata to their very base. The upper division of this limestone has not been recognized in this county.

The Tertiary and Later Formations.

The Tertiary formation has been described above in general terms. A detailed section of it cannot be given, because the exposures are scattered far apart, and generally not high; and because the details of the formation appear to be quite variable. The principal outcrops were observed at some points at the edge of the Cache river bottoms, and on the Ohio river, along the western and southern limits of the uplands composed of this formation; by describing them its character will be best exemplified.

Two miles south of east of Ullin, in the southwest quarter of section 30, township 14, range 1 east, close to one of the above named outcrops of limestone, I noticed fragments of the ferruginous conglomerate of flint pebbles and flint gravel in such quantity on the side of a hill, that I can entertain no doubt but that these rocks are in place in the upper part of this hill. Similar masses were observed at other points further south, seldom in large quantity, however, mostly at a sharp point or turn of a hill, or in steep breaks. They evidently underlie the higher part of the uplands, of which more proofs will be given hereafter, while softer strata, which disintegrate more easily, form the base of the hills, and are exposed only at a few points. Rocks of any description are quite scarce in this district on the surface of the ground.

In the side of the bluff close to Pulaski station, near the center of section 15, township 15, range 1 west, I noticed some dark gray clay, closely resembling the potters' clay of Santa Fé, mixed with ferruginous sand. The slope is strewn with thin shells of ferruginous sandstone, with pieces of the Conglomerate, and with pebbles, associated with which I observed pieces of brown iron ore containing a considerable admixture of sand, and evidently originating from a local accumulation of the hydrous oxide of iron in a part of the sandstone. Digging in a ravine a few rods farther northeast, the gray potters' clay was again found, and a little higher up the white, micaceous, finely-grained, shaly sand or silt, which is so characteristic a member of the Tertiary formation of this district. A streak of carbonaceous matter, an impure lignite, hardly an inch thick, was also observed close by, and in the south half of the same section, a fine white sand has been dug up at the foot of the bluff which is useful for building purposes and resembles the Tertiary sands of Santa Fé and Caledonia. Small outcrops of the same materials occcur two miles farther east, in the lower part of a ravine in the northeast quarter of section 13, and they have been found also in several wells.

South of Boar creek the uplands extend further west close on to Cache river. In the ravines we find occasionally flint gravel or pieces of the Conglomerate, and on the creek a bank of arenaceous shale, in the southeast quarter of section 29, township 15, range 1 west, and a bank of fine brown quartz sand in the southwest quarter of section 29. At the outcrop of the Clear creek limestone, in the east part of section 30, the latter is capped by the white micaceous, laminated, soft, shaly sandstone, and close by there is more Tertiary sand and arenaceous shale.

Near the bend of Cache river, where the ferry road ascends from the bottom, in the southeast quarter of section 31, township 15, range 1 west, several feet of the dark gray clay shale are exposed in the lower part of the hill, apparently the same as the Santa Fé clay, intermixed with streaks of sand and shells of ferruginous sandstone, as is common in this formation. Underneath it the white, micaceous, soft, shaly sandstcne could here be seen in place. Pieces of the ferruginous Conglomerate of flint pebbles and of hard ferruginous sandstone were then noticed loose in a ravine in the southwest quarter of section 5, township 16, range 1 west, and also in the north part of section 18, and at a few other points, but no rocks are found in place anywhere over these hills. Some sink-holes were observed on the hills in or near the southeast quarter of section 7 (?), but I hardly think that they are caused by underlying limestones, which is the almost universal origin of the sink-holes in Illinois and adjoining States. They are situated close to the head of abruptly descending ravines or breaks, and may be caused by the washing off of loose, fine, underlying sand, another portion of which, perhaps cemented by iron, offered more resistance to the percolating waters, and thus remained a barrier preventing the sink-hole from uniting with the break and becoming its head.

In the north part of section 18, or in the south part of section 7, township 16, range 1 west, the bank of Cache river is composed of argillaceous shale of gray color, slightly micaceous, and free of sand, iron and other impurities. It is at least 15 feet thick, and would probably yield an excellent clay for potter's ware. It is undoubtedly Tertiary, and may possibly form the continuation of the before-mentioned less pure clay bank. Near by, white sand, flint pebbles and sandstone are strewn in abundance. At an old mill site, in the north part of section 19 (or south part of 18 ?), 20 feet of such shale were exposed in the bank of the river, covered with loose flint gravel of brown color, and with huge masses of a conglomerate of such gravel, and sand cemented by the brown oxide of iron, which differed from the Conglomerate at other points, in being loosely and imperfectly cemented.

From this point southward the bluffs on Cache river continue steep, although not very high, to the east end of the bend, in section 20, where they make a turn towards the northeast, and leave Cache river, trending towards the Ohio. On the lower end of the branch which empties near this bend, I again observed a slight exposure of the gray clay shale. Thence eastward, to and beyond the railroad, the hills continue to be covered entirely with soil, sand and the brown gravel, which are struck in digging on them; and at a certain uniform level lower down, numerous springs indicate the presence of an impermeable stratum of clay. Near a branch, in section 12, wells pass through the gravel into the clay. A mile from the bluffs, inland, on a branch considerably below the summit of the ridge, in the northwest quarter of section 17, township 16, range 1 west, I observed 15 feet of the pebble Conglomerate in place. It was underlaid with loose pebbles, from which we may conclude that the iron ore, acting as a cement, has been introduced from above, and that the free or cemented condition of the pebble layers is subject to many local variations.

The railroad cut south of Villa-ridge, in the northeast quarter of section 5, township 16, range 1 west, passes through heavy beds of the brown siliceous pebbles, and of finer brown siliceous sand. Such sand is also exposed at several points in the south part of section 35, township 15, range 1 west, east of Villa-ridge, and a well dug on higher ground on the ridge, in the southeast quarter of section 35, passed through 18 feet of soil and yellow loam, 18 feet of cemented gravel, 11 feet of gravel mixed with sand. It is difficult to decide, in many cases, where the sand and gravel are in their original position and where re-arranged by later floods.

The southern end of the uplands, near the Ohio, is quite low and rather flat, with no exposures of rock strata. Near the site of the now abandoned town of America, situated in the centre of section 9, township 16, range 1 east, the low bluff bank consists of a yellow loam, not dissimilar to the Loess formation, and of some white fine sand, which differs from all the Tertiary sands of this district in being free of mica, and which appears, therefore, to be of Quaternary age. A public well was once sunk near the centre of section 9. It is said to have been 95 feet deep, and to have only passed through sand, gravel and the like, but not to have struck any rock or soapstone. It is, however, so long since the well has been dug, that I could not ascertain any particulars.

Lower Caledonia, formerly the county seat, but now merely a farm, is the next point where the river washes the bluff, which is here also quite low, and consists of a mixture of yellow clay and gravel, evidently a Quaternary deposit. The presence of the Tertiary clay shales underneath a slight covering in the beach is, however, betrayed by springs and grass tufts, which, some miles higher up the river, I learned to recognize as unmistakable companions of these shales. Signs of the shales are also recognized a short distance inland.

Caledonia, a mile farther up the river, is situated on much higher bluffs, in the north part of section 26 and the south part of section 23. Near the point where the line between these two sections strikes the river, the following succession of strata may be observed, in descending order:

1. Yellow loam soil and sub-soil.
2. Gravel, with fragments of ferruginous pebble Conglomerate.
3. Gray argillaceous shale, micaceous, plastic, apparently a fine potter's clay. At the outcrop it is stained by iron, which, however, seems to originate from above, and not to be contained in the fresh shale. The lower part is areno-argillaceous, and the highest imperfectly exposed portion appears to be lighter colored, and also mixed with fine arenaceous silt. Thickness, upwards of 20 feet.

—24

4. Fine, gritty, micaceous sand. At its top, and more numerous towards its base, it contains irregular hard shells of the same sand, cemented by iron into more or less hard rock. The exposed surface of the stratum is yellowish-brown, in consequence of the chalybeate waters which ooze over it, but the fresh sand is mostly white. It is 18 feet thick.

5. Dark gray and flesh-colored micaceous shale, containing much fine arenaceous silt and horizontal streaks of irregularly cemented ferruginous fine sand; 7½ feet thick. Particles of carbonaceous matter were also observed in this stratum.

6. Covered; 9 feet.

7. Dark gray, micaceous, plastic clay shale, with thin streaks of sand and ferruginous matter, similar to No. 5. Exposed thickness, 2 feet.

8. River beach covered with sand and gravel. The whole exposed thickness of the strata is therefore 56½ feet. The highest hills here reach from 120 to 150 feet above the river. The flesh-colored shale, No. 5, corresponds to a similar stratum at Santa Fé, in which I also found a streak of lignitic coal. A short distance above town, this stratum exhibits the strongest indication of coal which has been observed in the county. It is a thin streak or rather a thin pocketful of lignite and mineral charcoal. The seams of ferruginous sandstone at the base of No. 4, and in Nos. 5, 6 and 7, become quite a prominent feature above the town, where they increase in thickness.

Exposures are numerous along the Ohio, above Caledonia, and the strata are similar to those at Caledonia. Sulphuret of iron, in irregular concretions, is contained in large quantity in the shales, and we find, therefore, at numerous points, springs of chalybeate water. Some of the sulphuret has been oxidized and converted into the carbonate, of which I found pieces still retaining a kernel of the sulphuret in the centre. The sandstones, of course, contain all the iron in an oxidized form, as a hydrated peroxide.

In the southeast quarter of section 13, township 15, range 1 east, the sand No. 4 is most prominently exposed near the river, and continuing up a branch, I observed outcrops of ferruginous sandstone, and, towards the breaks, flint pebbles in profusion. These latter may be observed in most of the breaks back of the river in sections 14, 12, and farther on.

In sections 18 and 7, township 15, range 2 east, the lower part of the bluffs consists of gray micaceous and arenaceous silt, of impalpable fineness, which, higher up, turns white, and is exposed to a thickness of fifty feet. At one place it is capped by red sand, and generally the slope is strewn with ferruginous sandstone, which partly originates within, partly above these strata. Through section 8 the exposures are less numerous, but indicate the same formation. Then the hills fall off, and the next bluff, in section 9, consists of the rounded flint pebbles, cemented into a solid rock. Similar ones occur in section 3, and other bluff banks are formed by a mixture of the yellow surface loam with more or less gravel. The latter undoubtedly, and perhaps, also, the former, date from the present epoch, although they contain materials from the Tertiary strata. These latter, however, still underlay the uplands, which become higher near the river, in the east part of range 2 east, and they crop out in the bluffs at various points. In section 2 we find the white micaceous and arenaceous silt, and then, near the west line of section 1, a gray clay-shale, of which considerable quantities have been dug up at the base of the bluff bank, to be used at the pottery at Mound City. This is close to the outcrops of the St. Louis limestone.

Ascending a ravine a short distance west of the county line, in the northeast quarter of section 12, township 15, range 2 east, I observed more of the potter's clay. It was somewhat mixed with sand, at least near the exposed surface, but I was assured that lower down it was very pure. Above it follows a considerable thickness of the fine white micaceous material, which is laminated as at other points, but not quite so fine—rather more sand than arenaceous silt; so that portions of it form a good material for scouring. The whole branch is heavily strewn with pebbles and pieces of Conglomerate, which seem to be in place towards the summit of the ridge.

I have stated above that outcrops were less prominent at some distance from the main water courses; still we find sufficient exposures to satisfy us that the same kind of strata which we have observed along the Ohio continue under the whole barren region of the county. In the following, I will enumerate the principal exposures which have not been mentioned before:

On Briar creek, which runs through the west half of township 15, range 1 east, and empties into the Ohio near America, the first outcrop occurs in the southwest quarter of section 28, township 15, range 1 east; it is a clay shale. The next one is also shale, in the northeast quarter of section 29, on a ravine not far from the creek; and traces of shale and of white arenaceous silt were observed on branches of the creek in section 17. Nearly in its whole length the bed of the creek is strewn with gravel and fragments of the pebble Conglomerate, especially towards it head. With this Conglomerate, and undoubtedly originating from it, I noticed, in the northeast quarter of section 17 small pieces of limonite, an impure argillaceous variety of which, of a yellowish-brown color, has been sometimes collected by the farmers and used as a paint, after being calcined.

Shales are found, also, on a branch of Boar creek, in the southeast quarter of the adjoining section 18, and large pieces of the Conglomerate, especially in ravines in the southeast quarter of section 5, while the flint gravel is strewn about at various points.

In the northeast part of this same township, township 15, range 1 east, in the northwest corner of section 12, the hillsides are thickly strewn with the gravel, and lower down, in a ravine, I noticed pieces of the Conglomerate, and also of ferruginous sandstone, and strong indications of the clay shales. In the northeast quarter of section 2, shales were struck in digging a well. In the adjoining section 36, township 14, range 1 east, in the northeast quarter, large pieces of the Conglomerate were observed near the summit of the ridge. At the south side of Cypress pond, in the northwest quarter of section 28, township 14, range 2 east, huge masses of it may be seen at the foot of a soil-covered hill. I suppose it must have tumbled from a higher level, and that we would be more apt to strike limestone in digging at the edge of the pond than Tertiary strata. In the northeast quarter of section 34, township 14, range 2 east, a well dug on a little elevated upland, passed through 12 feet of yellow loam, some gravel, 20 feet of brownish-red sand, part of which was rather strongly cemented, and then reached a solid shale, which had to be worked with a pick. On higher ground of that vicinity, white sand, perhaps the shaly arenaceous silt, is struck in wells. Northeast of Post creek the low hills in the southeast quarter of section 24, township 14, range 2 east, contain a considerable thickness of this gravel. A well, dug close to the county line, near the southeast corner of the section, is 65 feet deep, and passed most of that depth through such gravel.

In regard to the age of the formations which have been described in the preceding pages, I can only remark that their lower portion (if not the whole of them) appears to be of the Tertiary age, while it has not been possible to determine the sub-division of that period to which it might be referred. It is characterized as Tertiary by some fossils which Mr. Worthen found in it, by its general appearance, and by the lignitic traces which it contains. Fossils appear to be very scarce in this formation, and they are mostly in a bad state of preservation. The only locality where any have been found, to my knowledge, is close to Caledonia. Those which have been collected there are in so poor a state of preservation that they could not be determined specifically. The silicified wood, which has also been found in the county, has, I believe, all been obtained in loose pieces on the river bank, from amongst the pebbles.*

The brown sand and deposits of siliceous pebbles answer, as I have stated elsewhere, very nearly to the description given of the Orange sand in Mississippi, which is considered as probably corresponding to the northern drift; and on the other hand they resemble the specimens in the State Cabinet from the northern part of the State, which are labeled as "Drift Conglomerate." Still I entertain strong doubts whether the sand and pebbles, including the Conglomerate, belong to an epoch distinct from that of the underlying shales. We have seen that the shales contain much sand, partly cemented to sandstone by oxide of iron. Such sand and sandstone can, I believe, not be distinguished from those in the upper part of the deposits, and they would seem to owe their origin to the same causes, operating in undisturbed succession. The flint pebbles composing these deposits are different from the material of which the drift boulders are made farther north. The northern drift, and even its southernmost outliers, contain much granite, horn-blende rock and similar rocks, but the pebbles in question are all composed of impure silex, and no traces of granite or other igneous or metamorphic rocks has been found amongst them. The northern drift extends as far south as the north line of Union county, high up, towards the water-shed of the Mississippi, or rather the Big Muddy and the Ohio. No trace of it is found over the dividing ridge nor south of it, and only in the latitude of Pulaski county we have these siliceous pebbles. If they should date from the Drift period, they must have been derived from a source different from that of the northern drift.

Economical Geology.

Coal.—Only the lowest barren portion of the Carboniferous formation extends into Pulaski county, and not the Coal Measures; therefore there is no stone coal in the county. In the Tertiary strata I

---

* The fossils from the Tertiary deposits in this county consist of cast of marine univalve and bivalve shells, some of the former of which appear to be casts of *Turritella Mortoni*, and would indicate the Eocene age of the beds in which they occur. A single shark's tooth was found in them, but this is not now in the collection. The specimens of fos s wood are quite abundant, and in a finely silicified condition, and are found most abundant in the ravines intersecting the bluffs and at a considerable elevation above the gravel beach of the river. One specimen was found *in situ* in a gravel bed forty or fifty feet above the river level. A. H. W.

observed at several points thin streaks of a lignite coal, but the prospects are by no means favorable for a paying stratum of such coal to be found. It must be borne in mind, moreover, that the coal of the Tertiary formation, the lignite or brown coal, as it is called, differs from the stone coal of the Coal Measures, in containing much more water in chemical combination, and consequently much less carbon, and that it has, therefore, a much smaller heating power than the stone coal proper.

Minerals.—Of metallic ores only iron ore has been noticed, which is extensively disseminated through the sand and gravel Conglomerates, in which it forms the cementing material. It is the hydrous peroxyd of iron, or limonite. Pure, I found it only in small pieces; generally it is more or less strongly mixed with sand and bound to the flint pebbles. Although the aggregate quantity of it must be very large, it appears to be at no one point accumulated in sufficient quantity and purity to form deposits which might be wrought with profit. I have mentioned that at one point, in the northeast quarter of section 17, township 15, range 1 east, this ore occurs in an impure state, mixed with clay, and has been gathered in the branch by the farmers of the neighborhood, who use it as paint, after burning it, whereby its originally yellowish-brown color is changed to red. This paint can, however, be manufactured much more cheaply and of far better quality than it can be here, where the quantity appears to be small.

The only other metallic mineral which has been noticed is the sulphuret of iron, the marcasite, which is disseminated in large quantities through some of the Tertiary shales, in which it forms irregular concretions. At present it may be considered as perfectly useless, but at some future time it may serve for the manufacture of sulphur, sulphuric acid or alum. It decomposes very readily when it is exposed to the air, and it is from it that the numerous copperas springs of this formation derive their mineral element.

The milk sickness has, at one point, at least, near the edge of Cache river bottoms, been traced to a low springy place, where a salt effervesced from the ground. After fencing this place the sickness disappeared from the neighborhood. The salt seemed to have been derived from the decomposition of pyritiferous clay.

Mineral Springs.—Besides the numerous small chalybeate or copperas springs which issue directly from the pyritiferous Tertiary shales, especially at the foot of the Ohio bluffs, there are some others which cannot, with the same degree of certainty, be referred to the same origin. Most noticeable are those in the bank of Cache river, below Ullin, on the south bank, in the northeast quarter of section 34, and on the north bank, in section 33 (?), township 14, range 1 west. The water of these springs contains much sulphate of iron, and perhaps, also, alum, and is said to act very injuriously upon the bowels. There are several springs close together, but they are not equally strong. The water of some may be drank without injury, that of others cannot.

The big spring at Wetaug is not a mineral spring, but a good limestone spring. It forms a funnel-shaped basin, some 30 feet in diameter, and of great depth. The water in it has a blue color with a whitish hue, such as we find it in many limestone springs. It discharges a considerable amount of water, which forms a fine brook. It is evidently connected with sink-holes and caves in the St. Louis limestone formation, in which it is situated, and its size depends upon the extent of the area thus drained by it. I have not observed any similar springs in Illinois, but they abound in the limestone formations of Southern Missouri, with exactly the same features.

Building Materials, Potter's Clay, etc.—The only building rock in the county is obtained from the St. Louis limestone formation, and in that by far the best comes from the lower division, the outcrops of which have been enumerated above. From beyond the limits of the county good building stone can also be got from the same formation in the southwest part of Johnson county, and the northwest part of Massac county, and on the Ohio from above. The same quarries may be depended upon for a good lime. Over the whole district, where stone is less accessible, brick of a good quality may burnt be almost anywhere from the yellow loam which forms the soil and sub-soil of the barren region. Also in the bottom, close to the Illinois Central Railroad, near Mound City Junction, large quantities of brick are manufactured for the Cairo market. Good sand for building purposes can be obtained at many points, most of which have been mentioned in the preceding pages.

The argillaceous shales of the Tertiary formation yield an inexhaustible supply of superior potter's clay. On the bank of the Ohio river, in the southeast quarter of section 2, township 15, range 2 east, much clay has been obtained for the pottery at Mound City. Mr. Koch, the proprietor of the pottery at this point, assured me that the clay from the bank of Cache river, in the north part of section 18 (?), township 16, range 1 west, was a very fine material to work. In fact, at most of the outcrops of the Tertiary argillaceous shales from Cache river to the Massac county line we find some strata which appear to possess the requisite qualities, although others are too much mixed with sand, stained with iron, or interspersed with iron pyrites.

The strata of white arenaceous silt, or shaly laminated sandstone, which I have frequently mentioned in the foregoing pages, yield at some points a fine sand, which, after being freed from a few coarser grains, is a fine material for scouring tin-ware and the like, and needs only to be better known in order the come to use. Such a point is on a ravine on the Ohio, in the southeast corner of the county, in the northeast quarter of section 12, township 15, range 2 east, close to section 1.

The siliceous gravel of the upper division of the formation is a superior ballasting material for railroads, and nothing better can be got for improving ordinary roads. From the cut near Villa-ridge the southern portion of the Illinois Central Railroad is supplied with this ballast; and I have no doubt that the company would gain by extending the use of these pebbles farther north.

Agriculture.

Under the head of "Surface Configuration" I have already described the character of the land and the growth of timber, as it changes with the varying quality of the soil. I need add little more. That portion of the country which is underlaid with the limestones (the northern and especially the northwestern portion) has a rich, light, warm soil, which yields the most ample reward for the labor bestowed upon it. It is suited to nearly every crop which has ever been tried on it, to corn, small grain, tobacco, cotton, and others. The southern latitude is favorable for the growth of all kind of early fruit and vegetables for the northern market. Strawberries have already been raised and shipped north in large quantity. I am not satisfied that orchards will do equally well. The trees grow finely, but it would seem to me that the situation was generally rather too low and exposed to frost, which might occasionally kill the more tender-budded fruit, and render the fruit crop more uncertain than it is on the elevated ridges farther north. The ridges in the yellow loam barrens farther south will probably give better results in that respect.

Of the wide bottom lands along Cache river, a large portion is very superior land, as may be seen from the growth of timber. The low bottom ridges or swells have a black sandy soil, which is more or less mixed with clay, and they produce most bountifully.

They are above the flood level, but are generally surrounded by lower land, which is not only flooded at times of high water, but is naturally wet and impassable during a large part of the year, cutting off communication with the higher land. Pure, healthy water is also not everywhere to be had on these ridges, but might be supplied by cisterns. The greatest obstacle to their more extensive cultivation is the malaria created in the wide surrounding swamps. The lower portion of the bottoms has also a fertile but somewhat heavy soil, though they cannot be cultivated at present. In the course of time they will become valuable. The large saw-mills along the railroad consume annually thousands of stately trees, and the wood-choppers are making considerable havoc amongst the bottom timber. The removal of the large trees has a drying effect upon the land. Places which, a few years ago, were continually wet, have now become dry land, and support a fine growth of corn. This influence will be felt more and more; and if, in the course of time, the channel of the river is clear of obstructions, and rectified where it is needed, and when the surface is broken with the plow, large stretches of swamp land will be reclaimed and converted into a fine agricultural district. The health of this district will thus also be gradually improved. Some attempts have been made towards draining swamp lands. Some years ago a ditch was cut from Swan pond, situated in sections 22, 23, 26 and 27, township 14, range 2 east, to Post creek, which empties into Cache river, in order to lay dry the pond; but it seems that those who planned the undertaking were incompetent for the task. The necessary preliminary levelings seem not to have been executed at all, or badly executed; for when the ditch had been cut, it was found that the flood water of Cache river would pass back through it into Swan pound. Accurate topographical surveys will be required for determining a feasible plan for draining the swamp lands of Cache river.

The main body of the upland of Pulaski county, between Cache and Ohio rivers, presents features which distinguish it from all the country farther north, while the adjoining county of Massac contains similar lands. We may distinguish it as the yellow loam region, and it is principally occupied by oak barrens, a description of which has been given above. The soil and sub-soil in this district are a yellow, more or less arenaceous loam, which reaches to a considerable depth. The oak barrens are most characteristically developed where the loam is least arenaceous and in the finest state of comminution; where it is more sandy, more white oak, and then a hickory and walnut growth, preponderate over the barren oak growth. This yellow loam barren region is confined to and co-extensive with the district occupied by the Tertiary formation, and it seems as if the loam was mainly derived from the disintegration of the argillaceous shales and arenaceous silt of this formation.

The soil in this district contains all the elements of fertility, and is naturally very superior where it has sufficient sand mixed in it to make it light. Where the quantity of sand is less it is apt to pack rather close, and resembles, in that respect, the soil of the barrens within the district of the coal formation, although it is far superior to it. The sub-soil, if taken from a depth of even ten or fifteen, or more, feet, needs a very short time to become mellow, and then produces nearly equally well with the upper soil. The richness of the land and the great store of elements of fertility can, therefore, not be doubted. All that is needed is to keep it well stirred, in order to prevent it from becoming too compact, and to cultivate deeply. No industrious farmer need be afraid to trust such a soil with his labor: he may be certain of being repaid, with large interest; but the tendency to cultivate overlarge tracts slovenly, proves injurious on this land, and it is therefore by many regarded as quite inferior. The northern emigrant, used to a more thorough system of husbandry, will find it different. Besides grain, tobacco and cotton, this district promises well for fruit, with which it might probably supply the northern market earlier than any other district in the State, while it has the same advantages of railroad transportation with the orchards of Union and Jackson counties.

CHAPTER XVI.

MASSAC COUNTY, AND THAT PART OF POPE COUNTY SOUTH OF BIG BAY RIVER.

BY HENRY ENGELMANN.

Massac county is bounded on the south by the Ohio river, on the west by Pulaski county, on the north by Johnson county, and on the northeast and east by Pope county. The latter county line runs from Big Bay river, first, due southeast over the summit of a dividing ridge between different small tributaries of Bay and Ohio rivers, which trend towards the sharp bend of the Ohio, known as the *Black Bend*, and then due south of that bend.

The adjoining part of Pope county, which I propose to describe together with Massac county, because both naturally belong together, embraces the northeastern slope of the above named ridge, and is bounded on the west by Massac county, on the north by Big Bay river, beyond which the county extends a considerable distance to the northward, and on the east by the Ohio river. At the south end it runs into a point between the *Black Bend* of the Ohio and the Massac county line.

Massac county has an area of about 244 square miles, most of which is more or less elevated timbered upland, while a small portion of it is occupied by a succession of ponds, cypress swamps and low bottom lands, in places several miles in width, which extend from the northwestern corner of the county, near Cache river, first southeastward, and then northeastward to Big Bay river, near the northeastern corner of the county. In the extreme southeastern part of the county we also find wide bottom lands and cypress swamps in the *Black Bend* of the Ohio.

The southern part of Pope county, limited as above, contains about 87 square miles of territory, most of which is hilly and broken, while it also includes some bottom lands, mostly studded with cypress swamps and ponds along Big Bay river and in the *Black Bend* of the Ohio.

Surface Configuration.

The surface configuration and growth of timber vary in different parts of this district, with the geological formations and their relative elevation. The northern part of Massac county, enclosed between the Johnson county line and the swamps and bottom lands which extend from Cache to Big Bay rivers, constitutes the first subdivision. It is considerably elevated and underlaid with the sandstones and limestones of the lower Carboniferous formation, and therefore resembles, in every respect, the adjoining southwestern part of Johnson county. At its southern margin, facing the bottom lands, it forms precipitous, high and rocky bluffs, while the ridge, except in the neighborhood of the creeks and their branches, affords fine, open farming lands, with a good, light and warm soil, covered with a heavy growth of good timber, consisting mainly of white oak, black oak, barren hickory, pignut hickory, black gum, some yellow poplar, sugar maple, mulberry, scaly-bark hickory, etc.

The second subdivision embraces the swamps and the low ridges adjoining the same. These swamps are formed by a succession of ponds and cypress and ash swamps, which extend from the northwestern corner of Massac county, from Cache river, in a semi-circle round the uplands to the northeastern corner of the county, to Big Bay river, and continue along the latter stream through Pope county to the Ohio river. They are surrounded by low, wet flats, which are intersected with slightly elevated ridges and swells. Round their margin we find frequently similar low ridges or gentle slopes between them and the higher hills of the foregoing and following subdivision, although at other points the bluffs rise at the very edge of the ponds. The width of this belt of low lands varies between a mile and a-half and four miles. Its outlines are quite irregular. Single ponds, connected with the main body by bayous, or merely by low depressions of the ground, extend as outliers far in between the higher hills.

This series of swamps seems to have no fall in either direction. The water which they contain is the result of the local falls of rain, and of the natural drainage of the immediately adjoining country, by several ravines and small creeks which empty into the same, but which seldom preserves a well marked channel after entering this district. Another portion of the water is derived from the overflows of Cache and Big Bay rivers. When the Ohio and Mississippi rise, they back up the water of these tributaries, so that when heavy rains fall along their upper course, the drainage is so much impeded that they overflow their banks and immediate bottoms, and pour their floods into these swamps. Thus it happens that at times the drainage appears to be from Cache river by these swamps to Bay river and the Ohio, and at others from Bay river to Cache river. Only a comparatively small portion of them is permanently covered with water. A larger area is occupied by cypress ponds, with an exceedingly spongy soil, which is, during part of the year, saturated with water, and almost always soft and wet. The main body consists of low, wet land, hardly elevated above the cypress ponds, which forms extensive flats round the swamps, and is intersected with slightly elevated ridges or swells, that have generally a more arenaceous, light and highly productive soil, and reach above the annual overflows. Similar low ridges, terminating in gentle slopes, separate the swamps at many points, from the higher hills.

The adjoining bluffs appear once to have been washed by a powerful stream, which gave them their present bold outlines. The sandy ridges correspond to those found in the Mississippi bottom in Alexander county, and in the Ohio bottom in this district, and are the result of former currents, ancient sandbars, or other accumulations of river sand, frequently caused in the first place by ledges of hard rock which obstructed the current, and are found at various points in digging wells, although they do not crop out. The exterior ridges have all a rock foundation. The flats then are formed by deposits of the finer river silt during overflows after the stream had sought a new channel. The wet character of this land is due, not to its absolutely too low situation, but to a deficiency of natural drainage, which fault might be remedied by artificial improvements, foremost of which would be the cutting of drains and the building of dams to keep out the water overflowing from the Cache and Big Bay rivers.

This whole subdistrict is very heavily timbered. The growth is the same as on corresponding lands in Pulaski and Johnson counties. In the swamps we find principally the bald cypress and the tupelo gum, also the white ash and some of the following trees. On a little drier ground on the flats, we meet, with varying relative frequency, the sweet gum, hornbeam, white ash, maple, white elm, water oak, pecan, Spanish oak, swamp white oak, bur oak, red oak, white oak, scaly-bark hickory, pignut hickory, and some yellow poplar, sugar maple, winged elm, beech, and others. The beech was especially noticed near Robinet creek.

On the sandy ridges the growth is very heavy, and consists principally of white oak, red oak, yellow poplar, sugar maple, mixed with others of the above mentioned trees which thrive on drier and richer soil. On the exterior ridges and adjoining slopes, much the same timber is found as on the sandy ridges. The white oak prevails, together with yellow poplar, sweet gum, sugar maple, common maple, black and white walnut, scaly-bark hickory, pignut hickory, black gum, Spanish oak, black oak, scarlet oak, red bud, paw-paw, etc. Cane used to flourish over this whole region, but is fast being destroyed by cattle.

The third sub-division embraces the bottom lands along the Ohio river. The principal bottom is that in the *Black Bend*, in the south east corner of Massac and the south point of Pope counties, mainly situated in, and occupying, the south part of township 16, ranges 6 and 7. This bottom much resembles the above described swamp district. It also presents long lines of sloughs and cypress ponds, sandy ridges and low flats. The yearly floods of the Ohio sweep clear over it to a depth of several feet. The timber there is very fine, consisting, on the sandy portions, principally of the swamp white oak, scaly-bark hickory, blue-bark oak, besides black walnut, sugar maple, some bur oak, a few yellow poplar, and, at wetter points, of water oak, sweet gum, ash, etc. In the bottom flats, which have a more tenaceous soil, and generally a lower situation, the forest is also fine, heavy, tall and dense, and consists prevailingly of the swamp white oak, Spanish oak, water oak, sweet gum, some white elm, scaly-bark hickory, and of large numbers of a curious variety of the barren hickory, which latter is generally confined to rather dry uplands, while this bottom variety attains a larger growth and somewhat resembles the scaly-bark hickory. I have not, thus far, observed it anywhere else. The swamps proper are timbered with the cypress, tupelo gum, pecan, and a few other trees, and frequently are merged into the flats by gradations.

A fine alluvial bottom extends, also, along the Ohio from a mile and a half below the mouth of Big Bay river to opposite the mouth of the Cumberland river. It is generally narrow, and only expands to the width of a mile near Dog creek. Below the Black Bend, the Ohio forms hardly any bottoms in Massac county. It is mostly confined by low bluff banks, with a gravelly beach at their base. The narrow strips of bottom land are principally timbered with willow, sycamore, silver-maple, cotton-wood, ash, pecan, box-elder, etc.

We now come to the fourth, last and principal division of this district, embracing all the uplands between the Ohio and the second and third divisions. The configuration of this area, is by no means uniform, but shows considerable variations of surface structure and growth. A large portion of it is occupied by the yellow loam lands which I have described in the report on Pulaski county, but they gradually change into allied formations.

In the extreme western part of the county the ridge is rather narrow and sharply broken, but becomes more rolling and open a little father east; and, wherever it is less cut up by the numerous ravines, running northward to the swamps and southward to the Ohio. The soil is the above described yellow loam, and the principal growth is white oak, black oak, barren oak (sour oak, an upland variety of the Spanish oak), a few post oak, barren hickory, pignut hickory, walnut, sumac and sassafras. In the southeast part of township 15, range 4, northwest of Metropolis, portions of the ridge are more level, at the same time generally decreasing in altitude; and then the post oak begins to prevail, and the land gradually changes to post oak flats.

The rolling yellow loam oak barrens continue eastward to the last line of range 4, and beyond, near the south and main forks of Massac creek, in the north part of township 15, range 5, and in the south part of township 14, range 5, and even across the ridge to the upper course of Robinet creek, in Pope county, in the southeast corner of township 14, range 5, where the oak brush is generally quite small, and the tall barren grass, the original growth of the yellow loam lands, still prevails. Similar barrens I noticed north of the broken ridge to be mentioned hereafter, near the upper course of Bear creek, in section 20, township 14, range 5, and in adjoining sections. In this eastern extension of the oak barrens the principal growth is still the barren oak and post oak, with some black oak, barren hickory, sassafras, hazel and sumac, interwoven with grape vines. Where the land is more broken, and sandy sub-strata happen to reach near the surface, the black oak becomes more numerous, and some white oak is found; at other points the laurel oak, and especially where the gravelly sub-strata approach the surface, and from this or other causes the soil is drier, the black-jack is found.

A sharply broken ridge, the summit of which is underlaid with a conglomerate of siliceous pebbles, extends from the southern edge of the swamps in the northeast quarter of township 15, range 4, northeastward round Massac creek through the southeast corner of township 14, range 4, then through sections 21, 30, 29, 28, 27, 26, and others of township 14, range 5, then much less sharply defined round the head of Massac creek, and again from the northwest corner southeastward through township 15, range 6, terminating in the extreme northeastern corner of township 16, range 6, and in the northwest part of township 16, range 7. Where this ridge is most developed it is very dry; the soil is sandy and changes downward into a hard and rough, yellow loam, and the timber is exclusively black-jack: but where the ridge is wider, and consequently less sharply broken, post oak and black oak are associated with it. On these wider portions of the ridge, and in the bottoms at the foot of the breaks, we find thrifty settlements of mostly German farmers, who, by their industry and hard labor, have reclaimed a country which, to the southern emigrant, appeared a barren wilderness.

South of this dividing ridge, especially in the southwest part of township 15, range 6, also some distance south of the south fork of Massac creek, in the middle of township 15, range 5, and extending into the northeast corner of township 16, range 6, the hills are considerably lower, sharply rolling, and timbered mainly with black-jack, post oak, barren oak, barren hickory, black oak, hazel, sumac, etc. Still farther south and west these hills gradually fall off and change into finely undulating post oak flats, the surface of which is sufficiently diversified to afford natural drainage, and which are amongst the best cultivated lands in the county. We find them especially in the south part of township 15, range 5, reaching a short distance south of the town line, into township 16, and in the northwest part of township 16, range 6. They are timbered mainly with large scattering post oak and some black oak and Spanish barren oak, and their soil is whitish, very finely arenaceous, and contains ferruginous grains; it can hardly be called an arenaceous loam. The flats vary, however, in quality. At some points where, locally, the soil is coarse and sandy, for example, in the west part of section 31, township 15, range 5, or where the surface is broken near ravines, I observed, mainly, white oak, black oak, pignut hickory, Spanish oak, and a few post oak; generally, however, the post oak, black oak and barren oak are associated with barren hickory, hazel, sumac, some winged elm, and at lower points with scaly-bark hickory, laurel oak and water oak.

Still further south, towards the Ohio or the Ohio bottom, from Massac creek east to New Liberty, the post oak lands gradually become lower, and are mostly below the flood level of the Ohio, so that they are annually inundated, which, together with their level surface configuration, renders them wet; and their soil, although it is arenaceous, is not sufficiently coarse to afford an easy drainage. The principal growth on these wet flats is post oak, water oak, Spanish oak, laurel oak, some black oak, barren hickory, scaly-bark hickory, sweet gum and similar trees. North of Brooklyn I observed numerous willow oak (*Q. phellos*), a tree which I have seen no where else in Illinois. Part of these woods are open, free of undergrowth, and the ground nearly bare of grass; others have a dense undergrowth of the same trees.

That portion of the uplands remains to be described which lies northeast of the above mentioned broken dividing ridge, or, in other words, the uplands in the southern part of Pope county. They differ from the uplands of Massac county, west of the ridge, in that they are underlaid with limestones and sandstone of the lower Carboniferous series, which crop out on all the creeks and frequently form high, abrupt and rocky bluffs on these creeks, and towards the Big Bay and Ohio rivers. Only the very summit of this upland, which continues high to the edge of these bluffs, is underlaid with the Tertiary Conglomerate, and some others of the more recent deposits. This whole district is, therefore, roughly broken, but on the summit of the ridges which extend between the different creeks and branches, there are fine bodies of agricultural lands, the timber on which varies with the quality and depth of the soil. At some points white oak and black oak prevail; at others, black oak and post oak; and where the soil is more shallow and drier, which is the case over a large portion of the ridge, post oak and black-jack are most numerous, together with some barren oak, barren hickory, and trees of an allied growth. At the lower end of the slopes, especially over the limestones referred to, the growth is similar to that of the northern part of Massac county.

I will close this division of the chapter with a few remarks upon the creeks. In the western part of Massac county the water courses are not long, and therefore small. In the eastern part of the district we find some considerable creeks. Those in the last described region, east of the dividing ridge, have mostly narrow valleys, with steep and frequent rocky slopes. Thus the bottom of Robinet creek widens only on its lower course, to an eighth of a

—25

mile, and while higher up it was exceedingly brushy, it is then timbered with fine white oak, red oak (the blue bark variety), swamp white oak, sugar tree, yellow poplar, a few beech, etc. The bottom of Barren creek is only a little wider, and otherwise similar. Dog creek has hardly any bottom land, and at many points has the appearance of a rocky mountain ravine. Along Elkhorn creek softer limestones prevail, and it has, therefore, more bottoms and arable slopes along its course. On the west side of the ridge hardly any rocks are exposed along the creeks, which, therefore, have quite a different character. Massac creek, in its upper course, forms merely a slightly depressed ravine between sloping hills, with a little bottom land, which is generally brushy. Where it has assumed its southern course, the bottom, for a long distance, averages about half a mile in width, is little depressed except below the adjoining uplands, and principally timbered with white swamp oak, water oak, laurel oak, bluebark oak, sweet gum, maple and similar trees. At their mouths most of the creeks emptying into the Ohio river assume the appearance of bayous.

Geological Formations.

The geological formations which outcrop at the surface, in this and the adjoining portion of Pope county, comprise the St. Louis group, and the Chester group of the lower Carboniferous series, and the Tertiary formation. They form the continuation of the same strata already described in the report on Johnson and Pulaski counties. The lower Carboniferous strata occupy, exclusively, that portion of Massac county north of the swamps, and extend across them nearly all around their southern margin, and in the northeastern part of Massac county, and further on, in Pope county, they form the bluffs along the Bay river bottoms, and along the Ohio, and reach several miles inland, southwestward, cropping out on all the creeks of that section. They terminate on the Ohio, near New Liberty, at the upper end of the bottoms of the *Black Bend*. Close to the southwest corner of Massac, in Pulaski county, they are again exposed in the bank of the Ohio, and there can be but little doubt that they extend underground nearly all under the county; but between the two last named points they do not reach above the low water of the Ohio, and have not been struck in digging wells. The Tertiary strata occupy the higher portion of the upland along the southern edge of the swamps and Bay river bottoms, and continue thence uninterruptedly to the Ohio, along the south side of the district, apparently dipping in that direction.

In the report on Johnson county, I have demonstrated that the dip of the lower Carboniferous strata was, with considerable regularity, to north and northeastward. On the whole, it remains unchanged in this district. Below the mouth of Bay river we find, however, one or more faults in this formation; that is, fractures of the strata, combined with relative displacement of the two parts, and a separation of formerly contiguous portions of the formation, whereby the natural sequence of the strata is, of course, entirely disturbed.

The geological formations of the district are, therefore, the following, in descending order:

1. Tertiary formations.
2. Chester group.
3. St. Louis group.

The St. Louis group consists of various limestones, some of which are oolitic. Its exposed thickness may be set down at 75 feet; but its aggregate thickness is undoubtedly much greater.

In order to properly understand the geological structure of the district, it will be well to recall to mind the sections of the strata close to the Massac and Johnson county line, at Indian Point and farther eastward, which I have given in detail in the report of Johnson county, for which see pages 381 and 386 of a preceding chapter.

From this point southeastward, the upland continues capped by the sandstone No. 8, but at the base of the bluffs limestone may be traced, extending to the southern extremity of the upland, in the northwest quarter of section 29, township 14, range 4.

From the cliff measured in the northeast quarter of section 3, township 13, range 3, the strata dip eastward towards Clifty creek, so that on the west side of section 1, only traces of the limestone were observed at the base of the hill, which consisted mainly of the sandstone No. 8. Close to the county line I observed, in the bank of Clifty creek, a ledge of sandstone, and heavy ledges of the same a little higher up the creek. Between these two outcrops I noticed some large slabs of a limestone similar to No. 9, and I am not certain whether these form a local intercalation in the lower part of the sandstone No. 8, or whether they really represent No. 9, much reduced in thickness. South from this point, in the northwest quarter of section 12, I observed considerable masses of sandstone on the bank of the creek, at the edge of a low bottom ridge. I believe this to belong to No. 10 of the Chester series, although it was not represented in the measured sections east of Indian Point. Possibly the rock may be tumbling masses of No. 8.

Southeast from this, on the east side of section 12, the bluffs exhibit considerable outcrops of limestone, and their higher portion consists of sandstone No. 8. The limestone is probably No. 9, with, perhaps, some St. Louis limestone strata at the base. Low bottom ridges between the bluffs and swamps, in sections 12 and 13, and in the adjoining section 18, are undoubtedly underlaid with the St. Louis limestone.

Sandy creek passes through the sandstone No. 8 down to the southwest quarter of section 17, township 14, range 4. Farther south, the sandstone is only exposed in the upper part of the hills, while their base, which is covered with soil, must be underlaid with No. 9 of the Chester series, and perhaps the topmost layers of the St. Louis formation.

The last outcrop of limestone was observed in the northeast quarter of section 30 (?), when the sandstone, in consequence of its dip, reaches down to the edge of the swamp. The limestone seems, however, to continue some miles farther near the water lever—at least, some hard-water springs at the foot of the bluffs, in the southeast quarter of section 16, appear to point to this conclusion.

I have stated before that the St. Louis limestone extends south of the swamps, cropping out at various points round their margin, generally capped by much more recent formations, and probably extending at no great depth all under the western part of Massac county. The first outcrop of an older rock, east of the Pulaski county line, is found at the edge of the swamp in the southwest quarter of section 18, township 14, range 3. It is a small exposure of a quartzose, finely-grained sandstone, probably corresponding to No. 10 of the Chester series, although its precise age can only be surmised, as the rock is found far away from other outcrops, and contains no fossils.

At the bottom of a well, in the southeast quarter of section 19, 25 feet below the surface, much chert was found similar to that derived from some portions of the St. Louis limestone. There can be little doubt but that this formation would have been struck by digging a few feet deeper. The first outcrop of it was, however, found some miles from there, on a slough near Cache river, in the northeast quarter of section 8, township 14, range 4. The rock is about 20 feet thick, partly close-textured, gray, sub-conchoidal and full of nodules of chert, partly crystalline and oolitic. It contains some fossils. Thence, southeastward, I observed more exposures of similar rocks along the edge of the swamps, in the southwest quarter of section 9, in the north part of section 16, near the middle of the south half of section 15, and on a bottom ridge across a slough in the southeast quarter of section 15. A fine large spring, such as we have frequently found in connection with caves and sink-holes of this formation, was noticed near the centre of section 16. The most prominent bluff of this limestone was, however, observed still farther on, east of the centre of section 22. The limestone reaches there to an altitude of 53 feet, and chert continues higher up, indicating that the limestone also reaches higher than it is actually exposed. The rock here is heavily bedded, very compact and not oolitic, but farther south, in section 22, and in the north part of section 27, where the bluff is much lower, we find white oolitic ledges, and above them the gray, close-textured, uncrystalline limestone, with sub-conchoidal and splintery fracture, which has been observed farther north.

Thence on, no more signs of the St. Louis limestone were discovered for several miles. On the rolling poplar hills, near the middle of the west side of section 1, township 15, range 3, I observed a sink-hole, which is an unfailing sign of limestones as sub-strata; and in the northwest quarter of the adjoining section 6, township 15, range 4, a well has calcareous water, which confirms my conclusion that the low ridges about there are all underlaid with this limestone. The next point where it has been actually discovered is, however, farther northeast, in the northwest corner of section 34, township 14, range 4, where, on one of the low bottom ridges, Mr. C. D. Morse dug a well, in which he passed through 20 feet of soil and clay and then 54½ feet of solid gray, sub-crystalline limestone, before he got water.

Two miles farther northeast, in the west part of section 23, township 14, range 4, the sandstone No. 8 forms prominent bluffs at the edge of the swamps. The base of these bluffs is covered with a talus, but some calcareous springs, especially in the northwest quarter of section 23, seem to indicate the presence of limestone at the base of the hills. These may, however, belong to No. 9 of the Chester series. The St. Louis limestone formation then dips underground and is covered by rocks of the Chester series. The next point where it rises again to the surface is 12 miles farther east, on the lower course of Bay river.

Near the middle of section 22, township 14, range 6, in Pope county, three-quarters of a mile below the lower bridge over Bay river, it crops out at the lower end of a ravine near the west bank of the river, only a few feet thick, and capped by a great thickness of the sandstone No. 8. Farther down the river, near the southwest corner of section 23, the limestone has attained a height of 40 or 50 feet.

It continues rising through section 26, where it contains numerous sink-holes, and across a branch into section 35. The rock is partly crystalline and light grayish, partly darker gray in color, and close-textured, with a rather uneven fracture, and resembles equivalent strata in the northwest part of Massac county, only that it is a little more granular in texture. In some portions, an oolitic structure can be recognized. It contains some thin intercalations of shales. Nos. 9 and 10 of the Chester series were not recognized in this vicinity. They have apparently become purely calcareous, and difficult to distinguish from the St. Louis limestone, as also on the Ohio, below Golconda.

At Mr. M. Bird's, near the centre of the southwest quarter of section 26, large masses of a highly cemented sand-rock are found at the foot of the higher bluffs, far below the upper layers of the limestone. They contain crystals of violet fluor spar, a mineral which is not found anywhere else in our State, except farther east in Hardin county, where it forms the gangue of lead veins, and at a few other points in Pope county. It is said that some fragments of galena were found at the same place, but Mr. Bird himself is not fully satisfied of the truth of this statement. I will refer to this question again, under the head of "Economical Geology." The sandstone appears to have tumbled down from the higher hills, and to have escaped disintegration by its great hardness.

The St. Louis limestone does not extend south of the north part of section 35, township 14, range 6. There, it is cut off by a fault which would seem to throw it down on its south side to a depth of several hundred feet. On the east side of Bay river the St. Louis and the lowest Chester limestone continue to form the lower part of the bluffs of the Ohio, capped by the sandstone No. 8, until they dip under the water level a mile and a quarter below Golconda, in the north part of section 31, township 13, range 7; but they rise up again close to the Hardin county line.

South of the fault the strata still dip more or less to the northward. The St. Louis limestone, therefore, reaches the surface again some six miles farther south, opposite the mouth of the Cumberland river. At times of low water some ledges of it may be seen in the bed of the Ohio, above as well as below the mouth of Dog creek, in the southwest quarter of section 34, township 15, range 7; and a mile and a half farther south, at the former site of Hammelsburg, in the northwest quarter of section 10, township 16, range 7, it may be seen in a ravine close to the river, with an exposed thickness of 20 feet. It is there partly the white oolitic rock, partly light gray and very close-textured, with conchoidal fracture and brittle. The higher sandstone is not exposed, but some loose pieces of it strewn on the slope indicate its presence. This is the last outcrop of the limestone, but it has been found in wells farther south and west. Mr. Simpson, in the northwest quarter of section 16, township 16, range 7, struck a thin, shelly sandstone at the edge of the bottom land, at a depth of about 40 feet. It was 4 feet thick, and followed by the limestone, which he penetrated some 10 feet, when he obtained water. In a well in the southwest quarter of section 8, also on low ground, the same sandstone and limestone are struck.

The Chester Formation.—The development of this formation in the district under discussion appears to be the same as in the adjoining county of Johnson, which has been discussed at length. The whole of the Chester formation seems to be represented here, with the exception of the uppermost limestone division, which has probably been carried away by denuding agencies. The facilities for observation are, however, not so good, because the strata are generally overlaid unconformably and covered with much more recent deposits.

In speaking of the St. Louis limestone, I have already described the outcrops of the sandstone No. 10, and of the limestones and shales No. 9 of the Chester series, in the northwestern part of Massac county, along the bluffs on the north side of the swamps, extending from Cache river to the southernmost extremity of these bluffs, and perhaps even into section 16, township 14, range 4.

The main portion of the upland of Massac county, north of the swamps, is underlaid with the sandstone No. 8 of the Chester series. It caps the bluffs near Cache river, at Indian Point; also, in the northeast quarter of section 3, township 14, range 3, the section of which has already been given. In that section it constitutes only the 25 upper feet, but close by it is much thicker, and forms numerous prominent cliffs round the top of the hills.

The upper course of Sandy creek, from Columbia to the southwest quarter of section 17, township 14, range 4, lies exclusively through this sandstone, while farther down the sandstone caps the hills. Near the southern extremity of the bluffs, in section 20, it finally dips down to the level of the ponds, and forms a continuous cliff round their margin, for several miles, about 60 feet high, and increasing in altitude. In section 16, southeast of Columbia, the bluffs are about 120 feet high, the upper 60 feet forming turreted vertical cliffs. The lower portion of these rocks is exposed in the northwest quarter of section 15, on the road from Columbia to the ponds. These lower strata are mostly soft, shaly sandstones and highly arenaceous shales, with intercalations of hard, smooth layers of variable thickness, while the higher cliff rocks are partly so firmly cemented sandstones that their appearance approaches that of quartz rock, and their fracture is irregular and splintery. They are not good building material; while farther west and northwest, strata of this formation contain superior building stones. On the ridge at Columbia we find a heavy bed of nearly pure quartz sand, and of rather fine grain, which is evidently derived from the disintegration of rocks of this formation, and furnishes a superior material for plastering.

These rocks continue farther north, along the edge of the swamps, and then up George's creek, through section 10, the southwest quarter of section 3, and the northeast quarter of section 4, township 14, range 4, to the county line. Their dip, over all this distance, appears to be decidedly to the northward, and new strata succeed above those mentioned before, so that I cannot estimate the aggregate thickness of the sandstone No. 8, in this vicinity, at much less than 250 feet.

At the county line it dips underground, and is overlaid with the Chester limestone No. 7, which, together with the higher sandstone No. 6, form a high hill just north of the line, which I have described in the report on Johnson county. All the upland north of the swamps and west of George's creek, in Massac county, is underlaid with this sandstone. East of George's creek it still forms the swamp bluffs, which are there about 60 feet high, until it suddenly dips underground in the southwest quarter of section 2, and is succeeded by the formation No. 7, which forms the bluffs from this point to the county line, in the northeast corner of section 2, generally with a capping of the sandstone No. 6. These two formations thus occupy only a small area, parts of sections 2 and 3, township 14, range 4. The limestone formation No. 7 was not sufficiently exposed in the bluffs to obtain a good section, but I only noticed, on top of the sandstone No. 8, some heavy beds of shales with thin intercalations of sandstone, forming beds of transition, and then heavy masses of Chester limestone strewn over the slopes. I obtained from the latter some fine specimens of Crinoidea, besides the ordinary Chester fossils.

South of the swamps we find an isolated outcrop of sandstone, probably sandstone No. 8, on a branch not far from the edge of the low lands, in the southeast quarter of section 35, township 14, range 4. Two and a-half miles farther north, at the edge of the swamps opposite to the cliffs near Columbia, and about one and a-half miles distant from them, begins another series of rocky bluffs. In the southwest quarter of section 23, they are mainly, if not altogether, composed of this sandstone, which is there exposed to a thickness of 100 feet. I am inclined to the opinion that there is some limestone at their base, from the nature of some springs issuing at their foot in the northwest quarter of section 23. These sandstones continue in the bluffs through the northeast quarter of section 23, and the southeast quarter of section 14, but in the south part of section 13, the hills grow lower, and the sandstones seem to dip gradually under ground, and to be succeeded by the limestone formation No. 7. In the southeast quarter of section 13, shales are exposed on a ravine, and near the middle of the east line of the southeast quarter of section 13 this limestone itself is exposed in the hillside, reaching from its base to a considerable altitude. It is mostly gray, with bluish and brownish spots, highly siliceous, and contains intercalations of shales. The hill is from 160 to 200 feet high in the southwest corner of section 18, township 14, range 5, and is entirely formed of this limestone formation, with the exception of the highest summit, which consists of the sandstone No. 6. No exposures of the limestone were observed south of the bluffs on the ridge, but at the foot of the bluffs it appears to extend northeastward through section 18. It does not crop out much, and I could trace it only by occasional masses of tumbling rock. Near the southwest corner of section 8 sandstone is quite low down, and on Bear creek, north of the centre of section 8, we find it at the water's edge, soon to be succeeded by a limestone formation, which may be No. 5, or more probably No. 7, of the Chester series. The formations appear to be much disturbed along the lower valley of Bay river, and the subdivisions could not be traced throughout. On the ridge south of the bluffs I found outcrops of the sandstone at various points on the ravines in the northwest quarter of section 19; also, on the head branches of Bear creek, in the northeast quarter of section 19, southeast of section 19, and farther east in the west part of section 20.

From Bear creek eastward, through the northeast quarter of section 8, the bluffs exhibit no rocks; but in the north part of section 9, we find them composed of a limestone formation of great thickness, measuring considerably over a hundred feet, and consisting of mostly grayish, sub-crystalline and siliceous limestones intercalated with shales, with Archimedes, Pentremites and other Chester fossils. An outcrop of part of this formation is illustrated by the following section, obtained in the northeast quarter of section 9, township 14, range 5:

1.	Ledges of limestone, of impure gray color, siliceous, forming the summit of the bluff	15 feet
2.	Steep slope, heavily strewn with tumbling masses of limestone, probably underlaid mainly with shales, perhaps intercalated with some limestone	30 "
3.	Limestone in heavy layers	26 "
4.	Slope, apparently underlaid with shales	21 "
5.	A ledge of limestone, and slope to the level of the bottom lands	10 "

These rocks dip to the eastward, and their last exposure was observed in the northwest quarter of section 10, at a spring at the foot of the hills; but they probably continue in the foot of the hills all through section 10. Back of the bluffs, on the low slopes, near a branch of Bear creek, in the southeast quarter of section 9, these limestones were also struck in a well, at a depth of only 12 feet, and they undoubtedly underlie a large portion of the low upland near Bear creek. The ridge east of Bear creek is, however, capped by a sandstone formation, which overlies these limestones. If these limestones overlie the sandstones in section 8, they would appear to be No. 5 of the Chester series, and the sandstones capping them No. 4; but if it was thus, I failed to find limestones corresponding to No. 7 farther eastward. I therefore suspect that these limestones are really No. 7, and do not overlie the sandstone on Bear creek, in the north part of section 8, but that this rock rises with a local dip above them, so that the sandstone east and west of the limestones is No. 6.

This limestone, whatever its position in the Chester series, is overlaid with a heavy sandstone formation, which forms numerous outcrops around the upper edge of the ridge east of Bear creek, near the southeast corner of section 9, thence extends through section 10, and appears to entirely compose the bluffs in section 11, and in section 12, at Robinet creek, where it forms cliffs 80 feet high. It extends also southward over the ridge near Bear creek, through section 15, and the west part of section 22, and thence to Robinet creek, and occupies the whole valley of the latter creek, from the Bay river bluffs to the head of its branches, forming numerous and nearly continuous outcrops, and many precipitous cliffs, in sections 12, 13, 14, 23, 24, 25, and the northeast quarter of section 26, township 14, range 5, and on more eastern branches in sections 30, 18 and 7, township 14, range 6, to the exclusion, as far as I know, of any other Chester rock, with the only exception of one point at the head of an eastern branch in the east part of section 18. Some of the highest portions of the ridge are covered with Tertiary or post-Tertiary deposits.

East of Robinet creek these sandstones continue to form the bluffs along the Bay river bottom, through section 7, township 14, range 6, but in the southwest quarter of section 8, near Mr. Bazor's, limestone crops out below the sandstone. This limestone contains Archimedes, is mostly gray, siliceous, partly crystalline, partly close textured. It is not much exposed, but would seem to dip to the northwest, so that it overlies the sandstones which compose the bluffs further east. It then would probably correspond to No. 7 of the Chester series. The sandstone farther east is No. 8. The only other point in this vicinity where any traces of limestone were observed, is a mile farther southwest, on the ridge on the east side of section 18. At the so-called Barnum's diggings, the southeast quarter of section 18, where, some years ago, a man prospected for lead ore, the limestone crops out on the slope, of bluish and grayish color, capped with some sandstone. It can only be traced into the northeast quarter of section 18, but is mostly hidden by tumbling sand-rock and by soil.

Below Mr. Bazor's, sandstones were observed in the bluffs, high up and low down, forming a series of bold and picturesque cliffs. It is the sandstone No. 8 of the Chester series, which can here not be less than 200 feet thick. It continues in the bluffs to near the mouth of Bay river, but on section 22 and 26 it only caps those bluffs, while the St. Louis limestone, or No. 9, forms their base.

On the branch which empties into Bay river from the southwest, in the southeast quarter of section 16, township 14, range 6, we find nearly continuous outcrops of this sandstone, from its head to its mouth, in the south part of section 16, the northwest quarter of section 21, and the south part of section 20, and it is exposed also at numerous points in the breaks through the southwest part of this township.

I have stated, in discussing the St. Louis limestone, that this formation was cut short by a fault near the mouth of Bay river. While north of the fault we find this limestone and the overlying sandstone, we observe south of it strata higher in the Chester series than anywhere else in this district, the sandstone No. 2, and limestone No. 3. The fault itself is not exposed, so that these formations could be seen in contact, but is hidden by the surface deposits. South of it, the strata dip again to the northward, as they did north of it, only locally stronger.

On the bend of Barren creek, only a short distance from the mouth of Bay river, in the northeast quarter of section 35, township 16, range 6, and also higher up the creek, on a dry branch in the southeast quarter of section 35, some ledges of the Chester limestone No. 3 run across the bed of the creek, capped, at an elevation of only a few feet, by the sandstone No. 2. This latter crops out also in the bank of Barren creek, in the southeast quarter of section 35, and on the branch in the southwest quarter of section 35, and extends some distance southward in the hills towards Bay City, in the southwest quarter of section 36, and in the northwest quarter of section 1, the north part of section 2, and at other points. The limestone No. 3 continues at the base of the hills towards the mouth of Barren creek, gradually rising. Bay City, on the Ohio, in the centre of the southeast quarter of section 36, township 14, range 6, is built on it. It is there of grayish and bluish-gray colors, partly craystalline, partly semi-crystalline or close textured, a rather impure limestone, alternating with beds of shales, and contains numerous Archimedes, Pentremites, Productus, and other Chester fossils, and is exposed to a thickness of 50 feet, while its actual thickness is probably greater. The bank of the Ohio river, below the limestone, consists of sandstones intercalated with shaly slates which dip strongly to the northward. They contain a seam of carbonaceous shales, with particles of coal, varying between one and three inches in thickness, only a few feet below the lowest limestone. A short distance farther down the river, near the township line, the lowest ledges of this sandstone No. 4 rise above the water level, dipping 45 degrees to the northeast, and a few yards farther on, the next lower Chester limestone, No. 5, rises to the surface at the same dip. It resembles No. 3, contains much spar in consequence of the fissures, which is received by being tilted, and has a considerable thickness; still, in consequence of the strong dip, it occupies only a small space in the bluff before the lower sandstone, No. 6, rises from underneath it, and forms the point of the bluff near the northeast corner of section 1, township 15, range 6. There the dip is all at once changed, and thence down the Ohio to Dog creek and beyond, the sandstone No. 6 forms the bluffs in nearly horizontal position, rising very gradually.

Up Barren creek the formations are also various, but they all belong to the Chester series. The limestone No. 3, although little exposed, can be traced up the creek through most of section 2, township 15, range 6, capped by the sandstone No. 2. In the southwest quarter of section 2 (?) the lower sandstone No. 4 rises from underneath the limestone and soon occupies the whole bluffs. At the forks of the creek, near the middle of the south line of section 3, sandstone forms the bank of the creek, and extends on the main branch to near the east line of section 9, and on Pistol's branch to near the middle of the south line of section 4; but I am not satisfied whether this is all No. 4 or whether there is an intermediate limestone formation No. 5, and the easternmost of the above named outcrops are then No. 6. In the southwest quarter of section 3, where the sandstone is exposed on the creek, I noticed a large mass of tumbling limestone, and the hills, from their shape, would seem to be formed of limestone. If this is so, then we have the limestone No. 5 and sandstone No. 6. Continuing up Pistol's branch we find limestones, probably No. 7, extending through the southwest quarter of section 4 and the southeast quarter of section 5, while the hills are capped with the above mentioned sandstones. On the main branch of Barren Creek the same limestone extends through the south part of section 9, and into the northwest quarter of section 16; also capped by sandstones. The limestones attain a considerable thickness and are of the common Chester type. Some of them would make a good building rock. On the main branch they exhibit numerous sink-holes. The overlying sandstones are also in part a good building rock. Near their junction with the limestones they are, in places, highly ferruginous—sufficiently so to form impure siliceous iron ores; and some of this limonite ore seems, also, to have been formed in the limestone formation, evidently by chemical precipitation from the Chalybeate waters by the lime. These latter ores are by far the purest of the two, but their aggregate quantity seems not to be large. The dip of the strata in this vicinity is towards the east. Just at the county line, at Mr. Shands Golithly's mill, in the northwest quarter of section 16, sandstones form a low outcrop in Barren creek. If we judge from the prevailing dip, this would seem to be the sandstone No. 8, as it would be overlaid by the above mentioned limestone; but in digging a well at the mill heavy masses of limestone are said to have been struck only a few feet below the surface, and apparently in place. Perhaps, then, the sandstone is only an outlier of No. 6 deposited in a denudation of No. 7.

Over the ridge, between Barren creek and Dog creek, sandstones are exposed at numerous points in the breaks, but no outcrops of limestone were observed. Where these pass through they must be covered with ditritus and soil.

We have seen that sandstones, apparently No. 6 of the Chester series, form the bluffs of the Ohio north of Dog creek, in sections 6, 7 and 18, township 15, range 7. Near the centre of the east half of section 7 I found the top of the ridge all underlaid with this sandstone, and in the upper part of the bluff it formed prominent cliffs. The rock is mostly firm, strongly cemented, fine grained, and contained locally particles of calcareous spar. About the middle of the bluff I noticed these shaly intercalations, and with them a mixed areno-calcareous rock, with Archimedes and stems of Encrinites; and lower down the shale seemed to continue to the base of the bluff. The height of the cliff above the bottom is generally between 70 and 80 feet, while the ridge rises higher. Towards Dog creek the bluff is lower and less abrupt. In this district the succession of the strata cannot be as plainly traced as some distance farther north, for causes stated above; besides, there are more local irregularities, strong variations of dip, such as we have found below Bay City, and I believe more faults, which can probably be demonstrated by comparing the strata on both sides of the Ohio.

I observed, on the south side of Dog creek, the following section in the northeast quarter of section 19 (?):

1.	Slope, strewn with sandstones, which are in place near by. Its lower end may be underlaid with shales	50 feet
2.	Cliff of Chester limestone; full of fossils, gray crystalline, hard siliceous	23 "
3.	Slope, with outcropping ledges of limestone	11 "
4.	Slope, apparently underlaid with shales	16 "
5.	Slope, with a ledge of rock at its upper end, which is, however, not exposed, probably limestone	18 "
6.	Slaty, finely-grained sandstone, and arenaceous slate, to the bed of Dog creek	8 "

The whole section measures 126 feet, of which between 50 and 100 are limestones and shales. Sandstones form the entire bluffs of Dog creek farther up in the northwest part of section 19 and in the adjoining section 24, and the east part of section 23, township 15, range 6, as far as any rocks are exposed along the creek. I noticed sandstones, also, on the flat, rather low upland, near the centre of section 19, and they capped the ridge west from there near the east line of section 19, south of the above section. The limestones form few outcrops, but can be traced southward along the bluffs, which are consequently more sloping. They apparently rise in that direction. On the upland, but considerably below the highest ridge, at Widow Neely's, near the southwest corner of section 20, two wells were dug in 1853. One passed through blue shales and a thin streak of black carbonaceous slate down to limestone; the other, at a somewhat higher level, close by the first, passed through limestone to the shales, and did not penetrate to the coal. On the east side of the higher hills, in the west part of section 29, I observed at various points these limestones, and sandstones above them; and it is so, also, on the ravines of Elkhorn creek, in the southeast and southwest quarters of section 30. The Black Slate (some say it was coal) was also found in a well in the southeast quarter of section 30. Lower down that same branch, in the southwest quarter of section 29, heavy outcrops of a sandstone were noticed, which seem to underlie the limestone and to dip to the northward. Farther southeast, on the south side of the wide valley of Elkhorn creek, east and south of the centre of section 32, township 15, range 2, we find again heavy outcrops of limestone, which reach from the bed of the creek to a considerable altitude, interstratified with shales. The rock here is mostly siliceous, sub-crystalline and splintery in fracture —an unmistakable Chester limestone. Sandstone forms the top of the higher hills; and a short distance farther down the creek, in the northeast quarter of section 32, much tumbling sandstone was observed on the bank of the creek, probably from the same ledges which we have found north of the creek, in the southwest quarter of section 29, which seem to rise above the last named limestone. On the lower course of the creek, in the southwest quarter of section 28, its channel is worn 20 deep into sandstones, which exhibit a strong dip to the northward. A short distance southeast from there, in the northeast quarter of the northwest quarter of section 33, at the edge of a low ridge, this sandstone occupies the few uppermost feet, and is partly so strongly cemented that it is flinty. It is underlaid with limestones. Another outcrop of the sandstone is in the bed of the Ohio, in the southeast corner of section 28. There, it dips several degrees to the west of northwest, and is partly highly cemented. Up Elkhorn creek the above mentioned Chester limestones continue from the centre of section 32, through the southwest quarter of section 32 and the southeast quarter of section 31, capped by sandstones; but both are exposed at a few points only. Then sandstones crop out near the creek, in the extreme southwest part of section 31, where they have been quarried to some extent. They continue some distance westward, apparently rising from underneath the limestone. Also, in the northeast quarter of the adjoining section 1, township 16, range 6, some hard sand-rock crops out in the bank of the creek. Close by, higher up on the hills, limestone is said to have been struck in a well, and some tumbling slabs of a highly fossiliferous Chester limestone were observed on the creek. Only the more recent deposits were noticed for some distance up Elkhorn creek, but in the southeast quarter of section 35, township 15, range 6, sandstones were observed on the creek and tumbling on the slopes. South of this creek only the lowest Chester sandstone was noticed above the St. Louis limestone, tumbling near Hammelsburg, in the northwest quarter of section 10, and *in situ* in wells in the northwest quarter of section 16, and in the southeast quarter of section 8, township 16, range 7.

Farther northwest, mostly in the brakes of the dividing ridge, we find a number of scattering outcrops of the Chester strata, and at other points they have been discovered in digging wells. Thus, in the southwest quarter of section 7, township 16, range 7, near the Pope county line, on the road leading west from Liberty, sandstones crop out, and have been quarried on the hillside. West and southwest of the head of Dog creek, in the southwest part of township 15, range 6, there are also numerous small outcrops of this kind. The sandstone forms, usually, uneven, hard and thin ledges. Thus we find it in the south part of section 21, in the middle and southwest parts of section 28, in the southeast quarter of section 27, in the northeast and west part of section 33, and at a considerably lower level on a branch in the southeast quarter of section 32. Near the centre of section 28 slaty shales were penetrated to a depth of 28 feet under a few feet of the sandstone. In the northeast quarter of section 27, on the upper course of a branch, some thin layers of limestone and shales are said to have been struck in a well, at a depth of 40 feet; and limestone has also been found in a well on the undulating flats near the centre of section 4, township 16, range 6, at a depth of 50 feet, but generally, even in deep wells, only Tertiary deposits are found. Near the head of Massac creek the Chester sandstone is also said to crop out, probably in section 35, township 14, range 5, and it is also exposed at a single other point on Massac creek, near its bend in the northeast quarter of section 7, township 15, range 5, some distance below the forks, extending a short distance along the creek. Its whole exposed thickness seems to be hardly more than 25 feet, and much less in each single outcrop. The ledges are usually hard, uneven, partly thin, partly heavy. Some of it has a porous texture, and can be wrought tolerably well for building purposes.

No other outcrops or traces of the Carboniferous formation have been discovered south and west of those last enumerated.

Tertiary and Post-Tertiary Formations.—These formations occupy by far the largest portion of the upland between the Ohio and the swamps. Most prominent we find in this district the conglomerate of siliceous pebbles, with ferruginous cement, commonly called cement rock, which seems to cap the dividing ridges, and thence to dip southwestward to the Ohio. Besides, we find immense quantities of the same pebbles uncemented, in many instances apparently moved from their original position, and re-deposited in the waters at a later period. The shales and other lower Tertiary strata, which we found exposed in Pulaski county, are seldom found in this district, except in deep wells.

In the hills on the Ohio, in Pulaski county, just west of the Massac county line, I observed gray potter's clay, white micaceous and arenaceous shales, or rather fine micaceous shaly sand, coarser sand and siliceous pebbles, and fragments of the Conglomerate. Continuing eastward into Massac county, we find, on the most sharply broken points of the ridge, flint gravel and pieces of the Conglomerate, and on the river bank escarpments of gravel, frequently mixed with more earthy material, evidently in its present form a Quaternary deposit, but then through sections 8, 16 and 15, township 15, range 3, as far as Fletcher's Landing, in the southwest corner of section 14, whenever the banks rise vertically, they consist of an arenaceous silt or sandy loam, of yellowish buff or whitish colors. The low water beach is in many places strewn with pebbles and Conglomerate.

At Fletcher's I observed a small outcrop of the Conglomerate in the river bank. The *Little Chain*, a rocky shoal, which extends across the Ohio, on the southwest quarter of section 19, and the northwest quarter of section 30, township 15, range 4, is formed by the Conglomerate, which also covers the bank there in large, tumbling masses. At this point, and farther east, I noticed, along the pebble-covered beach, a continuous succession of springs of copperas water, which certainly indicates the presence, at that level, of the Tertiary argillaceous shales and clays, which contain considerable sulphuret of iron, as we have stated in the report on Pulaski county. The higher bank shows, in many places, traces of white, shaly sand, mentioned above. Thus it continues across Five Mile creek; and farther on, towards Metropolis, we still find several such springs.

Metropolis is situated in the southeast quarter of section 2, township 16, range 4, extending into the southwest quarter of section 2, the southeast quarter of section 1, and southward to the Ohio, into sections 11 and 12. The low hills rise gently from the river, and have a flat top. In places they are strewn with gravel, and fine yellowish sand is exposed at several points near the town. It is probably Quaternary here, although similar sand has been found inter-stratified with the Tertiary shales.

On the Ohio, just above Metropolis, in section 12, is the site of old Fort Massac. Nearly all through that section, and extending a short distance across the range line, we find the Ohio low bluffs mainly consisting of the ferruginous conglomerate of siliceous rounded pebbles. It reaches a thickness of about 30 feet, and begins some distance above the low-water level. The siliceous material is of all sizes, but most of it is below the size of a hen's egg. The proportion of iron, although the rock derives its brown color and firmness from it, is generally quite small. The Conglomerate varies in hardness, and is intercalated with narrow seams of a much finer-grained material, a ferruginous sandstone. The base of the Conglomerate is nowhere exposed, but we may infer the presence of the Tertiary shales from numerous springs of chalybeate (copperas) water, which ooze out at the same level, evidently above a stratum which is impermeable to water, and forms a yellow scum on the low-water beach. Above the Conglomerate we observe a slightly indurated, white, yellowish or brownish quartz sand, which is rather finely grained, sharp, and contains some pebbles. An outcrop near the east line of section 12 has the appearance of the white, micaceous, shaly sand mentioned above.

Above the mouth of Massac creek, in the east part of section 7, and in section 8, township 16, range 5, the uplands along the Ohio barely reach above high-water mark. There the soil and sub-soil forms a vertical escarpment of a few feet in altitude, while the Conglomerate crops out in the beach at seasons of low water, and the copperas springs ooze out below it. I also observed small outcrops of the Conglomerate east of the mouth of Seven-mile creek, in the southwest quarter of section 9, and the northeast quarter of section 16. There the banks are so low as to be overflowed, and grow still lower in section 15, where they are more sloping and show no outcrops. In section 14 the banks are steeper, but not higher, and we occasionally find a piece of the Conglomerate.

Brooklyn, in the southwest corner of section 13, township 16, range 5, is built on the only point, within a distance of several miles, which reaches a few feet above high-water mark. It evidently owes this advantage to a base of solid Conglomerate. Although the latter does not crop out *in situ*, it is found in large tumbling masses on the gravelly beach, which is surmounted by a vertical clay bank. Above Brooklyn, the wide bottoms begin, and the formation is decidedly alluvial.

Off from the river, in the western part of the county, we find the siliceous gravel, the same of which the Conglomerate is composed, over most of the uplands, and exposed on the higher ridges and on steep points; but of the Conglomerate, I only noticed fragments. Thus we find it at numerous places in range 3, as well on the sharp ridge in township 15, range 3, as farther north in township 14, range 3. Even where the lower Carboniferous limestones crop out, the higher points are strewn with gravel. In digging wells, sometimes the Tertiary shales are struck. Thus a well in a low situation in the northwest corner of section 34, township 14, range 3, not very far from a point thickly strewn with the gravel, passed through 15 feet of soil and yellow clay, 10 feet of hard red sand, then about 10 feet of coarse gravel and pebbles, then shales and clay a few feet thick, and finally into what appears to have been the white micaceous shaly sand. On a high point in the northwest quarter of the same section (34), I noticed numerous pieces of the Conglomerate, together with some sandy limonite (brown hydrous oxide of iron), and lower down, near by, much of the gravel.

Numerous pieces of the Conglomerate were also observed on high steep hills south of the swamps, in the southeast quarter of section 1, township 15, range 3, and vicinity, and farther east, especially in sections 4 and 9, township 15, range 4, while on the uplands farther south toward Metropolis, outcrops are scarce on account of the undulating character of the land, and only banks of gravel were noticed now and then.

In section 2, township 15, range 4, I found pieces of ferruginous sandstone, which evidently originated from the same formations. A well dug in the centre of that section, on a low ridge, passed through about 12 feet of soil and yellow clay, 12 feet of red sand, hard to dig, then gravel and sand, then plastic clay, more sand and gravel, and was finally abandoned in sand. It must have reached the Tertiary strata.

The ridge begins to form a marked summit in this vicinity, beginning with a prominent gravelly knob in the southeast corner of section 11, whence it extends northeastward. In the south part of section 1, it shows conspicuous cliffs of the Conglomerate, and the latter caps the sharply broken dividing ridge north of Massac creek, in section 31, south part of section 30, sections 29, 28, 27, south part of section 22, and in section 26, township 14, range 5. It extends north of these summits over the ridge close to the swamps, where I found it in large masses, in the northwest quarter of section 17 and the northeast quarter of section 18; but perhaps it is not in place there now. I noticed it, also, at various points between Bear creek and Robinet creek, although the main body of that ridge is formed by the Chester formation. South of the main dividing ridge, towards Massac creek, I observed only tumbling pieces of the Conglomerate. A well dug in the northeast corner of section 33, on the gentle slopes near Massac creek, passed 60 feet deep into various layers of sand, gravel and clay; and a cistern on the main ridge, close to the Pope county line, near the centre of section 26, was excavated in the white micaceous shaly sand. On the upper course of Massac creek, in section 35, I found the bluffs in places rather high and steep and strewn with Conglomerate, with which I noticed, also, pieces of a highly ferruginous sandstone, apparently corresponding to similar rocks at Fort Massac.

The main dividing ridge changes its course at the head of Massac creek to the southeast, and continues quite sharply broken and capped with the Conglomerate by the heads of the Seven Mile creek, Barren creek, Dog creek, George's bayou and Elkhorn creek to near New Liberty, on the Ohio.

We find it thus in section 6, township 15, range 6, but more characteristically farther south and southeast in the east part of section 7, in the east part of section 18, in sections 8, 17, 20, 21, 22, part of 16 and 15, through sections 28, 27, 26, 25, in the northeast quarter of section 34, part of sections 35 and 36, all of township 15, range 6; then in part sections 2 and 1, township 16, range 6; and in section 30, township 15, range 7; and in section 6, north part of section 5; and in sections 4 and 9, township 16, range 7. The main body of this ridge is formed of the lower Carboniferous formation, which crops out at various points at its base and high up towards the summit; but the summit itself consists invariably of the Conglomerate. The latter extends at numerous points eastward from the main ridge, on the minor ridges between the smaller streams, to the river bluffs. I thus noticed it much over the older rocks, in the southwest part of section 14, range 6, between Robinet creek, Bay river and Barren creek, then between Barren creek, the Ohio and Dog creek, and between Dog and Elkhorn creeks. On the hills west of Hammelsburg, on the Ohio, on the east side of section 9, township 16, range 7, the Conglomerate has been struck, in solid strata, in wells, while flint gravel covers the slopes near the river. No signs of Tertiary shales, or other strata than the Conglomerate and gravel beds, have been discovered on these ridges south of the head of Massac creek, above the lower Carboniferous formation. On Elkhorn creek, between the outcrops of the latter, in the southwest quarter of section 36, township 15, range 6, I noticed, however, heavy deposits of sand, apparently of Tertiary age, but perhaps re-deposited in the Quaternary period, from which issues a small spring of copperas water, which may be derived either from Tertiary or Carboniferous strata in the hillside.

The district between Massac creek, the dividing ridge and the Ohio bottoms, is undoubtedly underlaid with Tertiary strata; but the surface configuration of the country, which gradually slopes from the ridge towards Massac creek and the Ohio, together with the facility with which these strata disintegrate, prevent their forming outcrops. The only information of the composition of the sub-strata is obtained in digging wells, because the beds of gravel which we notice occasionally might be derived from the Conglomerate on the ridge, and are certainly most, if not all, of Quaternary origin. Thus we find a gravelly beach all along the northern edge of the wide bottom of the *Black Bend* of the Ohio, where there is an ascent of a few feet to the upland.

On the gently rolling land east of Massac creek, in the southwest part of township 15, range 5, water is generally struck between 40 and 80 feet deep, the wells passing through yellow clay, then gravel and sand, and finally clay and sand.

Near the upper course of the south fork of Massac creek, on the low uplands in the southwest part of section 11, township 15, range 5, a well was dug to the depth of 110 feet, through sand, gravel, gray micaceous shale and other Tertiary strata, and no water was obtained.

Some miles southeast from there Mr. Sidner dug a well, in the southeast quarter of section 24, township 15, range 5, on the west side of Seven-mile creek and a few feet above its bank. He passed successively through yellow clay, gravel, then the white shaly sand, and finally dark colored shales with streaks of sand. Through these latter he passed 35 feet deep, and then abandoned the work at a depth of 75 feet, without having obtained water. The lower strata were unquestionably Tertiary.

A mile and a half farther east, on much higher ground, in the southeast corner of section 19, township 15, range 6, a gentleman dug at four different points, from 60 to 90 feet deep, without obtaining water. It appears that he did not strike the dark colored shales at that depth. Others, who obtained water in such deep wells, found it frequently much impregnated with copperas and other salts, which make it unhealthy.

Some miles farther south, probably near the middle of the east line of section 1, township 16, range 5, Mr. Willis dug 104 feet deep, and found nearly the same strata as Mr. Sidner.

Still farther southeast, Capt. Wood dug a well in the southwest quarter of section 9, township 16, range 6, to a depth of 62 feet. He passed through 14 feet of soil and yellow clay, 3 feet of gravel, then blue clay, slaty clay and pipe clay. The shaly white sand he struck at 44 feet, and found it 8 feet thick; then followed pipe clay, and finally gravel. In other wells of that vicinity dark colored shales were also found.

I might add more data, but these are amply sufficient to show that this whole district is underlaid, at some depth, with Tertiary strata.

Economical Geology.

Coal.—The coal bearing portion of the Carboniferous formation does not extend to this district, and there is, therefore, no prospect of finding stone coal. The thin streaks of carbonaceous matter which have been discovered at a few points in the Chester group, have induced many to think that paying seams of coal might be discovered by digging after them; but this hope is entirely futile. In relation to the prospects of finding coal in such formations, I refer to what has already been said in the report on Johnson county.

In Pulaski and Alexander counties the Tertiary shales contain traces of lignite, which are, however, likewise unpromising. In Massac county no such traces have been discovered, and the strata are so little exposed, that searching for this lignite would be expensive, with very little prospect of any practical results whatever.

Minerals.

Lead Ore.—There has been, at times, a good deal of discussion amongst the inhabitants in relation to the prospects of finding lead ores. Some loose fragments of galena have occasionally been picked up on fields northwest of Liberty, near the Ohio, on a low ridge at the edge of the swamps near Sandy creek, and at a few other points; but undoubtedly these pieces were dropped there by the Indians or early settlers who brought them from distant points for making bullets. Nearly all over the State, an occasional piece is thus found. The geological formation at these points is not favorable to lead bearing veins, and if the ore originated from the disintegration of lead bearing rocks in the vicinity, such pieces would not be found in the upper stratum of the soil, but deeper down on top of the bed rock.

At other points particles of calcareous spar in the Chester limestone have induced persons ignorant of practical mineralogy to suppose that they saw infallible signs of lead ore, while this spar in fact formed only part of petrefactions, or in some cases had been formed in crevices of the rocks in consequence of their fracturing by upheaving forces. The latter is the case a short distance below Bay City, on the Ohio. Sometimes swindlers, in a small way, may have worked upon the imagination of the owners of the land, in order to victimize them. Thus lead ore has been supposed to exist in the bluffs of Bay river, near the middle of the south line of section 8, township 14, range 6, and on a branch of Barren creek, in the southeast quarter of section 5, township 15, range 6. At the so-called Barnum's diggings, in the southeast quarter of section 18, township 14, range 6, even a shallow shaft was sunk into the Chester limestone, from which a few small particles of iron pyrites were obtained. A similar attempt was made near the centre of section 28, township 15, range 6, where they penetrated sandstones and shales of the Chester formation over 30 feet deep, with a similar result. On Robinet creek, in the northwest quarter of section 13, township 14, range 5, another man wasted much labor in sinking in sandstones of the Chester series. The only point where I have seen any indications which may lead to the discovery of a lead mine, is at Mr. Bird's, near Bay river, a mile above its mouth, in the southwest quarter of section 26, township 14, range 6. There we find large masses of the Chester sandstone No. 8, apparently tumbling, which must have been in place formerly at a higher point of the bluff, the base of which consists of the St. Louis limestone. These sandstones are highly cemented in consequence of some metamorphic action, which was probably contemporaneous with the formation of the crystals of fluor spar which are here disseminated through them. The formation is similar to that at the Rosiclare mines on the Ohio, in Hardin county. The fluor spar is not found anywhere in the State, except in connection with the lead ore in Hardin county, and at a few points in the eastern part of Pope county, where there are also traces of galena.

The existence of the fluor spar, as well as of the lead ore, depends, probably, upon extensive fractures of the entire rock formations, and although they do not probably fill the deep veins thus created, still I consider them as dependent upon these fissures. There appears to be such a fault near the Rosiclare mines; and we have seen that there is one at the mouth of Bay river. The fluor spar need not, necessarily, be accompanied by lead ore. It is said that some fragments of lead ore have also been dug up at Mr. Bird's, but the report is not sufficiently substantiated. It would be rather surprising that no more mineral should have been found amongst the rocks, if there was a vein of it. In order to test its existence excavations of the surface material along the bluff would be required, which should be made, not at random, but according to the well established rules which mining engineers follow in testing new ground.

Iron Ore.—Iron is extensively disseminated through the rocks of this district, but its ore is generally thoroughly mixed with silex, which not only reduces its percentage of iron, but what is far worse, damages its quality for smelting. The Conglomerate, of which I have spoken in the preceding chapter, owes its solid character principally to the iron, without which it would be merely a bed of pebbles. Still, the percentage of iron in it is generally small. Some sandstones connected with this Conglomerate, and with the lower strata of the Tertiary formation, contain much more iron, so that they may be looked upon as very impure, sandy iron ores, and so, also, some portions of the Chester sandstones; very little iron gives, however, to the rocks a dark color, and it is exceedingly doubtful whether such rocks could ever be profitably smelted. The richest might perhaps be used in conjunction with pure and rich ores, if convenient to a furnace, but as these rich ores are wanting, the poorer ores cannot be worked to advantage. I noticed such ferruginous rocks especially in the northwest quarter of section 34, township 14, range 3, in the northwest quarter of section 17, township 14, range 5, at some points in the bluffs on the Ohio, on a branch of Barren creek, in the southeast quarter of section 5, township 15, range 6, and in the southeast quarter of section 30, township 15, range 7.

Near Golithly's mill, on Barren creek, and also in part at the above mentioned branch of the creek in section 5, I observed much richer iron ores, a brown hematite of fair quality. This ore appeared to have been formed by the chemical action of the Chester limestones upon percolating chalybeate waters. The shape of the loose pieces of ore, strewn over the slope, would seem to indicate that they did not form part of a large mass of ore, but were, rather, disseminated through pockets in the rock. Some excavations will have to be made before this question can be settled positively. A bed, or probably bunches or pockets of ore, might perhaps be found at the junction of the limestone with the overlying sandstone.

On Elkhorn creek, in the northeast quarter of section 1, township 16, range 6, on a knob of Conglomerate, I noticed highly ferruginous masses of rock, and on the slope highly ferruginous sandstones, and a heavy mass, very rich in iron, perhaps of similar origin as those at the above named mill. The iron ores in this whole district seem to originate from the Ter tiary period, when they were deposited as sulphurets, and by gradual oxidation changed into sulphates, aud permeated other strata, when they were still further changed to hydrous oxids.

Other Minerals.—As far as I could ascertain, no other minerals have been discovered in this district besides those already mentioned. Where the fluor spar, in connection with the lead ore, is found in sufficient quantity and purity, it may be sold for the manufacture of hydro-fluoric acid which is used in the mechanical arts. The sulphuret of iron is found in large quantities, disseminated through some of the Tertiary beds, but it is worthless.

Mineral Springs.—Of mineral springs, we can only mention the numerous small springs of copperas water along the Ohio beach, of which I spoke in connection with the Tertiary formation, and a similar spring on Elkhorn creek. They are of no economical or medicinal value.

Building Materials.

Most of the sandstones of the Chester formation, which in other districts are partly very fine building rocks, are here mostly too hard and uneven, and cannot be dressed with sufficient facility to form desirable building rocks. At some points, however, tolerable good sandstones have been found, and by proper search they might probably be discovered at other places. Various beds of the Chester limestone will do pretty well as building stones, and the St. Louis limestones can be used to advantage. Those near the Ohio can be dressed easily, are durable, and look finely. In most parts of the district good brick could be easily obtained. Most of the Chester limestones are two impure to make a good lime, but some can be burned to advantage, although the lime is not white. Some of the St. Louis limestones are better adapted for making quick-lime.

Sand for plastering is obtained at numerous points, as well from the Chester limestones as from the more recent formations.

The Conglomerate and the strata of pebbles make the very best road material, and can be obtained in all parts of the county, while the white, fine, shaly sand furnishes, in some places, a superior polishing material. The Tertiary shales and potter's clays are not found in this district near enough to the surface, as far as we know, to be available, although they undoubtedly extend into Massac county.

Agriculture.

In the chapter on the surface configuration of this district, I have discussed in detail the character of the land in different sections of this county, together with its growth of timber and quality of soil, so that I may refer the reader to those pages. Although there are some dry and rather poor sections to be found, the average quality of the land is such that, if properly cultivated, it will rank amongst the better lands of our fertile State, and some portions cannot be surpassed by any others in the State. In some districts it is difficult to obtain water, and wells of over a hundred feet deep are dry. This is a serious disadvantage. It is easy to procure water for the household use by digging cisterns, but it is a drawback in the management of stock.

Indian Remains.

I cannot close these remarks without inviting the attention of archæologists to the Indian Mounds on Sugar-camp lake, in the *Black Bend* of the Ohio. I did not visit them personally, but from the accounts received, there seem to have been extensive fortifications and mounds, which probably belong to the same class as those in the Mississippi bottom opposite St. Louis, and at other points farther up the Ohio. My authority is Mr. Simpson, who lives near New Liberty, not far from the Ohio. He came there with the first white settlers, in 1809, and is satisfied that they could not have been made by the Indians who then lived in this vicinity. They would, therefore, seem to be of much greater antiquity.

NOTE.—The term "conglomerate," used by Mr. ENGELMANN in his report on this and Pulaski counties, does not refer to the Carboniferous conglomerate, but to the ferruginous Tertiary conglomerate of those counties. A. H. W.

CHAPTER XVII.

POPE COUNTY, NORTH OF BIG BAY RIVER.

By Henry Engelmann.

Pope county is bounded on the east by the Ohio river and Hardin county, on the north by Saline county, on the west by Johnson and Massac counties, while at the south end it comes to a point between the Massac county line and the Ohio. The northern portion of the county is separated from its southern extension by the Big Bay river, which enters the county near the southeast corner of Johnson county, and thence runs east and southeastward to the Ohio. In connection with the report on Massac county, I have already discussed the geology of the southern part of Pope county, which forms a narrow strip of land between the Bay and Ohio rivers and Massac county, to which latter it would seem naturally to belong. In the following pages, I propose to describe the northern portion of the county, and I will apply the name of Pope county, generally, to that northern portion, without further qualification.

Northern Pope county embraces ranges 5 and 6, and the western two-thirds of range 7, east of the third principal meridian, in townships 11, 12 and 13, south of the base line, except a few square miles cut off by the Ohio and Bay rivers, and also some sections in range 6, township 14, in the fork of these two streams. It contains about 277 square miles, all of which is heavily timbered, hilly, and more or less broken. Through its extreme northern portion, in a direction a little north of east, extends the high dividing ridge which forms the water-shed between the tributaries of the Saline river, which runs northward, and the water courses running southward more directly toward the Ohio. The hills extend southward to the bluffs of the Ohio and Bay rivers, and there are no extensive alluvial bottom lands.

The geological formations in Pope county are the same which prevail over Johnson county, and its surface configuration, growth of timber and quality of soil are closely related to those of that county. The Coal Measures proper do not extend into Pope county, but we find, at various points, outcrops of the thinner and more irregularly developed coal seams of the Conglomerate, which attain some local importance, and also some thin streaks of coal and carbonaceous matter, in the underlying Chester formation. Iron ores are extensively distributed through this county. They are mostly rather impure, and not near enough to the deposits of stone coal to be worked at present; but they will certainly become valuable in the course of time. Lead ore has been discovered at various points. The chances of its successful exploitation will be discussed under the head of Economical Geology. A superior material for queensware has also been found, and quite a number of chalybeate springs were observed, some of which have attained some local celebrity.

Surface Configuration.

The surface configuration of Pope county is analogous to that of Johnson county, and closely connected with its geological formation. The rocks are alternations of bodies of sandstone, limestones and shales. The sandstones withstand disintegration with considerable force; they form more or less wide and level ridges, and deep and narrow valleys, with steep slopes, which are frequently interrupted by boldly outcropping ledges of rocks, of considerable thickness. The limestones and shales, on the contrary, form more rolling and often gently sloping hills, and open arable valleys. The dip of the strata, in part of the county, is northward; in another portion westward and northwestward. Traversing the county in these directions, we find, therefore, a succession of high ridges, mostly gently sloping, with the dip of the strata to the north or northwest, and presenting abrupt declivities to the south and southeast; they are generally capped with ledges of sand-rock, while the lower slopes are frequently underlaid with shales and limestones, and are much less steep than the upper ones. Each successive ridge is generally formed by a formation higher or lower, in the geological series, than that of which the preceding and following ones are composed. The water-courses sometimes run parallel to the trend of the strata, and continue for long distances between the same ledges of rocks; sometimes they break through the strata, at considerable angles to their trend, and form cross valleys. The northwestern portion of the county, near the head waters of Big Bay river and Lusk creek, is entirely occupied by the sandstones of the Conglomerate, and are roughly broken, far more so than most of the other portions of the county, although high hills and cliffs extend south to the Ohio and Bay rivers, and continue across the latter. The soil in the ridges and on the slopes is generally a yellow sandy loam, such as we have described in Johnson county. It sustains a fine growth of white oak, black oak and hickory, much mixed, on the more calcareous tracts, with the yellow poplar. The agriculturist will perceive that this soil must be rich and strong, and that, with proper tillage, this district will rank high amongst the rich agricultural lands of our State.

Geological Formations.

The geological formations of Pope county correspond to those of Johnson county, which have already been described in detail. They all belong to the lower division of the Carboniferous period, to the Conglomerate, Chester group, and the St. Louis limestone. The Coal Measures proper do not extend into Pope county, but the Conglomerate contains several thin strata of stone-coal in this county, and the Chester group still thinner seams, which latter are, however, of interest only to the student of geology, and of no practical value. In the northwestern half of Pope county the strata form the undisturbed continuation of those of Johnson county, being moderately upheaved, and dipping generally a few degrees to north or northwest. More violent disturbances have taken place farther southeast, by which the continuity of the strata has been partially destroyed. A fault passes diagonally from southwest to northeast, through the northern part of this county, from near the southeast corner of Johnson to the northwest corner of Hardin county, and continues farther into Saline county. The strata visibly affected by this disturbance are the Conglomerate and the Chester group. Northwest, as well as southeast of it, the strata dip, generally, to the northwest or north. Over a considerable distance it appears to form a regular fault, the southeastern portion having slid down several hundred feet. At other portions of the line the disruption of the strata appears to have been less complete. There a violent uplift only seems to have taken place over a narrow space, whereby the lower strata have been brought to the surface in a narrow anticlinal fold. The strata on the summit and southeastern flank of the fold, which were considerably fractured and disrupted, have subsequently been disintegrated and eroded to a greater or less degree, leaving the lower strata exposed. The rocks on the northwestern flank of the fold, the dip of which corresponds, in direction, to the general dip of the formation, show very little apparent disturbance. In consequence of this fault the Conglomerate occupies the northwestern part of the county, and another band of the same rock appears in the southeast, passing diagonally across it and surrounded by outcrops of the Chester strata.

In the southwest part of the county, near Big Bay river, the strata dip northward. Along the Ohio, above the mouth of Bay river, the dip is north of west, and along the east line of the county the dip is westward. This last change is caused by an upheaval in the western part of Hardin county, where, near the southeast corner of township 11, range 7, some upper Devonian rocks are thrust to the surface at a point from which the strata dip for miles in every direction.

St. Louis Limestone.

The St. Louis limestone occupies only a small area in Pope county, near the Hardin county line, east of Grand Pierre creek, and, perhaps, at the base of the Ohio bluffs, below Golconda. At the former point it occupies about one square mile, in the southeast quarter of section 22, and the east part of section 27 and 34, township 11, range 7, rising eastward from underneath the sandstone No. 8 of the Chester series towards the above mentioned centre of upheaval in Hardin county, which it surrounds from all sides. This rock is readily distinguished from the Chester strata, Nos. 9 and 10 of which seem to be wanting here, so that it is directly overlaid by the sandstone No. 8 of the series. Its aggregate thickness reaches several hundred feet, but only its upper portion is exposed in Pope county.

The St. Louis limestone, at this point, is of pure bluish or pale grayish colors, partly compact and of a close, finely and evenly grained texture, partly sub-crystalline, and much of it coarsely crystalline. Some of the layers, especially in the lower division of the formation, are darker blue and full of concretions of chert. Fragments of the latter fill the bed of all the ravines and branches, and thus afford a characteristic sign of the presence of this formation.

On the Ohio the Chester sandstone No. 8 forms the bluffs near the east line of the county, but the St. Louis limestone, or else the limestone No. 9 of the Chester series, must reach close to the surface at their base. Limestones rise gradually above the low-water line of the Ohio, a mile and a half below the mouth of Lusk creek, below Golconda, and soon become more prominent, and form the base of the bluffs, the more conspicuous summit ledges of which consist of Chester sandstone. They thus continue to the Bay bottom, and appear to descend underneath the water level a short distance below the lower Bay ridge, near the north line of section 22, township 14, range 6, rising again and forming conspicuous outcrops on the west side of Bay river.

These rocks, in the Ohio bluffs, differ considerably in their lithological character and general appearance from the Chester limestones. They are whitish or light bluish, partly coarsely crystalline, and rather purely calcareous, partly close-textured, splintery in fracture, and full of concretions of chert. I noticed in them no Archimedes, but numerous *Pentremites*, such as *P. godoni* (HALL), and other Chester fossils. They are generally badly preserved. I did not get any from the lowest layers of these outcrops between Golconda and the Bay river, and can therefore not say positively how thick this Chester limestone No. 9 is in this vicinity. To judge from the exposures near Rosiclare, I would expect the Chester limestone to be thick (at Rosiclare it measures 100 feet), and not to find the St. Louis limestone above the Ohio level in these bluffs.

The Chester Group—Lower Division.

I have shown in the foregoing pages that the lowest members—Nos. 9 and 10 of the Chester series—do not appear to be developed in the northeast of Pope county, near the Hardin county line, although their representatives may yet be found there, but that they crop out on the Ohio, below Golconda, as the lowest strata in the bluffs between Lusk creek and Bay river, which are capped by the sandstone No. 8 of the Chester series. These strata there are differently developed, and present a different lithological appearance from those described as No. 9, in Johnson and the adjoining counties, of which they form the continuation. Their lithological character exhibits a far greater affinity to the St. Louis limestone, from which they cannot readily be separated here, except by their fossils.

The sandstone No. 8 holds a prominent position, and attains a thickness of probably 250 feet, where it is best developed. It is generally a more or less fine-grained, siliceous sandstone, mostly of whitish or light yellowish-brown colors, often full of minute brownish specks from oxide of iron. It sometimes forms heavy, massive layers or breaks in thin, smooth or irregular slabs, and is generally well suited for ordinary building purposes. It occupies a narrow area on the east side of the county, between the Hardin county line and Grand Pierre creek, as far as it is not taken up by the above mentioned outcrops of the St. Louis limestone. From the large bend of Grand Pierre creek, near the county line, in the southeast quarter of section 15, township 11, range 7, half a mile below the mouth of the East Fork, southward to the Ohio, this sandstone occupies the east side of the creek, dipping westward, while higher Chester strata form the bluffs on the west bank. The Stockton ford of Grand Pierre, at which some galena has been discovered, in the southwest quarter of section 22, township 12, range 7, is also formed by this sandstone, which there reaches to the west side of the creek. It extends, also, half a mile up Little Grand Pierre, forming several fords in the northeast quarter of section 33, township 12, range 7. On the Ohio it forms prominent bluffs, from the Grand Pierre to the Hardin county line, and also for about a mile below the mouth of that creek; but then it dips underneath the low-water level, below the Rock Quarry landing, in the middle of the west half of section 4, township 13, range 7. The higher Chester strata form the bluffs of the Ohio from this point to the mouth of Lusk creek, above Golconda; but the sandstone reappears underneath them half a mile above the mouth of Lusk creek, near the south line of section 18, township 13, range [illegible], and may be seen at various points from there to Golconda, at times of low water. It becomes prominent again below Lusk creek, at Golconda, where it rises rapidly into a high cliff, and continues as the most characteristic formation, capping the Ohio bluffs to the Bay river bottom, into the north part of section 23, township 14, range 6, while a mile and a quarter below Lusk creek the lowest Chester limestone rises above the low-water mark, and, thence on, occupies the base of the bluff.

Back of the Ohio this sandstone extends a short distance on the south bank of Lusk creek; then it occupies the ridge back of the river bluffs, towards Mill creek, on the east side of which it can be traced through the eastern portion of section 35, township 13, range 6; and the sandstone in the south part of section 3, an the southwest quarter of section 3, township 14, range 6, at the edge of Bay river bottom, would still seem to belong to this formation, which appears to dip underneath to the water level of the Bay in the north half of section 8, but is not exposed there. On the south side of Bay river this sandstone forms thebluff as far up as section 8.

The Chester Group—Upper Division.

The study of this part of the formation was rendered somewhat difficult by the various upheavals and faults of which I have spoken above, and which cause, at many points, an abrupt alternation of the formation. Still, after having once discovered the true character of these disturbances, I was enabled to trace the different sub-divisions of the Chester series with a considerable degree of exactness. The section which is given of them, in my report on Johnson county, seems, however, not to answer altogether for their development in Pope county, especially in the eastern part. The lowest limestone—No. 7 of the series—seems to retain the thickness and general character which it presented in Johnson county, but not so the higher numbers, especially the sandstone No. 2, which appears to become reduced to a few feet in thickness, so that the limestone Nos. 1 and 3 are sometimes exposed in the same slopes, without a very noticeable interruption. Such a change cannot surprise us in a formation which consists of such numerous alternations of entirely different rocks, each of which demands for its formation a complete change of conditions, including the depth and extent of the ocean, the proximity and elevation of the dry land, etc.; and that such changes of level have actually and repeatedly taken place during the Chester period, is, moreover, placed beyond doubt, by the thin seams of coal which we observe in various parts of the formation, and which required for their formation a very shallow stage of the water, or rather marshy flats, as they are undoubtedly formed by the accumulation of a swamp growth of plants, while the sandstones contain some remains of similar plants; but the limestones above and below them contain exclusively marine shells, which could only have lived and been deposited in the ocean.

The upper division of the Chester series, between the sandstone No. 8 and the Conglomerate, occupies a considerable area in this district, west and northwest of the above mentioned outcrops of sandstone, extending to the main bluff ridge of the Conglomerate, in the northwestern part of the county, which stretches from a short distance northwest of Glendale to near the northeast corner of the county. Within this area, however, the above mentioned fault occurs, which runs diagonally from northeast to southwest, through nearly the whole county, and on the southeast side of which the Conglomerate again occupies a prominent ridge, locally several miles in width, which, of course, diminishes the area of the Chester group.

This ridge is the one which begins west of the mouth of the east fork of Grand Pierre, and forms the dividing summit between that and Little and Lusk creeks, with an abrupt eastern edge, and sloping towards the last named creeks; it is cut in twain by Lusk creek, which breaks through it at its principal bend, above the mouth of Baty's branch, but continues southwest from there round the heads of Flat Lick and Root Lick branches towards Dixon Springs. Southeast of this ridge all the members of the Upper Chester series are represented; but northwest of it only the higher members are exposed, as far as I could discover.

The bluff of the Ohio at the mouth of Lusk creek, just north of Golconda, in the middle of section 19, township 13, range 7, presents the following section:

1.	Sandstone, capping the bluff; No. 6 of the Chester series	20 to 30 feet
2.	Slope, strewn with sandstone, and probably also underlaid with it	25 "
3.	Siliceous limestone, not all well exposed	31 "
4.	Slaty shales, principally	35 "
5.	Siliceous and slaty limestone	8 "
6.	Slope, apparently underlaid partly with shales, partly with limestones	37 "
7.	Covered with the sandy alluvium of the river bank	22 "
8.	Sandstone No. 8 to low-water mark	5 "

Total height, from 183 to 193 feet.

The limestones present the ordinary lithological character of the limestone No. 7, are all highly siliceous, impure, of grayish color, and are mostly semi-crystalline or sub-crystalline. They contain numerous fossils, Archimedes, Spirifer, Athyris, Pentremites and Corals; but it is difficult to obtain fine specimens.

As we turn up the Ohio river we find the sandstone No. 8 disappears below the low-water mark, near the south line of section 18, and the bluff is then entirely composed of the limestone No. 7, and the sandstone No. 6, of the Chester series. The strata dip northwestward, while the river runs southward in section 18. Near the north line of section 18 the limestone also partially disappears underground, and only its highest ledges form the bank of the river, while the bluff is principally composed of the overlying sandstone. Thus it continues through section 8, where the river runs nearly parallel to the trend of the strata. On the west side of section 4 the limestone has again attained an altitude of 80 feet above low-water mark, and a short distance farther on, near the Rock Quarry landing, the sandstone No. 8 has once more reached the surface, and the higher members of the formation do not extend any farther up the river.

Turning north, along Grand Pierre creek, we find this sandstone occupying its east bank for more than 10 miles, as before stated.

The first exposure on the west side is over a mile from the Ohio, between the forks of the main creek and the Little Grand Pierre, where this sandstone forms the bed and bank of both streams, while the limestone No. 7, capped by the sandstone No. 6, forms the bluffs. Although not everywhere plainly exposed, these formations continue in this position north, along the west side of Grand Pierre creek, through township 12, and the south part of township 11. In the southeast quarter of section 15, township 11, range 7, near the Hardin county line, the sandstone No. 8 is still exposed in the bank of the creek, while the limestone No. 7, and the sandstone No. 6, form the bluff on the west side of the creek, near by. From this point, however, the sandstone No. 8 trends eastward, into Hardin county, and the sandstone which crops out half a mile farther north, on the main creek, and on the east fork in the northeast quarter of section 15, is probably the higher sandstone, No. 6.

From the forks of Grand Pierre creek it is not more than one and one half or two miles north to the high dividing ridge of Conglomerate. The Chester strata dip, therefore, rapidly northward, one after the other. This may be seen to the best advantage on a branch of the east fork, which runs from north to south, just beyond the line of Hardin county, through sections 2 and 11. On it we find the whole series of the upper Chester strata, in their regular order of sequence.

On the upper course of the main creek the stratification is rendered very irregular by the combined influences of the two disturbances,—of the one which centres on the west side of Hardin county, and would here cause a strong dip to the northwest, and of the continuation of the diagonal fault, which may here, perhaps, merely cause an uplift. Near the ford, on the Golconda and Equality road, a short distance above the mouth of the east fork, on the northeast quarter of section 15, we find the bed and the bank of Grand Pierre creek formed of sandstone, as stated above. A little farther up the creek, where these strata have dipped underneath the bed of the creek, a considerable bluff of Chester limestone sets in; and the next outcrop, at the south point of the following bend, consists also of limestone, perhaps the same as the last mentioned, but farther up the creek. Alternating sandstones and limestones, of the higher portion of the Chester series, follow in rapid succession, all dipping successively underground northward. Thus, just below the mouth of the western branch, in the northwest corner of section 15, we find a limestone in the bed of the creek, apparently No. 3; close above the mouth of the branch a sandstone, No. 2; and a little farther up, in the southeast quarter of section 9, the succeeding limestone No. 1 of the Chester series forms the bed of the creek, and the lower part of the hills. Near the first outcrop of this limestone, the current, some years ago, washed a deep hole in the bed of the creek, and laid bare a stratum of slates, and a little coal was also said to have been found here. Up the main creek, through section 9, the limestone continues, capped by the Conglomerate sandstone. It seems to dip northwestward like the others. In the north part of section 9 this sandstone reaches to the foot of the hills, and farther on, heavy cliffs of it extend along the creek in the north part of section 9, and in the southwest quarter of section 4. Then, for some distance, no rocks were observed in place, but on nearing the county line, I noticed Chester limestones in the bed of the creek in the northeast quarter of section 5, apparently No. 3 of the series; and near by the Chester limestone No. 1 reaches high up in the hills, and is exposed on the north side of the county line, on both sides of the valley, north of the northwest corner of section 5, and north of the northeast quarter of section 5, and the northwest quarter of section 4. Underneath it traces of the sandstone No. 2 were discovered at several points. Only the very highest summit of the ridge, near the county line, in section 6, and in the northwest quarter of section 4, consists of the Conglomerate. The limestone appears, however, to extend merely a short distance into Saline county, and then to dip rapidly to the northwestward, underneath the Conglomerate.

These last exposures of the Chester limestone, near the head of Grand Pierre creek, are situated on the line of the before mentioned northeast and southwest fault. It is raised here to a high elevation, when we should expect it deep underground, if the dip continued as before and the continuity of the strata was not broken. The exposures were, however, too limited to determine, without more minute investigation whether we have a regular fault or break in the strata, as farther southwest, or whether the fault has here been changed into a mere violent uplift, with an anticlinal axis and without an actual break in the continuity of the formation.

Near the western branch of Grand Pierre we find the uppermost Chester limestone in the slope in the southwest quarter of section 9, township 11, range 7, and near the northwest corner of section 16, and in the bed of the branch farther west, in the northwest quarter of section 17, where the Conglomerate reaches nearly down to the water level. A sandstone, apparently No. 2, forms the bed of the branch in the northeast quarter of section 17 and the northwest quarter of section 16; but the hills on the southeast side of the branch, in the northwest quarter of section 16, appear to be composed of the Conglomerate, and the formations here seem not only to be disturbed in their stratification, but also irregularly developed. Some distance up the hill, on the south side of the branch, on the west side of section 16, I noticed, under the roots of a fallen tree, slate and some particles of coal, and sandstone seemed to form the hill in a much disturbed position, apparently the Conglomerate. Farther up the branch, in the southeast quarter of section 17, its bank consists of slates, which, at their base, appear to contain a carbonaceous streak. Mr. John S. Johnson, who lives near by, bored there, and thinks he passed through a thin seam of coal, some feet below the bed of the branch; but he is not positive about it. The hillside west from there shows prominent cliffs of sandstone. At Mr. Johnson's house, on the north side of section 20, there is some sandstone exposed in the branch, and higher up some shale and slate, with 16 inches of coal, which is said to be rotten and impure, and unfit for use in the blacksmith shop. A few feet higher up the hill we observe a heavy cliff of sandstone; then again some large blocks of Chester limestone, which can not be far out of place, while the higher portion of the hill consists of Conglomerate. The exposures in this vicinity are quite puzzling, and I can only explain them as a local irregularity in the development of the formations.

Turning south, on the west side of the main Grand Pierre creek, we find numerous outcrops of the different Chester limestones and sandstones, which are here crowded into a narrow belt, between the creek and the dividing ridge to the west, which is capped by the Conglomerate. With these Chester strata we find, at several points, a thin seam of coal. Thus, near Mr. Weston's place, in a ravine half a mile west of the creek, six inches of an impure shaly coal were observed in the southeast quarter of the southeast quarter of section 21, township 11, range 7. It occurs apparently in the upper layers of one of the sandstones, probably No. 4 of the series; while limestones crop out close by. A thin seam of coal is said to have been discovered, also, on a ravine on the west side of section 4 (?), township 12, range 7, and more on a branch near the middle of the north line of section 17, township 12, range 7, apparently, also, in the sandstone No. 4, where it is said to have varied in thickness from half an inch to four inches.

The upper limestone, No. 1, was observed high up towards the ridge, in the southeast quarter of section 29 (?), township 11, range 7, and again at the head of a branch near the west line of section

5, township 12, range 7. Following down that branch through section 8, the northeast quarter of section 17, the northwest quarter of section 16, and the south part of section 9, to Grand Pierre creek, I again observed the various members of the Chester series. First in section 5, west of the Golconda and Equality road, the limestone No. 7, which was there partly bluish-gray, close-textured, nearly conchoidal in fracture, full of concretions of flint, and partly gray and semi-crystalline. It is at least 80 feet thick, and probably much more, and is capped by the Conglomerate. On the east side of the road, on the south side of section 5 and in the northwest quarter of section 8, we next find in the bed and bank of the branch, some shaly layers and thin and uneven strata of sandstone, which evidently underlie the above named limestone, and seem to be No. 2 of the series. Where the branch next turns eastward, in the northwest quarter of section 8, a ledge of this sandstone may be seen rising in the hillside; and we soon find the next lower limestone, No. 3, rising to the surface from underneath it. At the next bend, towards the south, the next lower sandstone, No. 4 of the Chester series, is then exposed in the south part of the northwest quarter of section 8, and continues along the branch through the southwest quarter of section 8, and into the north part of section 17. This sandstone attains a considerable thickness, but many of its layers are thin, hard and uneven, and it contains the thin streak of coal already mentioned. In the northeast quarter of section 17, and farther down, we find the limestone formation No. 5, and near an old mill site, near the middle of the north line of the northwest quarter of section 16 (?), the next lower sandstone, No. 6; while a quarter of a mile farther east, on the banks of Grand Pierre creek, the limestone No. 7 is exposed, capped by No. 6, as well below as above the mouth of the branch. The sandstone No. 8 makes its appearance first a short distance east of the creek, west of the northeast corner of section 16.

Near the mouth of Little Grand Pierre, in the northeast quarter of section 33, township 12, range 7, the bed of the creek is formed by the sandstone No. 8, which here dips underground, and the hills by the limestone No. 7 and the sandstone No. 6. No. 7 continues to form the base of the hills on the north side of Little Grand Pierre, through section 33; but in the northeast quarter of section 32 the sandstone No. 6 has dipped down to the water level. No. 7 is no more exposed in this vicinity; only at the foot of the hills on the southeast side of the west branch, near the middle of the southeast quarter of section 32, its presence is indicated by numerous sink-holes. The sandstone No. 6 extends some distance up the Little Grand Pierre. It forms a ford on a county road, near the middle of the south line of section 29, while the hills on both sides of the creek, in the southeast quarter of section 29 and in the northwest quarter of section 32, are mainly composed of the limestone No. 5, capped by the sandstone No. 4.

On the west branch No. 6 is exposed at various points in the southeast portion of section 32, while No. 5 forms the hills on the north side of the branch, in the middle of section 32, generally capped by the sandstone No. 4, and extends in the base of the bluffs through the southwest quarter of section 32 and probably into section 31, where it appears to dip underground. Farther up the west branch there seems to be a local irregularity in the stratification, for at the ford, on the Golconda and Equality road, we find sandstones which would naturally appear to form the continuation of the last named ledges, but really seem to be the lower sandstone No. 6, because from their northward dip we find limestones in the foot of the hills and at some points reaching high up on the slopes, capped by a sandstone which cannot possibly be any other than No. 4. The limestone No. 5 continues thus along the creek through the northwest corner of section 31 and the west part of section 30. Then No. 4 descends to the bank of the creek, extending through the southwest quarter of section 19 and into the northwest quarter. It is overlaid and succeeded by the limestone No. 3, which is exposed along the creek in the southwest quarter of section 18, township 12, range 7, and in the northeast corner of section 26 and the northeast quarter of the southeast quarter of section 13, township 12, range 6. A thin body of sandstone then follows in the southeast quarter of section 13, evidently No. 2; and in the northeast quarter of section 13, and in the southeast quarter of section 12, the creek runs through the limestone formation No. 1, which is here hard, close-textured, sub-conchoidal in fracture, bluish-gray in color, and highly siliceous. From the last outcrop of this limestone the Conglomerate reaches to the summit of the dividing ridge towards Lusk creek. Two miles farther south, on the north side of section 25, township 12, range 6, this ridge is equally high, and falls off even more precipitously to the eastward; but there the Conglomerate is much thinner, and underlaid high up on the hillside with a Chester limestone, which is, however, not much exposed. Underneath this follows a heavy and prominent ledge of sandstone, which must correspond to No. 2, but has much more the general appearance of an outcrop of the Conglomerate than No. 2 generally presents. Lower down follows, partially exposed, the limestone No. 3, while the limestone No. 5 seems to form the bank of the west branch, and the sandstone No. 4 the lower slopes, although the latter is not exposed just there. The upper part of this section reminded me much of what I had observed at Mr. Johnson's, in the northwest quarter of section 20, township 11, range 7.

Near the Golconda and Marion road the Conglomerate forms the summit of the same ridge in the middle of section 35, township 12, range 6; the southern slope, however, in the southeast quarter of section 35, contains the uppermost Chester limestone, and the sandstone No. 2 was observed at the foot of the ridge. Through the northeast quarter of section 2 and the southwest quarter of section 1, township 13, range 6, we find principally the limestone No. 3 along the road, capped in places by the sandstone No. 2. These two still form the low ridge near the north line of the northwest quarter of section 12, but do not reach farther south near the road. In section 12 the sandstone No. 4 is only found off the road at the head of ravines.

Mr. Gordon Thompson, in digging a well at his house, near the road, in the middle of the southwest quarter of section 12, passed through 16 feet of soil and clay, then a thin layer of this sandstone, then 15 feet of shaly slate, and finally, according to his own account, through 18 inches of stone coal and black shale. This appears to be the same coal seam which has been discovered six miles farther northeast, on the branch of Grand Pierre, where it was quite thin. The sandstone found on the ridge in section 13 still appears to belong to No. 4, and only those nearest the Ohio and Lusk creek to No. 6. The intermediate limestone, No. 5, is not exposed on the road.

At the mouth of Lusk creek, on its north side, we have the Chester sandstone No. 8 in the bank of the Ohio, and the Chester limestone No. 7, capped by the sandstone No. 6, in the bluffs. I have already given a section of these rocks at the beginning of this chapter. The bluffs thus continue westward, on the north side of the creek, for over a mile; but gradually the strata dip lower, and at the bend, near the northwest quarter of section 24, the limestone has disappeared, and the sandstone No. 6 forms the bank of a ravine, while the bluff on the west side of it consists of the limestone formation No. 5, capped by the sandstone No. 4. The limestone is here hardly more than fifty or sixty feet thick. In its lithological appearance it cannot be distinguished from No. 7, to which it generally bears close resemblance. The limestone No. 5

continues in the lower part of the bluffs all through the east part of section 14; then the sandstone No. 4, which capped it all along, reaches the water level. I thus noticed it, especially at the mouth of a small branch a quarter of a mile east of the northwest corner of section 14; also, at the mouth of Four-mile branch, on the south side of Lusk creek, in the southwest quarter of section 15, and at the ford in the northeast quarter of section 16. The next higher limestone, No. 3, then forms a bluff at least 80 feet high, in the southwest quarter of section 11 and the southeast corner of section 10; while farther west, in the southwest quarter of section 10, it is capped by the sandstone No. 2, which is here quite thin; and the higher hills farther north, in section 10, contain the highest Chester limestone, No. 1, capped by the Conglomerate. On the west side of Lusk creek, the limestone No. 3 forms the bluff in the northeast quarter of section 16, capped by the sandstone No. 2, and soon the hills rise still higher, and the limestone No. 1 occupies the summit near the north line of section 16. No. 2 dips underneath the water level in the southwest quarter of section 9. Thence on, through the north part of section 9 and sections 4 and 5, the limestone No. 1 forms the base of the bluffs, and their upper portion consists of the Conglomerate. The last outcrop of the limestone occurs just below the mouth of Baty's branch, not far from the township line. Its aggregate thickness is probably about one hundred and sixty feet. On the Golconda and Glendale road, on the ridge a mile west of Lusk creek, this limestone is exposed in the northeast quarter of section 17, township 13, range 6, but near the north line of this section the Conglomerate forms the summit.

On the Four-mile branch of Lusk creek, which is four miles west of Golconda, the sandstone No. 4 extends from its mouth, in the southwest quarter of section 15, upwards through the west part of section 22, and the east part of section 21, into the northeast quarter of section 28. There the limestone No. 5 rises to the surface from underneath the sandstone, and continues up the branch through the east part of section 28, and the southwest quarter of section 27. It is last exposed at the foot of the summit breaks, near the southwest corner of section 27. The summit itself, on the Vienna road, perhaps contains No. 4. The sandstone No. 6 caps the ridge between the forks of Mill creek, in the northwest quarter of section 35, and in the south part of section 34, township 13, range 6, and continues southwestward to the bluffs of Bay river, while the limestone No. 7, with its ordinary appearance and fossils, crops out at the foot of this ridge, in the forks of Mill creek, in the southeast quarter of section 26 (?), and in the slopes on the north side of the south fork of Mill creek, in section 35, and in the north part of section 3, township 14, range 6; the underlying sandstone, No. 8, is exposed in the banks of that branch near the forks, and higher up through section 35, and on the branches of Bay river, in the south part of section 3.

The limestone No. 7, capped by the sandstone No. 6, continues westward, apparently without interruption, and forms the bluffs on the north side of Bay river, through sections 4 and 5, township 14, range 6, and section 31, township 13, range 6, to the bridge and old mill site on the county road, in the northeast quarter of section 36, township 13, range 5. A mile north from there, near the town of Columbus, the limestone has dipped underground. The sandstone No. 6 is exposed there in the bank of a branch in the southwest quarter of section 30, and in the southeast quarter of section 30, and also a quarter of a mile farther north in the northwest quarter of section 30, while the next higher limestone, apparently No. 5, capped at many points by the sandstone No. 4, occupies the hills northeast of the town, in the northeast quarter of section 30, and also the bluffs northwest of the town, in the direction towards Flat Lick creek, in the northwest quarter of section 30, and in the northeast corner of the adjoining section 25, township 13, range 5. Farther north, towards the head of Flat Lick creek, I found the upper Chester limestone, apparently No. 1, extensively developed in the hills on the east side of the creek, in the west part of section 18, and in the southwest quarter and centre of section 7, township 13, range 6. It undoubtedly also forms the base of the hills on the west side of the creek, which are capped by prominent ledges of the Conglomerate, which here extends much farther south than on the other side of the creek. On Root Lick creek, the Chester limestone does not extend farther north than the southwest quarter of section 14 and the southeast quarter of section 15, township 13, range 5, and near Hill's branch, to the southwest corner of section 16.

West of Flat Lick creek, in the west half of section 25, the Bay river bluffs consist of about 30 feet of limestone, capped by some sandstone, perhaps Nos. 7 and 6 of the Chester series. This sandstone then forms a continuous outcrop westward into section 26, to near Root Lick creek. On the west side of the latter, in the northeast quarter of section 27, the hills consist principally of a limestone, probably of the next higher division, No. 5, overlaid with some sandstone, apparently No. 4; while at their base I noticed traces of a lower sandstone No. 6. Thence west I found the uppermost of these sandstones prominently exposed through section 28. In the southwest quarter of section 28, the limestone underneath it is again visible, and nearer to the Bay, in the southeast quarter of section 29, a lower sandstone, apparently No. 6, rises to the surface. This sandstone forms a prominent bluff thence on along Bay river. It rises gradually as the bluff extends southward into section 32, and reaches a thickness of certainly 100 feet, if not more, while at some points it presents a bare cliff of 40 feet. Finally a lower Chester limestone, apparently No. 7, makes its appearance underneath it and continues, capped by the sandstone, to the scuth point of the bluff, in the west part of section 32 (?), township 13, range 5, near the Metropolis and Glendale road, where it is exposed in a thickness of some 70 feet. Thence the bluff turns northward; the limestone soon disappears, but the capping sandstone, No. 6, is exposed in the northwest quarter of section 32, and in the southwest quarter of sec'ion 29, along the edge of the bottom land. Near the middle of the west half of section 29, the hills on the east side of Sugar creek present a higher division of the Chester limestone. North from there, on the other side of Sugar creek, in the northwest corner of section 29, we find the hills composed of sandstones, which extend thence west to the Johnson county line, which they strike on the west side of section 19. These sandstones, if the stratification was undisturbed, would appear to be No. 4; but my examinations in the adjoining county make me consider them, in part at least, as No. 6, and from the following it will be seen that there are irregularities here which I was not able entirely to unravel, without a more extended examination. At one point these rocks present a singular appearance, as of a dyke tilted up in the direction of north and south, or rather, as if the eastern portion of the hill had slipped down, leaving the rocks on the west side protruding. I suppose we see here really the effects of a fault, because a short distance farther north we find the strata in the face of the bluff strongly tilted. The course of the great disturbance which passes from northeast to southwest through the county, points in this direction, and I suppose the irregularities here are connected with this disturbance, although I cannot point out its exact limits and connection.

Proceeding north along the bluffs, on the west side of Sugar creek, we soon find the sandstone rises at a high angle to the northward, on the west side of the southwest quarter of section 20, and one of the Chester limestones makes its appearance underneath it. The dip, however, changes suddenly, and the sandstone descends again with a moderate angle to the northward. I noticed it various points lower down, and it forms a low bluff in the bank of the creek below the Vienna road in the southwest quarter of section 17. On the east side of the creek limestones appear to form the main portion of the hills in the middle of section 20, only capped by some sandstone on the highest point, and near the middle of the north line of section 20, Chester limestones form the main body of the ridge between Sugar creek and Hill's branch, at least 100 feet thick, and capped by only a few feet of sandstone, which may, perhaps, be the last outlier of the Conglomerate.

Farther up Sugar creek we next find sandstones forming low bluffs at the lower edge of the hills in the extreme north part of section 17 and in the south part of section 8. In the southeast quarter of section 8, a Chester limestone is exposed in the hillside above these sandstones, and the latter soon disappear underneath the bed of the creek, while the limestone appears to continue, without interruption, to the northwest corner of section 9. In this vicinity it is overlaid with another sandstone formation, which, gradually dipping down to the northward, becomes the lowest formation along the creek, through the southwest quarter of section 4, and extends into the north part of the same section. This sandstone contains a thin seam of stone coal, at least four inches thick, which has been discovered in the bed of the creek at an old mill site in the northwest quarter of the southwest quarter of section 4, but was under water at the time of my visit. Perhaps this sandstone is No. 4, and the coal the continuation of the seam which we have found in this formation, on the branches of the Grand Pierre creek. In the hill side above the old mill, near the middle of the east line of section 5, I observed a higher Chester limestone, capped in the higher hills by another sandstone. The limestone extends, also, through the low hills in the northwest quarter of section 4, and farther north, and it crops out at various points along the creek through the east part of section 33. The higher sandstone then makes its appearance in the upper portion of the low bluffs, and reaches, in the northwest quarter of section 34, to within a few feet of the bed of the creek; but the limestone appears to extend a long ways farther up the creek, which runs here from east to west, although it is little exposed, and the hills seem to be formed of the higher sandstones. This latter is No. 2 of the Chester series. It attains a very considerable thickness, and thus differs from the description given of its scanty development farther east. It occupies the ridge between Sugar creek and Haze's creek, south of Glendale, and also dips gently to the northward.

Bay river heads in the Conglomerate, but the highest Chester limestone makes its appearance underneath the sandstone near the mouth of Little Bay creek, in the southwest quarter of section 8, township 12, range 5, and extends thence down Bay river, gradually rising. Near the south line of section 18 it has attained an altitude of at least 100 feet, on the east side of the river, and is still capped by sandstone, which extends into the northeast quarter of section 19 and forms the summit of the ridge thence eastward, while the limestone underlies the slopes on the south side of the summit, towards Haze's creek, in sections 19, 20, 21 and 22. Most of this limestone is hard and siliceous, and the intercalated clay shales form, at some points, barren spots or scalds. Near the Bay bridge, in the northwest quarter of section 19, the lower sandstone No. 2 has reached the surface, and extends thence down that stream to beyond the Johnson county line, and eastward up Haze's creek, which is a main branch of the Bay, through sections 30, 29, 28, 21, and over the ridge south of Haze's creek, as I have stated before. At Glendale, which is situated in the southwest quarter of section 21, township 12, range 5, this sandstone No. 2 forms the banks of the creek, while the limestone No. 1 is exposed only a few feet higher up. On the north prong of Haze's creek this limestone appears to dip under ground near the north line of section 14. On a small branch I saw its highest ledges capped by the Conglomerate in the southeast quarter of section 15, and near the east prong I observed it on the slope underneath the Conglomerate, in the southeast quarter of section 14 and in the south part of section 13, and at some springs near the southeast corner of section 13 and at some springs near the southeast corner of section 13 and northeast corner of section 24. Half a mile west from there, down the branch, we come to some sandstones which are intercalated between the Chester limestones. Some of the sandstone forms hard, thin, irregular layers, and part of it forms a quartzite or solid bed of quartz-rock, evidently in consequence of a local metamorphosis. It may be best seen in the northeast quarter of section 24, where the creek falls over the lowest ledge of it to the underlying limestone. The aggregate thickness of this intercalation can hardly exceed ten feet. I found the quartzite again at many points in the hills farther southwest, on the west side of section 24 and in the east part of section 23, on top of the lower Chester limestone, and also on the county road in the northeast quarter of section 24, and at other points.

These few layers bear little resemblance to the heavy body of sandstones which have been described as No. 2 in the lower part of the creek, but their thickness corresponds nearer with that of the

No. 2 of the eastern part of the county. A more detailed examination would be required, however, to enable us to trace all the minutiæ of the changes which the formation undergoes, and which are of no practical importance.

Near the mouth of a small branch of Haze's creek, in the southwest quarter of section 23, I observed a lower sandstone, apparently the same as that near Glendale, in the bed of the stream. The hills consist, however, of Chester limestones and shales, which are capped by a few feet of sandstone, which is partly cherty, and evidently forms the continuation of the bed of quartzite. The limestone is here rich in fossils, especially *Retzia vera* and *Athyris ambigua.*

Continuing northeast along the edge of the high ridge, we soon come to the waters of Lusk creek. Near the Golconda and Marion road the Conglomerate caps the high point in the southwest quarter of section 8, township 12, range 6; but thence the ridge falls off rapidly towards the south, and the lower hills are formed by the upper Chester limestone, in the southeast quarter of section 8, and in the north part of sections 18, 17, etc. I observed these limestones also in the northeast corner of section 19, the northwest corner of section 20, and near the branch in the southwest quarter of section 17, where I obtained from them a variety of Chester fossils, *Archimedes, Pentremites, Productus pileiformis,* various *Spirifers,* etc. Near the forks of that branch, in the northeast quarter of section 20, some layers of sandstone rise from underneath this limestone, and form a conspicuous little bluff; but only a few rods farther on other thin layers of Chester limestone rise out of the bed of the creek, underneath this sandstone, which can only have a very limited thickness, and is apparently No. 2 of the Chester series. It rises rapidly as we continue down the branch, and soon forms the summit of the bluff hills in the northeast quarter of section 20. The slopes are there covered with masses of tumbling sand-rock, but at various places traces of the limestone are recognized in the hillside. Near the east line of section 20 the sandstone seems to pitch down again towards the east, and we soon reach Lusk creek and the Conglomerate, having passed the line of the fault. Along this portion of Lusk creek, for several miles up and down, the Conglomerate extends in the bank and in the hills east of the creek, with the same regularity as the Chester sandstone No. 8, on Grand Pierre, and the diagonal fault seems to coincide nearly with the course of the stream. On its northwest side we generally find, therefore, the upper members of the Chester series. Thus the bluffs half a mile below the branch, on the west side of Lusk creek, in the south part of section 20, present outcrops of a Chester limestone, capped by some sandstone, apparently Nos. 3 and 2. Lower down, the bluffs on the west side of the creek continue high, and are apparently formed of the same strata to the south line of section 30; then, near the northeast corner of section 31, we come to a small branch with the Conglomerate in its bank, and the creek there enters this formation, while the Chester strata evidently continue westward over the hills.

In the northwest quarter of section 21, and in the southwest quarter of section 16, township 12, range 6, I observed only sandstones along the banks of Lusk creek, but in the southeast quarter of section 16 some ledges of sandstone rise abruptly to the northwest, and presently we find underneath them an outcrop of Chester limestone. This is a little below the crossing of the Marion road, and on both sides of that road, west of the creek, we find heavy exposures of this limestone, which is very hard, of gray color, crystalline, or close textured, and full of chert. I obtained from it various Chester fossils, especially *Archimedes, Productus pileiformis, P. elegans, Spirifer lineatus, Spiriferina octoplicata*, and others. A few rods farther north some old lead diggings are in this same formation, while a short distance farther west and northwest, in the northeast quarter of the southeast quarter, and the southwest quarter of the northeast quarter of section 16, we find a lower sandstone rising from underneath this limestone, with a slight dip to the south or southeast, conformable to the limestone itself. This dip is undoubtedly soon reversed and only caused by the proximity of the greater disturbance. In the limestone and shales which overlie this sandstone in the rear of the diggings, in the very same hill in which they are located, I observed Chester fossils. This limestone is evidently one of the highest of the Chester series, probably No. 1, or perhaps No. 3.

The lead diggings are a few rods north of the Marion road, in the face of the bluffs of Lusk creek, in the southeast and northeast quarters of section 16, township 12, range 6. The bluff is mostly covered with soil and detritus, but we see, at various heights, outcropping masses of limestone, which is partly compact, gray and sub-crystalline, but much of which is highly crystalline, with large crystalline masses of calcareous spar, and has disseminated through it white, bluish, or violet fluor spar, galena, zinc blende, and traces of copper. It is evidently the Chester limestone in a state of partial metamorphism, and is undoubtedly interstratified with shales, the same as everywhere else. A shallow excavation on the side of the hill reveals a heavy deposit of a white clay, which has been claimed to be kaolin, and of which some fine queensware is said to have been made. It is exposed to a thickness of about 15 feet, but not sufficiently to determine whether it forms an intercalation in the limestone, and is then an altered shale, or whether it is an irregular deposit on the side of the hill, formed in connection with the mineralization of the limestone. Just above the diggings the limestone reaches to the top of the hill, but a higher point of the sharp summit, a few rods farther northeast, is capped by some feet of sandstone, which is also considerably altered, and has become hard and cherty. A few rods east of the diggings, that is, in the direction of the creek, the hillside is covered with sandstone, a large portion of which appears to be in place, and which reaches to the summit rising northwestward. It is evidently the same sandstone which we found a short distance below the mines in the bluffs rising abruptly with and above the limestone from the bed of the creek, and it seems to me as if the exposure of the limestone, on both sides of the road, in the face of the bluff, were merely due to the circumstance that the bluff there recedes towards the northwest, while the strata trend northeastward. The overlying sandstone is thus removed from the face of the bluff by denudation, and the underlying limestone is exposed to view. The limestone on the west side of the hill is not much altered, and the mineralization seems to be confined to the east side of the hill. On the east side of the creek the Conglomerate sandstones dip a few degrees to the northeast, in a direction directly opposite to the dip of the rocks on the west side. A simple explanation of these irregularities is to be found in the fact that the above-mentioned fault passes through here in the direction from northeast to southwest. The rocks on the east side of the break have settled down several hundred feet, and the Conglomerate, a higher formation, has thus been carried down to a level with the Chester limestone on the opposite side of the creek. The rocks on the west side of the break have also yielded near the point of fracture, while a little farther distant to the westward, they dip slightly towards the northwest, and seem to have been forced down some distance near the point of fracture, so that we there find them strongly dipping towards the break, or southeast. I do not mean to say that the whole disturbance has been the result of a subsidence without any upheaving action; because no subsidence can take place without a corresponding elevation at a near or distant point; but it makes little difference in the result whether we assume that the rocks on the east side have subsided, or those on the west side have been upheaved. One thing is certain, viz: that the strata have had their continuation broken, have been fractured, and that extensive fissures must have been formed, which have been a cause of the mineralization of the limestone at the diggings.

Continuing northward up the creek on its west side, we find the bluff, as far as can be ascertained, formed of, and strewn with, sandstone belonging, apparently, to the Conglomerate. The limestone is little exposed, but evidently forms the west side of the bluff ridge. On the branch in the southwest quarter of section 10, township 12, range 6, I again observed the lower sandstone of the Chester series, and it appears to extend up that branch at least to near the centre of section 9, while the hills on both sides consist of the uppermost Chester limestone. North of the branch, in the middle of section 10, the main bluff is still formed of the Conglomerate, but the Chester limestone reaches high up in the west side of the bluff hills, off the creek, and is somewhat veined with calcareous spar. The sandstone there is also somewhat altered, hard, cherty, and contains a little fluor spar. The stratification is evidently strongly disturbed. At this point, also, some holes were dug after galena, but with very unsatisfactory result, as little or none was found.

I noticed another outcrop of highly tilted ledges of sandstone on top of the bluff ridge, in the north part of section 10. In the northwest quarter of this section, high cliffs of undisturbed Conglomerate extend on both sides of the creek; but turning west along Lusk creek, in the southeast quarter of section 3, we soon come to a ravine on the south side, on which we again noticed tilted ledges of sandstone, while farther west the bluff consists of Chester limestones. Here, then, we have another point on the great fault. Farther on west, in the south part of section 3, the bluff is not very high, and mainly composed of limestone, with a little sandstone on top. It rises gradually, thus indicating a dip to the southeast. Near the middle of the south half of section 3, I observed some sandstone in place in the bed of the creek at the foot of the limestone bluff, evidently a Chester sandstone. Round the bend, near the old Gilbert place, near the middle of the east line of section 4, some Chester sandstone is in place in the bed and bank of a branch, while the hills are formed of limestone, with an intercalation of several feet of sandstone, so that here Nos. 1, 2, 3 and 4 seem to be represented. Near the northwest corner of section 3, the Chester limestones are still exposed along Lusk creek, but then a heavy bluff of the Conglomerate sandstone sets in above them, and the strata exhibits a strong dip to the northwest, which carries the Chester formation underground in a short distance, so that the towering bluffs near the bend of the creek, in the southwest quarter of section 34, township 11, range 6, consist of the Conglomerate to their base.

On the north side of Lusk creek, in the southeast quarter of section 3, the hills also consist of Chester limestones and shales, just above the mouth of Little creek, while next to that creek the rocks belong to the Conglomerate. The fault passes through just west of Little creek. In its vicinity, in the southeast quarter of section 3, the limestone is again veined with calcareous spar, and on a ravine of Lusk creek, in this vicinity, a short distance back of the creek, several holes have been dug in search of galena. I noticed in their vicinity, besides the limestone, black and gray shales and slates and masses of strongly altered silicified sandstone, all, especially the slates, interspersed with fluor spar. Besides the fluor spar, which forms no regular vein, nor even well defined pockets, I also observed some calcareous spar, but no galena. It is said, however, that some galena has been found there.

Little creek follows the same general direction as Lusk creek below its mouth, which coincides very near with the course of the diagonal disturbance, as we have seen. Little creek, nearly all along, meanders between cliffs of Conglomerate, but the upper Chester limestones on the west side of the fault underlie the hills a short distance west of the creek. Thus most of section 3 and the northwest corner of section 2, township 12, range 6, are mainly underlaid with the Chester limestone, and also the east half of section 34, the west half and part of the east half of section 35, the southwest quarter of section 26 and the southeast quarter of section 27, township 11, range 6, etc. Near the creek the Chester limestone is again exposed in a bluff on the west side, near a sharp bend of the creek, in the southeast quarter of section 35. The forks of the creek, in the northwest quarter of section 36, are in the Conglomerate; but turning up the main or north fork, we at once find the sandstone dipping strongly to the southeast for some distance, and soon the limestone makes its appearance underneath it. Farther up that branch we again notice outcrops of the limestone in the vicinity of Mr. John A. Wasson's place, in the lower part of the hills in the northeast quarter of section 25, while the ridge towards the southeast consists of Conglomerate. The limestone near a chalybeate spring at this point is veined with calcareous spar, but no signs of any other mineral were observed. Close by, on the main creek, near the county road, the Chester limestone is also exposed, and dips with a strong angle towards the southwest. It is overlaid with Conglomerate sandstone, which dips in the same direction, trending from southeast to northwest, and very soon form the bank of the creek. This trend does not correspond with the general course of the disturbance which we have followed thus far, and may be due for more local causes; still this outcrop of the limestone is in the continuation of the great fault. From this point it is only a mile and a half farther northeast to the outcrops of limestone, on a branch of Grand Pierre creek, in the northwest quarter of section 20, township 11, range 7. The lower hills on the east side of section 24 are also probably underlaid with the limestone, but the formations farther up Little creek are somewhat obscure. Sandstones are evidently in the higher hills, but a spring in the bank, in the southwest quarter of section 13, has altogether the appearance of a limestone spring. In the southeast quarter of section 13, many years ago, somebody dug on a low ridge for mineral, and excavated a hole apparently in loose masses of sandstone. Some of this sandstone contains small veins of calcareous spar and is somewhat altered. The strata in this vicinity seems to be strongly tilted, but are little exposed.

Conglomerate.

This formation, in Pope county, does not differ essentially from the Conglomerate of the adjoining county of Johnson. Some of its sandstone strata are rendered conglomeratic by an abundant admixture of small quartz pebbles, but this is not a peculiarity entirely confined to it, but is also met with occasionally, although seldom, in the Chester sandstone. The principal difference in the development of this sandstone, in this county, consists in the presence of a small seam of coal in the very lowest stratum of the formation, which was not seen in Johnson county, where the lowest coal seam in this sandstone generally occurs much higher up in the formation. The continuation of this higher seam has also been discovered in Pope county. We need, however, not be surprised at meeting with coal near the base of this sandstone, because we have found thin seams of it extending far through the Chester formation, at a much lower geological level; and the Battery-rock coal, in Hardin county, on the Ohio, which forms the continuation of one of the Kentucky coal beds, probably the Cook coal, is also in the lowest portion of the formation which we designate as Conglomerate, but which embraces the lower Coal Measures of Western Kentucky.

In the foregoing pages, in describing the Chester formation, I have incidentally traced already the outlines of this formation. We have seen that in, consequence of the great diagonal fault, we find two separate bodies of it—the one occupying the northwestern and northern part of the county, and the other on the southeast side of the fault extending in a band, generally from two to three miles wide, east of Little creek, the middle course of Lusk creek, and farther southwest.

This latter portion of the formation occupies the summit and northwestern slope of the dividing ridge between Grand Pierre creek, below its upper forks, the lower course of Lusk creek, and the lower course of Bay river, on one side, and Little creek, the middle course of Lusk creek below the mouth of the latter, and the upper Sugar creek, on the other side. It begins in section 16, township 11, range 7, and is very conspicuous thence southwestward in the abrupt declivity of the southwestern edge of the summit of this dividing ridge. At the head of the west branch of Grand Pierre, it reaches far down from the summit to the junction of the upper forks, in the southeast quarter of section 12, township 12, range 6; and in some places there its dip towards the northwest is plainly visible. Farther south again, in the north part of section 25, where the ridge falls off very abruptly, it forms merely the highest summit ledges; so, also, at the extreme southern point of the ridge, on the east side of Lusk creek, in the northwest corner of section 10, township 13, range 6, and on the opposite side of Lusk creek south of the centre of section 9, and on the county road, on the northeast quarter of section 17. Dipping northwestward, this formation descends to the water level of Lusk creek, near the south line of section 32, township 12, range 6, just below the mouth of Baty's branch, and extends in both banks of the creek for about a mile, forming bold cliffs and picturesque wild scenery, hemming the creek within a narrow gorge. Baty's branch itself runs from head to mouth entirely through these strata, through a roughly broken district, full of rocky cliffs. Farther southwest it crosses Flat Lick creek, near its head, on section 7, township 13, range 6, forming prominent cliffs, with some conglomeratic ledges in the bluffs on the west side of that creek, reaching southward into the northwest quarter of section 24 and the north part of section 23, township 13, range 5. Then it passes in bold cliffs around the head of Root Lick creek, in the southwest quarter of section 14, and the southeast quarter of section 15, and caps a high summit in the north part of section 21. Hill's branch rushes through a gorge in the lowest layers of the Conglomerate, in the southwest quarter of section 16, a short distance north of the Golconda and Vienna road, below the Dixon springs, and I noticed the same formation again in section 17; but I am at a loss to locate its southwestern extremity. I am not certain whether it passes west of Sugar creek; probably it does not.

The limits of this body of Conglomerate, on its north and west sides, are by no means so prominently marked, on account of the dip being towards the northwest; still they can, in many places, be traced very readily. Near the Golconda and Independence road it ends in the ridge east of the main fork of Little creek, near the southeast corner of section 24, township 11, range 6. The more eastern fork passes entirely through this formation, which, near the mouth of this fork, extend a short distance up the main creek to near the southwest corner of section 25, and then down Little creek to its mouth and a short distance west of it, with the exception of a single point near a western bend in the south part of section 35. On Lusk creek it begins above the mouth of Little creek, in the southeast quarter of section 3, township 12, range 6; extends then southward a short distance west of the creek to the vicinity of the old lead diggings, on the east side of section 16; thence down it occupies the east bank of the creek, reaching across it only at a few points, to near the northwest corner of section 32, when the creek, changing its course, breaks through this formation. Farther on, the northwestern boundary of the Conglomerate passes over the uplands, and can not be traced so readily.

In this portion of the formation coal has been discovered at a few points only, but enough to show its wide distribution. A short distance east of the county road from Golconda to Glendale, in the breaks of the ridge, towards Lusk creek, in the southeast quarter of section 8, township 13, range 6, some traces of coal have been discovered. The ridge is capped by the lower ledges of the sandstone, while the lower portion of the bluffs consists of Chester strata. The coal seam is evidently in the very lowest portion of the Conglomerate. It was not well exposed, but seems to be very impure and only a few inches thick. The owner had once dug a few feet into the bank, but did not find it better. It is capped by shaly arenaceous strata. On the west side of Lusk creek, opposite the mouth of Baty's branch, some more coal is exposed on the southwest quarter of the southeast quarter of section 32, township 12, range 6, in the lower part of the bluff. The rocks here are also the lowest strata of the Conglomerate. They dip at a considerable angle. The coal lies directly between heavy beds of sandstone, and is, for several yards, 22 inches thick, of good quality, contains little ashes and sulphur, and has been mined, in a small way, by stripping, for the use of the blacksmiths of the neighborhood. It is bituminous, like all the other coals of this district. The seam is, however, subject to great changes. Only a few feet distant the coal is mostly replaced by a shaly slate, of dark color, of which there was no trace at the other point, and above the slate I observed about a foot of sandstone and then two inches more of coal. The sandstones above and below the coal are so heavy that even stripping becomes laborious and can be carried on only to a limited extent. Other points should be tried, but it is impossible to foretell what the quality and thickness of the coal might be there. This is probably the same coal seam which has been described before; the difference of altitude being due to the dip of the formation.

Some miles farther northeast another coal digging has been opened, known as Widow Anderson's, near the middle of the west half of section 14, township 12, range 6. It is on a branch of Lusk creek, in the middle of the Conglomerate district. The coal is there capped by some feet of rather thinly and unevenly stratified sandstones, intercalated with shaly layers, which have to be removed in order to get the coal. The coal was not well exposed at the time of my visit, the holes being filled with water; but it seemed to be hardly more than 18 inches thick. It is reported, however, to have been found thicker; and here, too, it may vary. This coal is not quite as pure as that opposite Baty's branch, still it can be made use of in smith fires, and is far more easily accessible than that in the other digging. Possibly this may be the same seam. The character of the rocks is so exceedingly variable that their different appearance does not prove anything. At any rate, this stratum of coal, although, perhaps, changed in thickness and quality, might be easily discovered at other points in this vicinity, by taking into account the northeastern trend and northwestern dip of the formation. It may become of considerable importance to the neighborhood.

About three miles farther northeast, in the southeast corner of section 36, township 11, range 6, a thin streak of coal has been struck in a well, on a high ridge. It was one inch thick on one side of the well, and thicker on the other. A mile and a half farther west, in a ravine, a short distance west of Little creek, near the township line, east of the middle line of section 35, some coal and slates are also reported to have been noticed. The coal seemed to be quite thin. I did not see this exposure. It must also be in the lowest layers of the Conglomerate, in close proximity to the fault. The traces of coal in the northwest quarter of section 16, township 11, range 7, near a branch of Grand Pierre creek, appear also to come from the lowest part of the Conglomerate.

The other body of this formation, which occupies the northwestern and northern portion of the county, extending west into Johnson and north into Saline counties, presents also a well defined southeastern border, generally capping, at its extremity, a high ridge with a steep southeastern declivity. At the Johnson county line it begins north of Bay river, in section 18, township 12, range 5. It crosses that river near the mouth of Little Bay creek, in the southwest quarter of section 8, then caps a narrow spur of the ridge, on the east side of Bay river, extending as far as the northeast quarter of section 19. Then it turns east, forms the summit of the ridge north of Glendale and Haze's creek, in the south part of sections 16 and 15, crosses Haze's creek near the north line of section 14, and caps the ridge farther east and northeast, passing through the southeast quarter of section 14, south part of section 13, etc. On the Golconda and Marion road it begins in the high hills, in the southwest quarter of section 8, township 12, range 6, and it forms the banks of Lusk creek, from the southwest quarter of section 34, township 11, range 6, upwards. Then its border turns northward, through section 34 and into section 27, and thence eastward through the north part of section 26, striking Little creek below the Independence road, in the north part of section 25, township 11, range 6. There, it seems to make a turn towards the north, but we find it again in the ridge near a branch of Grand Pierre creek, in the northeast corner of section 19, township 11, range 7, and in the west part of section 17. It crosses another branch of the creek near the middle of the south line of section 8, and extends eastward through the southeast quarter of section 8, and the west part of section 9, crosses the main creek near the south line of section 4, and finally forms the high summit on the dividing ridge, in the northeast corner of the county, in section 3, between the headwaters of Grand Pierre and Eagle creeks.

It covers the whole county north of this line, with the exception only of the small outcrops of the Chester formation, in section 5 and the northwest quarter of section 4, township 11, range 7, near the head of Grand Pierre creek, on the course of the diagonal fault. This whole area is roughly broken, and similar in all respects to the corresponding portion of Johnson county. The numerous creeks and branches have generally no bottom lands on their banks, and the hillsides present bold cliffs and a rugged, often picturesque, scenery. The arable lands are confined to the ridges, which are mostly narrow.

The coal seam at the base of the Conglomerate was found in the west, as well as in the east, part of the county. It is exposed in the breaks of a small branch of Haze's creek, in the northeast quarter of section 15, township 11, range 5, where it contains hardly more than two inches of pure coal, although its thickness is, at one point of the outcrop, increased to six inches by the intermixture of shales. It is intercalated in the very lowest beds of the sandstone, which is here partly somewhat conglomeratic, or, rather, contains numerous coarse, rounded grains of quartz; and a little lower down in the ravine the underlying Chester limestone crops out. Again, this coal is exposed in the bank of Little creek, a short distance below the crossing of the Golconda and Independence road, in the southeast quarter of section 24, township 11, range 6. It is said to be eight or ten incher thick, but perhaps not all of this is good coal. The sandstones are here intercalated with some shales, and dip at a high angle towards the southwest. A short distance farther up the creek the underlying Chester limestone rises from underneath the Conglomerate with a corresponding dip.

Some coal has been discovered in the hills within half a mile of this place, in the direction of the general trend of the strata, that is, towards the southwest, in the northwest quarter of section 25. It has never been opened, and is probably the same seam.

Farther west, in the hills on the west side of Little creek, in the southeast corner of section 23, a coal seam eight or ten inches thick is said to crop out in a formation of sandstones and slates. I am told that, occasionally, some coal has been got out there by blacksmiths, and also from another ravine, a quarter of a mile farther south.

I am not satisfied whether these coal seams are not considerably higher in the formation than the first one, although they undoubtedly belong to its lower portion. The same may be said of an outcrop of coal which I examined a mile farther north, also on a branch of Little creek, in the extreme southeast part of section 14. I found there shaly sandstones, underlaid with two or three feet of bluish-gray slates, and then coal, much mixed with slate. Both together are eighteen inches thick, where I measured them; but only the upper eight or ten inches appeared to be sufficiently pure to be burned. The lower portion was more a carbonaceous slate. The same seam crops out on the other side of the hill, in the north part of the northeast quarter of section 23. Another outcrop of stone coal occurs on a branch of Grand Pierre creek, in the northeast quarter of section 18, township 11, range 7, near Mr. Wallace's place. The thickness of the seam is variously stated to be from four to twelve inches. It is also in the lower portion of the Conglomerate, but can hardly be near its base.

On Little Bear creek, a branch of Lusk creek, I observed a thin seam of coal, in the extreme southeast part of section 29, township 11, range 6. It is from six to eight inches thick where it has been exposed, and is covered with some shaly strata, while the hills show numerous outcrops of the sandstone. This is in the lower part of the formation, but apparently far above its base.

The upper part of this formation crosses the county line from Johnson county, near the head of Little Bay creek. We then recognize it around the head of Bay river, and on its east side as far south as the south part of section 3, township 12, range 5; also on the Golconda and Marion road, near the head of Bear creek, in the south part of section 30, township 11, range 6, and around the head of Lusk creek, and some distance south between its branches. It also occupies the whole county north of these points.

The coal seam, separating the upper from the lower Conglomerate, was observed at the head of Miller's creek, a branch of the Little Saline, in the breaks on the north side of the high dividing ridge, near the middle of the south half of section 20, township 11, range 5. In the bed of the branch sandstone is in place, while the bank consists, to a height of 10 feet, of slaty shales. In these, a few feet above the sandstone, we find black, highly carbonaceous slate, changing into slaty coal, which appeared to be about one foot thick. In the outcrop it is too impure for general use, but might be better at other points. The sandstones below the coal lower down form bluffs along the branch. A short distance above the outcrop of coal there is a weak copperas spring in the bed of the ravine, which is probably caused by the sulphuret of iron in the shales and coal in this formation.

No coal has thus far been observed on the branches of Bay creek, except near Mr. Joel Claredy's in the northeast quarter of section 3, township 12, range 5. The outcrop is on the upper course of a small branch, and consists of some shaly slates of gray and black color, with 12 inches of slaty, impure coal. No other rocks are exposed close by, but lower down the branch, and all along Bay river, in this vicinity, the lower Conglomerate is exposed in high cliffs, while the ridge south of the coal, in the southeast quarter of section 3, presents a high rocky summit of peculiar appearance, which seems to be formed of the upper part of this formation.

At the head of Haze's creek, in the northwest quarter of section 31, township 11, range 6, some coal is also said to have been discovered, but no traces of it were exposed at the time of my visit, and I could not obtain any definite information in regard to it. I should expect, however, to find the Claredy seam either here or else a little higher up towards the head of the branch.

The only point on the head waters of Lusk creek, where coal has thus far been discovered, is at the place known as Henry's diggings, in the southeast corner of section 9, and along the east side of the northeast quarter of section 16, township 11, range 6, apparently, also, at the base of the upper Conglomerate. The point where the digging has been done, and the coal is thickest, is in the slope some feet above a dry branch. The coal is there from 20 to 24 inches thick, of pretty good quality, and rests on a blue or black carbonaceous and arenaceous slate, underneath which is sandstone. It is capped by several feet of blue and gray shaly rocks, which are followed by sandstones. A little higher up the branch its bed consists of the bottom slate and the bank of the coal, which is here rather thinner than before. It is capped by only a few inches of shale and then sandstone. Still a little higher up the branch, a few inches of coal are exposed, with sandstone above and below; and at one point the coal is divided into three different streaks in the sandstone. All three exposures show, evidently, the same bed of coal; and we have here another instance of mutability of this formation. Another outcrop of the same seam is on Mr. Moss' land, a little farther south, in the south part of the northeast quarter of section 16. If proper search was made by digging in the slopes near the base of the upper Conglomerate, the same coal seam would undoubtedly be discovered nearly all around the outcropping edges of this formation, except where it is locally crushed between the sandstones.

The other discoveries of coal in the county are on the waters of Saline river. Two miles north of Henry's diggings, in the north part of section 4, township 11, range 6, on a branch of Block House creek, fragments of coal and slate are said to be often washed out by rains, but the seam has never been discovered. Undoubtedly the same seam is exposed, however, half a mile north of the county line, on another branch of the creek, in the southwest corner of the northwest quarter of section 34, township 10, range 6. It is, perhaps, the same as at Henry's diggings.

The next outcrop of coal is high up on a ravine, on Caney branch of Little Saline creek, at Mr. Griffith's, in the northwest quarter of the southwest quarter of section 2, township 11, range 5. The summit of the hills consists of sandstones, while in the ravine some shales and slates are exposed, underneath which the coal has been laid bare by digging. I am told that the coal was 18 inches thick, and inclosed in black slate. A little lower down the ravine I noticed eight feet of shaly sandstone, and then solid ledges of sandstone. I am not quite satisfied that this coal seam is the one at the base of the upper Conglomerate, or whether it is higher in the series.

Half a mile southeast of the village of Stone Fort, just south of the Saline county line, at Mr. Stucker's, in the northwest quarter of the northeast quarter of section 5, township 11, range 5, some coal has also been discovered, on a branch of Pond creek, in a low hill. The highest rock there is a sandstone, several feet thick, partly in shaly layers, which dips several degrees to the north-northwest, underneath it follows some feet of shaly layers, then some slate and the coal, which was not exposed at the time of my visit. It seems to have been slaty and thin, although some persons state that it measured two and one-half feet. It is probably the same seam as the one described last. The sandstone above the coal forms a low bluff ledge along the ravine, a few rods lower down, and I there noticed signs of the coal, but it very soon dips underneath the water level.

Economical Geology.

Coal.—From the foregoing pages it appears that coal has been discovered at numerous points in Pope county, but that it forms generally thin and irregularly developed beds of merely local importance. Those divisions of the Carboniferous formation which contain the rich strata of coal farther north and northwest, in the State, do not extend into this county, and we find here merely the lower numbers of this formation, which are far less productive.

The following is a tabular enumeration of all the points where stone coal has been discovered in the county:

Number.	Owner, Neighbor, or Name of Place.	Township.	Range.	Section.	Quarter.	Thickness *Inches.*	Remarks.
1	Stacker's	11	5	5	N.W. of N.E.	12(?)	Some persons stated the thickness
2	Griffith's	11	5	2	N.W. of S.W.	18	[at thirty inches.
3	Ely Warren's	11	5	20	S. half	12	
4	Henry's	11	6	16	N.E. of N.E.	23	These three are different outcrops
5	Henry's	11	6	9	S.E. of S.E.	A few in	of the same coal seam.
6	Moss'	11	6	16	S.E. of N.E.	Thin	
7	Branch of Block-house creek	11	6	4	N. half		Loose fragments of coal in branch.
8	Head of Haze's c'k	11	6	31	N.W.		Traces of coal
9	Shaffelberger	11	6	29	S.E.	6 or 8	On Little Bear creek
10		11	6	14	S.E. corner	8 or 10	On a drain of Little creek
11		11	6	23	N. of N.E.		The same as the last one
12		11	6	23	S.E. corner	8 or 10	Reported to me. I did not exam-
13		11	6	26	E. of N.E.		ine them.
14	John A. Wasson's.	11	6	24	S.E.	8 or 10	On Little creek
15		11	6	25	N.E. of N.W.	Thin	
16		11	6	35	S.W. of S.E.	Thin	Reported in the bluffs of Little c'k.
17		11	6	36	S.E. of S.E.	Quite thin	seam; in a well on a ridge
18	Wallace's	11	7	18	N.E.	Variously	reported, from 4 to 12 inches
19	'Squire Johnson's.	11	7	20	N. of N.W.	16	Rotten, impure coal
20	Smoot's	11	7	16	S.W. of N.W.		Fragments of coal on the slope,
21	Weston's	11	7	21	S. of S.E.	6	Shaly coal....[under roots of trees.
22	Joel Claredy's	12	5	3	N.E.	12	
23		12	5	15	S.E. of N.E.	2 to 6	On a drain of Haze's creek
24	Dr. Koch's	12	6	32	S.W. of S. E.	12 to 22	On Lusk creek
25	Anderson's	12	6	14	W. half	18 or more	
26		12	7	4	(?) S.W.	Thin	Reported.
27		12	7	17	Mi'dle of N. line	½ to 4	
28	Old Mill	13	5	4	N.W. of S. W.	At least 4.	On Sugar creek
29		13	6	8	N.E. of S. E.	A few	
30	Gord. Thompson's	13	6	12	S.W.	18 inches o	f coal and slate in a well.

Of this list, Nos. 21, 26, 27, 28 and 30 are thin streaks of coal in the Chester formation, which are entirely unpromising. I mention them only on account of the scientific interest attached to them, and because some persons might build fallaceous hopes on them, or any other outcrops which might, in future, be discovered in similar situations.

The other numbers all occur in the Conglomerate. Of these, Nos. 9, 10, 11, 12, 13, 14, 15, 16, 19, 20, 23, 24, 29, and probably, also, 25, 17, and perhaps 18, are different outcrops of apparently two, perhaps three, or even four coal seams at the base and in the lower portion of this formation. They are, at most points, too thin and impure to be worked with profit, even on a limited scale, for the local supply of the neighborhood, and present a great degree of irregularity in their development, changing rapidly in thickness and quality. At a few of these points only we find the coal sufficiently thick to be worked profitably, and at the same time of good quality—such as Nos. 24 and 25. How far this increased thickness of these seams extends can not be judged before hand with the least degree of certainty; it can only be ascertained by digging, for we have seen that No. 24 changed entirely within a few yards. In the course of time the same strata will be laid bare at many other points, and then we may expect to find them at some of these equally thick or thicker, so that they will afford an abundant local supply of coal.

The numbers 3, 4, 5, 6, 7, 8 and 22 appear to be different outcrops of the coal seam between the lower and upper Conglomerate, and perhaps Nos. 1 and 2 form the continuation of the same layer, but I rather think they are from a higher horizon. These strata are a little more promising than those in the lower part of the sandstone, as may be seen from the foregoing table; and we know, from the reports on the counties farther west, that the continuation of this seam in those counties can be profitably worked at various points. Still the thickness of the stratum is quite variable, and it is generally too thin to pay for working at any considerable depth. The quality of the coal is frequently inferior, and it is at most points considerably charged with sulphuret of iron, and it is also slaty. As long as timber is so abundant in this district, and good coal can be obtained at a moderate cost from other points these inferior coal strata will hardly be worked extensively.

Of course the coal seams might easily be traced from the points at which they have been discovered, by following the outcrops of the strata around the hills, and digging through the superficial deposits at convenient points. In some places the coal seams might possibly be found thicker than in any of the enumerated outcrops, but it would be unsafe to calculate on that, and they would undoubtedly preserve their very irregular character.

Iron ores.—Iron is largely disseminated through the rocks of Pope county, especially through the sandstones of the Conglomerate formation, in which it is at many points sufficiently concentrated to form iron ores, generally in the form of the hydrous peroxide (the brown hematite or limonite ore). We find this ore principally in two horizons, in the lower part of the upper Conglomerate and near the base of the lower, close to the junction of the latter with the uppermost layers of the Chester limestones. The chalybeate waters percolating the sandstone were evidently decomposed on nearing this limestone, and the iron precipitated. The iron ores, having been deposited within the strata of sandstones, are consequently mixed with sand to a greater or less degree. At some points the sandstones are merely impregnated with the ore; at others we find pieces of nearly pure ore, interspersed with sandy portions; while at some the iron appears to prevail to such an extent as to form rather pure ores, with only small admixtures of sandy masses. The sand is a very unwelcome admixture to iron-masters, because, being intimately mixed with the ore, it easily combines in the furnace with the iron and forms slag, instead of separating in a metallic form, a tendency which can only be checked by a very large addition of lime and an increased heat of the furnace. This renders the process more expensive and produces other unwelcome results.

One of the places where the ore is most abundant in the upper Conglomerate is just south of the summit of the dividing ridge, near the head of Little Bay creek, close to the line of Johnson county, in the northwest quarter of section 30, township 11, range 5. There I observed large pieces of partly pure, partly highly arenaceous ore, lying loose on the slope; and I noticed similar points farther east, especially on the ridge near the upper course of Bay creek, in the southeast quarter of section 13, township 11, range 5, and farther on. Ferruginous layers of sandstone are frequently exposed in this horizon, but I have never yet seen the ore exposed in a solid bed, which it would nevertheless seem to form at some points.

The iron ore at the base of the lower Conglomerate seems to be more concentrated, and, consequently, purer. Some of the best samples of the ore were obtained just below the summit of a high ridge east of Lusk creek, near the northwest corner of section 10, township 13, range 6. The slope consists of the upper Chester limestone, while the summit is formed by the Conglomerate. This ore was found tumbling near the junction of the two formations, which is not exposed. It would not require a very great expenditure of money and labor to ascertain, by removing the soil and detritus, whether the ore there forms a regular bed or occurs merely in detached masses. It would seem to form a regular stratum, because we observe the ore at many other points at the same geological level—for example, a mile farther northwest in the bluffs on the west side of Lusk creek, in the south part of section 5, township 13, range 6, and at other places.

In the northeast quarter of the northwest quarter of section 25, township 12, range 6, at the abrupt edge of the continuation of the same summit, the lowest layers of the sandstone are considerably ferruginous, full of small nodules of the iron ore, but the ore is scattered through a great thickness of rocks, and not sufficiently concentrated to be available. Some miles farther northeast, in the southeast quarter of section 29, township 11, range 7, much tumbling ore was observed in an analogous position; also, on Haze's creek, in the south part of section 11, township 12, range 4, and at other points. Nowhere in this county did I observe this ore actually exposed in a regular stratum in the rocks; but a short distance beyond the county line, in the northwest corner of Hardin county, in section 2, township 11, range 7, such a bed of ore is exposed in a branch of Grand Pierre creek, at the junction of the Conglomerate and Chester formations, and I have observed a similar ore bed in the same position, far to the northwest, in Jackson county, on a branch of Kincaid creek.

In order to determine whether the iron ores of Pope county are developed in sufficient quantity, and of sufficient purity to be made available for the manufacture of iron, it would be necessary to prove the proper strata by a series of systematically conducted excavations. Although there is a vast amount of timber in the county, the principal fuel for high furnaces would have to be stone coal, because the broken character of the county would render the transportation of charcoal from a distance too costly; and besides, most of the lands are held in small tracts by farmers. The vicinity of a good coal bed, or facility of transportation to the Ohio, or to a railroad, would then be the conditions required to make even a rich ore bank profitable.

Lead Ores and Fluor Spar.—Lead ores have been discovered at several points in Pope county, but thus far only in small quantities. They are generally accompanied by fluor spar, a mineral which occurs only in Pope and Hardin counties in this State, nor, I believe, in any other of the Northwestern States, except in a similar connection south of the Ohio river, in Kentucky. Both of these minerals appear to occur only in such places where the strata have been fractured by faults or violent upheavals. The deep fissures thus formed either admitted the minerals from a great depth, and enabled them to permeate the fractured strata nearer to the surface, or else these fissures induced a segregation of these minerals from the fractured strata themselves, in which they may have before been diffused, in such a state of mechanical division, or dilution, as to be imperceptible. The limestones are by no means the exclusive, but they are the favorite depositories of the galena, and therefore the heavy limestone formation underneath the Chester series is the richest in galena in this district. It is this formaticn which contains the lead ores in various parts of Hardin county. Wherever these minerals are present, the adjoining rocks have undergone a mineralization, the sandstones have become firmly cemented, and exhibit a transition into quartzite; while the limestones have become more or less crystalline, are veined with spar, and have, in some cases, lost all semblance of their former state, and of the unaltered rocks close by.

In the south part of Pope county, fluor spar has been discovered in altered strata of the sandstones No. 8 of the Chester series, in the vicinity of the fault near the mouth of Big river, as I have stated in a former report.

In the same strata some galena has been found at the Stockton ford of Grank Pierre creek, in the west part of the southwest quarter of section 22, township 12, range 7. There the sandstone No. 8 forms the bed and bank of the creek. It is traversed by numerous irregular fissures, whereby the lines of stratification are entirely obliterated. The general dip of the strata is undoubtedly to the westward, and in this sandstone we find, within a limited area, bunches of calcareous spar and numerous small granules of galena. Some holes have been dug on the eastern bank, in which blue shaly strata were struck underneath a few feet of sandstone, but no farther discoveries were made; nor is it likely that paying quantities of galena will ever be found there. The upper layers of this sandstone are those exposed at the ford. It is considerably thick in this vicinity, probably some 200 feet; and the galena is, most probably, sparingly disseminated in the sandstone, although very likely it is contained in larger quantities in the underlying limestone. The limestones above the sandstone are not exposed close to the ford.

About four miles farther north, the St. Louis limestone rises to the surface near the east line of Pope county. Little over a mile east of the county line, we observe in this vicinity a centre of upheaval where Devonian rocks are brought to the surface, and whence the strata dip strongly in every direction for miles around. In the upper portion of these tilted limestones, we find some fluor spar and galena, both in Pope and Hardin counties, in the vicinity of the county line, and various excavations have been made in search of lead ore at a point where the fluor spar or calcareous spar had been observed on the surface. In 1849, this vicinity was explored and proved by various parties, who did not, however, obtain satisfactory results. The most extensive of these excavations is situated on a branch of Grand Pierre creek, in the southeast quarter of section 22, township 11, range 7, a quarter of a mile west of the county line, not far from Mr. Baldwin's. There, on the north side of the branch, a drift was carried forward 300 feet into the hillside, all through this formation northward, in the direction of its trend. Half way between the mouth and the end of the drift, a shaft was sunk about 60 feet below its level. No regular vein nor even a well defined mineral-bearing opening was discovered. A part of the limestone was somewhat altered; it contained single crystalline masses and small irregular veins of white and blue fluor spar, with larger or smaller particles, and chunks of galena, and some blende. The amount of lead ore thus obtained was not large, and the whole aspect of things did not warrant a further prosecution of the work. Nearly opposite the mouth of the drift, on the south bank of the branch, I observed veins of calcareous spar in the limestone. This point, too, was proved, but soon abandoned as unpromising.

Half a mile farther northeast, a short distance east of the Hardin county line, in the northwest quarter of the southwest quarter of section 23, township 11, range 7, a trial shaft was sunk, and some specimens of a green mineral obtained, which proved to be the white carbonate of lead, tinged green by a minute admixture of carbonate of copper, which are both evidently products of the oxidation of the sulphurets of these ores. Hereabout, and also in the same formation at Rosiclare, the copper ores occur only in very small quantity, so that they are liable to be overlooked entirely.

White, violet-colored, or light greenish fluor spar was further noticed at several points a little farther south, in the same strata, at all of which places it has been dug into, especially just east of the county line in the northwest quarter of section 26, township 11, range 7; then at the Hogg place, in the southwest quarter of section 26 (?), and west of the county line, in the northeast quarter of section 34, and near the center of the east half of section 34, township 11, range 7. At this latter place some galena was observed, together with calcareous spar. At none of these points was a definite lode struck, but the minerals seem to have been scatteringly disseminated through the rock, and not in sufficient quantity to justify the continuation of the explorations.

All the other points at which fluor spar and galena have been discovered in the county are in the Chester formation, in the vicinity of the fault, which passes diagonally from northeast to southwest through the county. The best explored point is on the west side of Lusk creek, just above the crossing of the Golconda and Marion road, in the southeast quarter of the northeast quarter, and the northeast quarter of the southeast quarter of section 16, township 12, range 6, and is known as Whiting's diggings. They are situated in what appears to be the uppermost member of the Chester series, which consists of limestones with intercalations of shales. The limestone is locally altered; it has become crystalline, and contains masses of calcareous spar, with fluor spar, galena, zinc blende, and traces of copper pyrites, very much as at the above named points, where the St. Louis limestone is similarly mineralized. Some considerable excavations have been made, but apparently with indifferent results. I could not obtain a satisfactory account of the progress and results of the work; but it seems that the ore was not accumulated in a vein, but disseminated through the rock in single chunks, together with the other minerals. The fault must pass within a few yards of the diggings, and east of them, and the mineralization of the limestone does not appear to have extended to any great distance from the fault. On the west side of the narrow hill the limestone is neither altered nor mineral bearing. The mineralization most probably extends northeastward in the neighborhood of the fault, although the fissure or fault itself may not carry any galena. On digging in any other direction the limestone would soon be passed through, and the underlying shales reached, which are intercalated between the different limestones. The galena is not likely to extend into the shales, although it may be found again beyond them in the next limestone. The fact that the single bodies of limestone are not thick, and are frequently interrupted with shales, and lower down also with sandstones, reaffirms me in the conclusion that the ore deposit, thus interrupted, would not be likely to be very extensive, even if it was rich at one point, in these Chester strata. By penetrating to a great depth near the fault, we could get to the lower Chester limestone, and finally to the St. Louis limestone. I should not be surprised if considerable lead ore was stored in this latter formation, which seems to be the lead-bearing rock of this district, and that the lead ores near the surface were merely a scattering outlier of the hidden riches. But this limestone is at least five or six hundred feet below the surface here, and the expense of sinking to that depth would not be justified, by the present indications, from the natural exposures of the strata.

A mile northeast of the first digging, also on the west side of Lusk creek, and close to the line of the fault, in the southwest quarter of section 10, the Chester limestone is again veined with calcareous spar, and tumbling masses of the overlying sandstone are somewhat altered, cherty, and contain some fluor spar. Here, too, some holes were dug in the hope of striking a vein of galena, but apparently without success. Not much labor seems to have been expended here, and the work has not been done systematically.

A similar point is a mile farther northeast, in the hills, in the forks of Lusk and Little creeks, in the southeast quarter of section 3, township 12, range 6, of which I have already spoken in describing the Chester strata in this vicinity. No valuable discoveries were made here, either, although some galena is said to have been found with the fluor spar. At other points of this neighborhood, even nearer to the fault itself, no signs of mineralization were discovered. Although the prospects are not very promising, it would be quite interesting, and, possibly, remunerative, to prove this whole district more systematically than has been done heretofore.

Some miles farther northeast, near the line of the same disturbance, close to Mr. John A. Wasson's, in the northeast quarter of section 25 (?), township 11, range 6, I found some of the Chester limestones somewhat veined with calcareous spar, but no traces of fluor spar or galena, which I had been led to expect from current reports. North of this, in the southeast quarter of section 13, township 11, range 6, where the same strata appear to be similarly disturbed, loose masses of sandstone cover the hills, and contain, at one point, small veins of calcareous spar, and are somewhat altered. Here a hole was dug many years ago in search of galena, with apparently no satisfactory result.

At all the above named points there were more or less indications of the presence of valuable ores, although it appears, from the preceding remarks, that the hopes founded on them have not, thus far at least, been realized. On a branch of Haze's creek, in the northwest quarter of section 24, township 12, range 5, some years ago, a hole was dug to the upper Chester strata in search of mineral, by a Mr. Bailey. His expectations appear not to have been well founded; at least I could not see anything that would, in the least, point to the presence of any valuable minerals.

The lead ores of Pope county have not yet been tested for silver, but most probably they contain a small proportion of this metal, like the Rosiclare galena of Hardin county.

Mineral Springs.

There are quite a number of springs in Pope county, the water of which contain sulphate of iron (copperas) as its principal mineral ingredient. They are commonly, although improperly, called sulphur springs, which name is generally understood to designate springs containing sulphureted hydrogen. These copperas springs may be recognized at once by the yellowish-brown deposit of hydrous oxide of iron (iron rust) which they deposit. They originate from the oxidation of the sulphuret of iron, disseminated through the Conglomerate and Chester formation, and through our coal seams, and occur at numerous points throughout these formations. The other ingredients of these waters, wherever they contain any other in appreciable quantity, are salts of magnesia, lime, etc.

The most noted of these springs in Pope county are: one at the head of Miller's branch of Little Saline creek, on the south side of section 20, township 11, range 5; one near Mr. John A. Wasson's near Little creek, in the northeast quarter of section 25 (?), township 11, range 6; and the Dixon springs, near Hill's branch of Sugar creek, north of the lower Golconda and Vienna road, in the southwest quarter of section 16, township 13, range 5. This latter spring has some reputation as a watering place, and is frequently visited by persons from Paducah.

The medical properties of the waters of these springs are the same as those of the springs in Johnson county. The iron salt in the water, in the first place, stimulates the system and operates on the bowels; but when it is used longer than a few days, its astringent qualities gain the upper hand, and its further use is then in most cases, to say the least, not advisable. Some physicians are of the opinion that the iron of the water is particularly beneficial in this climate, where miasmatic influences prevail, and the composition of the blood is affected by them, and requires a corrective afforded by the iron. An artificial compound of iron would, however, in most cases, be used more conveniently, and to better effect.

Efflorescence of Salts.

In the bluffs of the Ohio river, under overhanging cliffs of one of the Chester sandstones (No. 6 of the series), I observed the efflorescence of a salt covering the rock and filling crevices between shelly portions of the sandstone. This is about three miles above Golconda, below a vineyard belonging to Dr. H. Koch, of St. Louis, in section 8, township 13, range 7. These salts proved, on examination, to be natural Epsom salts, the hydrous sulphate of magnesia, the *Epsomite* of the mineralogists, which has been observed in similar locations in several of the adjoining States, and at other points in Illinois.

A similar efflorescence was observed in the bluffs of Bay river, in the northeast quarter of section 32, township 13, range 5, apparently in the same Chester sandstone, where the salt is even more abundant. It is eagerly sought for by wild and tame animals.

This *Epsomite* occurs hardly in sufficient quantity to be of any value, but I mention it because it has been frequently mistaken for saltpetre, and on account of the scientific interest attached to its discovery.

Clay.

I saw several samples of clay from different parts of the county, which, if we may judge from their appearance alone, might be serviceable for making ordinary potters' ware. One of them was in the hands of Mr. Weston, who lives in section 22, township 11, range 7; but the most important deposit of this kind is the white clay which is found at the lead diggings, in the east part of section 16, township 12, range 6, near Lusk creek. The pure portions of this clay—some of it is mechanically mixed with extraneous impurities, which deteriorate its quality—are purely white, or have a slightly bluish tint. It is from uneven to subconchoidal in fracture, without the least grit, unctuous to the touch, and adheres vigorously to the moist tongue. When moist it is translucent, and by long exposure and working it becomes plastic, which it is not when it is newly dug. It is a rather pure silicate of alumina, free of iron, magnesia and other substances which would affect its color and fusibility. It withstands a very intense furnace heat without showing signs of melting, and is, therefore, a very superior article for manufacturing queensware. I have seen articles, said to have been manufactured from it, of very superior quality. If we consider that the earths of all the famous porcelain manufactories of the old world are artificial mixtures of various clays, etc., it appears reasonable to expect that this clay could serve as the principal ingredient for a similar manufactory. It has been claimed to be kaolin or porcelain earth, but this is an error. Kaolin is a silicate of alumina formed by the decomposition of feld spar, while the clay in question, although it may be similar to kaolin in composition, is not formed in that way.

A complete analysis of this earth has not yet been made, but a series of preliminary tests which I have instituted have proved its purity and the difficulty of melting it. Its less pure portions might be advantageously made into fire brick.

It is exposed on the side of the hill, about 15 feet thick; but the excavation is not sufficient to determine the true character of the deposit. Perhaps it is an altered shale of the Chester series, intercalated between the limestones, which has assumed its present condition through the same agencies which caused the mineralization of the limestones, at the time when the galena and fluor spar were deposited. In this case it would form a regular stratum, although some distance in the hill it would gradually change to an ordinary shale, such as it was before it was altered. Perhaps, however, it is only a deposit on the side of the hill and in immediate connection with the fault which passes there through the formation. The value of this clay depends in a large degree upon the quantity to be obtained, and upon the proportion between the entirely pure and the mixed portion of it, which can not be determined except by farther digging. It can be wrought easily, and is accessible by a good road. Its distance from the Ohio is about 10 miles.

Building Materials.

Pope county is rich in ordinary building materials, in sandstones and limestones, for plain masonry and for heavy work, such as culverts, bridges, wharves, and the like. For the latter purpose many boat-loads of sandstones, from the bluffs below Golconda, of the Chester sandstone No. 8, are being taken to Cairo. This point has been selected on account of the facility with which the rock can be quarried and loaded on flat-boats; but many other localities along the river would afford equally good material.

The sandstones of the Conglomerate are not generally good building stones, but single layers of this formation are excellent. Thus fine building stone might be quarried in the lowest portion of the Conglomerate on the slope of the ridge northwest of Glendale, in the northwest quarter of section 20, township 12, range 5, and at other points. The sandstones of the Chester series afford a vast amount of good building stones in various parts of the county, and some of these strata are also suitable for window-sills, door steps and similar work, although few would seem to be at all adapted for ornamental work. Many of the limestones of the Chester series are also good for ordinary building purposes, while a portion of them is too hard and work too badly to be of much use. The St. Louis limestone formation, however, which crops out at some points near the Hardin county line and the lowest Chester limestone, at the base of the Ohio bluffs, below Golconda, contains layers of a very superior rock, which dresses finely and is very durable. It has been quarried at Mr. Foot's place, on the bank of the Ohio, three miles below Golconda.

The higher Chester limestones are generally too impure and siliceous to be burnt to lime, but at some points they can be made to supply the local demand with a dark-colored quick-lime, which is good for making mortar. The limestones of the St. Louis formation are generally purer, and part of them make the very best white lime. Sand for building purposes abounds throughout the county.

Millstones.

The lowest strata of the Conglomerate form the summit of the extreme southwest spur of the ridge, which extends between Bay river and Haze's creek, near the northwest corner of section 20, township 12, range 5, a mile northwest of Glendale. There is one layer of these sandstones which consists of siliceous grains of sand, which are firmly cemented together without losing their roughness. This rock can be used for millstones. In former years quite a number of millstones were quarried on this summit, to be used in the small country mills of the vicinity, and some are said to have been taken from this point as far as Vandalia.

Agriculture.

I need not say anything in relation to the soils and agricultural resources of Pope county, except that my remarks in regard to Johnson county apply exactly to this, also. The geological formations, the surface configuration, the growth of timber and the agricultural features are the same in both.

Indian Remains.

I can not close these remarks without referring, as a matter of general interest, to the ancient works of the aboriginal inhabitants of this country. Arrow heads, stone tools, and such like relics, are found in many places; and the Indians seem to have preferred here, as elsewhere, for their burial places, the high points of the bluffs, which afford an extensive view over the surrounding country. Numerous small mounds or piles of rock mark these points.

I also observed one of their fortifications of the kind generally designated as *stone forts*, by the present inhabitants. This fort is on the west side of Lusk creek, a short distance below the mouth of Bear creek, near the southwest corner of section 34, township 11, range 6. Lusk creek here runs through a narrow gorge, between high cliffs of sandstone, forming a sharp bend. In this bend projects a narrow spur, lower than the main ridge, with rocky vertical sides, which is only accessible from the direction of the main ridge, with which it connects by a narrow neck. Across this neck the Indians had built a wall of rocks, loosely piling the numerous tumbling blocks of sandstone which covered the hill. The spur beyond this wall was then easily defensible, and evidently served as a place of refuge in times of danger. From the fort they could descend to the creek for water by a difficult avenue, which it was utterly impossible to scale from below if it was defended from above. Thus the occupants of the fort could resist the attacks of a superior force, and if not entirely surrounded and largely outnumbered, so that they could be cut off from the creek, they would hold out as long as they had food. Undoubtedly many a fierce battle was waged around these defenses.

CHAPTER XVIII.

ALEXANDER COUNTY.*

This county forms the southern extremity of the State, and is bounded by the Mississippi on the west and south, by the Ohio and Cache rivers on the east, and by Union county on the north. It includes an area of about 220 square miles, more than one-half of which is alluvial bottom land, occupying the borders of the streams above named, and in the southern portion of the county these bottoms extend entirely across it, from the Cache river to the Mississippi. The bottom lands are generally flat, and are interspersed with cypress ponds and marshes, and a portion of them are too wet for cultivation without a thorough system of drainage, and are subject to annual inundations from the floods of the adjacent rivers. The most elevated portion of these lands, however, has a light, rich, sandy soil, and is susceptible of a high state of cultivation. They are heavily timbered with white oak, swamp white oak, bur oak, Spanish oak, yellow poplar (tulip tree), shell-bark and pig-nut hickory, ash, beech, and white and sugar maple, all of which are found on the highest bottoms, and indicate a soil sufficiently dry for cultivation. The swampy lands are characterized by the growth of the cypress, sweet gum, pecan, tupelo gum, cottonwood, willow, etc.

In the northern portion of the county, the Silurian and Devonian formations predominate, and the surface is roughly broken, and the arable lands are mostly confined to the creek bottoms and the more gentle slopes adjacent to the streams. The river bluffs above Santa Fé are generally steep and rocky, often presenting towering cliffs, or rugged chert hills, entirely destitute of timber, or but partially covered with scrubby trees and shrubs that find a scanty foothold in the rocky surface. The southern boundary of these older formations is

* This and the three following counties are reported in part from the observations of Mr. Henry Engelmann. A. H. W.

also defined by a line of bluffs, similar in their appearance to those on the Mississippi. These extend about half way across the county, in the lower part of township 15 S., and then trend off northeastwardly, leaving a bottom from three to five miles in width between them and the Cache river. These bluffs appear to have been washed by a powerful stream at some former period, and no doubt owe their origin to the same cause that excavated the valley of the Ohio.

The following section illustrates the relative position and thickness of the formations in Alexander county:

	20 to 30 feet.	Alluvium.
	50 to 60 feet.	Tertiary.?
Lower Carboniferous.	7	Lower Carboniferous limestone (?) and Siliceous shales.
Devonian.	40 to 50 feet.	Black Slate, passing into Siliceous shales and flint rocks.
	7	Hamilton, Corniferous and Onondaga groups.
	250 to 300 feet.	Oriskany group, Clear Creek Limestones.
Upper Silurian.		Band of brown Siliceous shales.
	250 feet.	Lower Helderberg Limestone.
Lower Silurian.	150 feet.	Cincinnati group, limestone, shale and sandstone.
	75 feet.	Trenton Limestone.

The alluvial deposits of this county, as we have already remarked, cover the lower portion of the county, from the south line of township 15 south, to the Ohio river; they also skirt the western bank of Cache river, nearly to the north line of the county, and occupy a large portion of township 14 south, range 3 west, in the northwest corner of the county, forming a wide bottom between the limestone bluffs and the Mississippi. They consist of irregularly stratified beds of sand and loamy clay, alternating with vegetable humus, similar to those seen almost anywhere along the banks of our large rivers. Their greatest thickness above the low-water level of the river probably does not exceed thirty feet.

Tertiary (?).—The outcrop of this formation, as we have elsewhere remarked, is restricted to a few of the most southern counties in the State, and although we have obtained fossils of this age from localities much further north, we have been unable to identify the strata from which they came. This group forms a narrow belt across the southern portion of the State, overlying unconformably the most southern outcrops of the palæozoic rocks. Beginning on the Mississippi, just above Santa Fé, in this county, it forms a narrow belt extending south to the alluvial bottoms, and very probably underlying these, it extends eastward through the southern extremity of Pulaski, Massac and Pope counties, terminating on the Ohio river, along the lower course of which it forms numerous outcrops. The best exposure of beds belonging to this group, in this county, we found near Santa Fé, on a small creek, which empties into the Mississippi just above the village. They consist of a series of sandstones and shales, with variegated clays, which were overlaid by a bed of ferruginous Conglomerate precisely like that on the Ohio river, in Massac county. These beds form the following section here:

Ferruginous Conglomerate	4 feet
Yellowish sand and sandy shale	15 to 20 "
Variegated clays	6 "
Sandstone and shale	25 to 30 "

These beds dip strongly to the southward, and probably plunge beneath the alluvium of the Mississippi bottoms. Specimens of siliceous wood are common in this vicinity, and may be picked up in the ravines intersecting these beds, but no other fossils were obtained from the group in this county.

The variegated clays are vermilion-colored, purple and yellowish, though sometimes nearly white. There are some spots of vermilion in the sandstone and shale, though the prevailing color is an ashen gray. These beds form the bluffs of the river for about a mile above Santa Fé, when the shales of the Cincinnati group come in, and a short distance back from the river these are overlaid by the succeeding limestone. Mr. ENGELMANN mentions the occurrence of a thin seam of lignite close to Santa Fé, but does not give its thickness or its relative position in the group, but we did not meet with it in our examinations in this vicinity.

Lower Carboniferous Limestone and Siliceous Shales.—No outcrop of limestone, that could be properly referred to the Carboniferous period, was seen in this county; but Mr. ENGELMANN describes outcrops of this limestone on the east side of Mill creek, in Pulaski county, and suggests that it may possibly extend further west into the northeast corner of Alexander. Siliceous shales, probably of the age of the Kinderhook group, occur in township 14, range 1, on Grimes creek, and outcrops are noticed by Mr. ENGELMANN on sections 6 and 7. These siliceous shales are associated with a loose chert, that has probably been derived from an overlying limestone, the calcareous portions of which have entirely disappeared by decomposition, under the influence of atmospheric agencies. The exposure of these shales did not admit of an accurate measurement at any of the outcrops that were seen.

DEVONIAN.

BLACK SLATE, HAMILTON AND CORNIFEROUS BEDS.

The Black Slate is reported by Mr. ENGELMANN as outcropping on a branch of Caney creek, in the eastern part of section 17, township 14, range 1 west, the slope above being covered with siliceous shale and chert of the lower Carboniferous series. This formation is associated, in this county, with some cherty, siliceous limestones, which pass into a compact, brittle flint-rock, that probably represents the Hamilton and Corniferous beds, if they are represented at all in this county. These last named beds are quite siliceous and cherty in Union county, and probably thin out and disappear to the southward, becoming more and more siliceous and cherty in that direction; for, in Tennessee, north of Nashville, where we have had an opportunity of examining the beds at this horizon, the Black Slate is found immediately overlying the Upper Silurian limestone, with no indications of the presence of the intervening limestones of Devonian age, which we find in Illinois, and which are here more than 300 feet in thickness.

ONONDAGA GROUP.

Underlying the siliceous rocks above described, we find in this county some striped siliceous shales, which, in this region, are known under the local name of "Calico rock," and these pass downward into a white quartzose massive sandstone, sometimes so soft and incoherent in its structure that it readily crumbles to sand under a blow of the hammer, while at other points it becomes exceedingly hard, and partakes of the characters of a true quartzite. The entire thickness of this sandstone, with the striped shales above it, probably will not exceed an average of fifty feet. The sandstone is locally fossiliferous, and its characteristic species in Union county, where it has been more thoroughly examined, will be given in the report on that county. Mr. Engelmann estimates the thickness of the sandstone at not more than thirty feet, and it is seldom that a thickness of more than fifteen or twenty can be seen at a single outcrop. The principal exposures of this sandstone are the following: On the head-waters of South Ripple creek, near the north line of section 8, township 14, range 2, and continuing thence southward to the hills on the upper course of Sexton creek, on the southwest quarter of section 21, and the northwest of section 20. Its outcrop also continues round the head of Sandy, and forms a part of the high ridge east of that creek, and with a northeastward dip it descends to the edge of the flats on the southwest quarter of section 19, township 14, range 1 west, and then disappears below the water level. Its most easterly outcrops are the one last mentioned, and one on the northeast quarter of the same section, on the Jonesboro road, between Jackson and Caney creeks, on section 24, and the southeast corner of section 23, township 14, range 2, and also on James creek, not far from the Union county line, on section 2 of same township, to the east of which this sandstone disappears below the creek level.

The overlying siliceous shales are also but seldom well exposed, but were seen at the edge of the flats west of Caney creek, on the northwest quarter of section 20, township 14, range 1 west, in the lower part of the steep hills on the east side of the Jonesboro road, near Caney creek, on the southwest quarter of section 18, also on the northwest quarter of the same section, also on the southeast quarter of section 12, in township 14, range 2 west, and on the hills north of Grimes creek, near the Union county line, on the northeast quarter of section 2, in the same township, and thence descending eastward along the creek to the east line of section 2, and perhaps even to section 6 of the adjoining township 14, range 1 west. From thence it extends westward, probably nearly as far as the sandstone, but the outcrops were generally hidden in the slopes of the hills. These siliceous shales have afforded no fossils, as yet, to enable us to determine precisely to what part of the Devonian age they most properly belong, but their immediate connection with the sandstone, which, from its fossils, appears to represent the Onondaga limestone, has induced us to include the shales also in the same group. The out-crop of this sandstone, and the siliceous shales associated with it, cause a decided change in the topographical features of the country, wherever they appear; the high precipitous hills, formed by the cherty limestones below. disappear, and the country becomes comparatively level, and better adapted to agricultural purposes.

ORISKANY GROUP.

Clear Creek Limestone.—In the first volume of the original report on the Geological Survey of Illinois, we included, under this name, the great mass of cherty and silico-magnesian limestones, which were, found in the southern portion of the State, immediately above and resting upon strata of Lower Silurian age, that were referred without hesitation to the Cincinnati group of our general section, because we were unable to discover any decided change in the lithological characters of the rock that would enable us to fix with certainty a line of division between what were evidently beds of distinct geological age. Subsequent investigations, and a more complete collection of the fossils which belonged to the upper and lower divisions of the mass, led to the conclusion that the upper division represented, at least in part, the Oriskany period, and the lower, the Delthyris shale beds of the Lower Helderberg series of the New York Geologists. Hence, in the second volume of the Illinois Report (see Introduction, p. viii.), we separated the beds in accordance with the palæontological evidence, although still unable to find any well marked line of separation on lithological grounds. More recently we have again visited Perry county, in Missouri, where this group is well exposed, and in the hills to the southwest of Wittemberg we found a bed of calcareous shale, only a few feet, apparently, in thickness, and occupying a stratigraphical position about midway in this group of cherty limestones. At the lower terminus of the exposure of these rocks, below Bailey's landing, where they consist only of the lower division of the series, we also observed that the limestones were succeeded apparently by a similar shale, in loose masses, strewn along the shore of the river, immediately below the point where the fossiliferous beds of limestone dipped below the river level. This bed of shale did not appear to attain a thickness of more than ten or fifteen feet, and, I have no doubt, forms the line of demarcation between the Upper Silurian and Devonian strata.

In the section of the rocks of Alexander county, given on a preceding page, we have included the cherty limestones above this brown shale in the Devonian series under the name of Clear creek limestone. At some localities it is quite calcareous, and consists of alternations of thin bands of siliceous limestone and chert, passing locally into heavy beds of chert. In this county limestones are less abundant in this group than in the counties north of this, and it is here almost entirely made up of chert rock, and cherty siliceous shales, which form, by decomposition, a white plastic clay, locally known as "Chalk Banks." Its maximum thickness in this portion of the State may be estimated at about two hundred and fifty feet, but no locality was seen in this county where it could be accurately measured. It caps the river bluffs in the northwest part of the county, and outcrops over the northwestern part of township 15 south, range 2 west, the eastern part of sections 1, 12 and 13, in range 3 west, the southwestern part of township 14 south, range 2 west, and some of the adjoining portions of range 3 west. The region underlaid by this formation is usually very broken and hilly, and the arable land is restricted mainly to the valleys of the streams. Its outcrop forms steep hills, the slopes of which are covered with loose masses of flint, without timber, except upon the summits, and even these are but scantily covered with a scrubby growth. Very few fossils were obtained from this group in this county, and a list of its most characteristic species will be given in the report on Union county, from which most of the species have been obtained.

*Lower Helderberg Limestone.**—This is the next group in the descending order, and commences, as already observed, with a few feet of brown shale, succeeded by thin beds of siliceous limestone, alternating with layers of chert. The chert also ramifies through the limestone strata in bands and nodules. Towards the base, the

*This limestone occupies exactly the same stratigraphical position as the Niagara limestone in other portions of the State, as well as in Wayne and Decatur counties, in Tennessee, and a different designation has been given to it here, from the specific character of its fossils solely.

calcareous matter predominates, and we find some heavy beds of mottled limestone, the predominating colors being brownish-red, gray, and buff. At the base of the upper Silurian formation in this county, we find at one locality, about two miles above Thebes, a coarse-grained, steel-gray limestone, from three to four feet in thickness, containing the peculiar group of fossils figured on plate 6, of this volume, the most remarkable of which is the fine Trilobite, the *Dalmanites Danæ*, which has not yet been identified at any other locality in the State. The species figured on this plate are associated in this bed with globular coral, like Heliolites, a Zaphrentis, and some other undetermined forms.

These Upper Silurian limestones attain a thickness of about 250 feet in this county, and the region over which their outcrop extends differs but little in its topographical features from that of the cherty limestones of Devonian age already described. Indeed, the upper portion of the group now under consideration can scarcely be distinguished by its lithological characters from the cherty beds that overlie it, and it was entirely on palæontological evidence that we were able to decide that the one was Upper Silurian and the other Devonian. Very few fossils have been obtained from the limestones in this county except from the bed of dark-gray limestone at the base. At Mr. W. H. Sanders' place, about five miles north-north-east from Thebes, the reddish-brown limestones at the base of the series contained *Orthoceratites* in abundance, but owing to the hardness and massive structure of the rock, good specimens could not be readily obtained.

Most of the fossils characteristic of the siliceous limestones of this series have been obtained from the exposures on the west side of the river, below Bailey's landing, where the whole series of strata pitches below the water level in a distance of about a quarter of a mile, affording such an opportunity of examining the different layers as we have found nowhere else. The species obtained from this locality are the following, that appear to be identical with, or closely allied to, species that are considered characteristic of the Lower Helderberg limestones of the New York series: *Orthis subcarinata, Cyrtina Dalmani, Trematospira imbricata, Spirifer perlamellosus, Acidaspis hamata, Platyceras spirale, P. pyramidatum*, etc.

The general outcrop of these Upper Silurian rocks is along the Mississippi bluffs, and forms a narrow belt, extending eastward from the bluffs, to the distance of from one to three miles. They also outcrop along the range of inland bluffs, running northeasterly from Santa Fé, and extend nearly to the point where they bend abruptly to the northward, on section 28, township 15 south, range 2 west. The cherty portion of this limestone forms, by decomposition, a white chalky clay that can scarcely be distinguished from that of the Devonian cherts, one of which was seen, according to Mr. ENGELMANN, on the southwest quarter of section 3, township 16 south, range 3 west. Taken as a whole, the conditions under which these Upper Silurian and Lower Devonian strata were deposited, appear to have been remarkably uniform. Scarcely any changes can be detected in the lithological characters of the strata, and yet we find as decided changes in the specific characters of the fauna which characterize the upper and lower divisions, as we usually find in passing from one geological system to another. I know of no similar example in the palæozoic rocks of the west, where so complete a change has taken place in the organic life which characterizes the different geological periods, without a corresponding change in the physical conditions under which the enclosing sediments were accumulated.

Cincinnati Group.—This group is represented in this county by two divisions, the upper one a dark blue compact limestone, and the lower a chocolate colored sandy shale, passing downward into a brown sandstone. The limestone attains a thickness of about forty feet, and has a partly concretionary structure, which gives an uneven surface to the strata. It is a very fine-grained compact rock, breaking with a conchoidal fracture, and resembles very closely the "*Glass Rock*" of the lower Trenton beds near Galena. The layers of limestone are separated by thin partings of brown shale, in which the crinoidea, crustacea, and other fossils of this group, are found preserved in a very perfect condition. The most common fossils it affords are the following: *Glyptocrinus fimbriatus*, *G. decadactylus*, *Tentaculites incurvus*, *T. tenuistriata*, *Asaphus canalis*, *Cyphaspis Girardeauensis*, *Orthis Missouriensis*, with an undetermined species of *Conularia*, *Cyrtolites imbricatus*, etc. This limestone outcrops on a branch of Mill creek, about three miles southeast of Thebes, on the Unity road, where it overlies the chocolate-colored shale, and only the lower beds of the limestone are seen. On Orchard creek, about two miles below Thebes, this rock is well exposed, directly on the road from Thebes to Santa Fé. The creek falls twenty-five feet over this limestone at this point, affording a good exposure of the strata. It is quite thin-bedded, the layers varying from one to six inches in thickness, and are somewhat flinty. At this point the shale below the limestone is not exposed, but on another branch, half a mile below,

—30

there is an exposure of forty feet of the shale overlaid by the limestone. One mile and a-half above Thebes, on the river bank, the shale is seen overlaid by the limestone, and dipping to the northward. The upper layers here present a finely brecciated structure, and are overlaid by a coarse-grained, steel-gray limestone of the Upper Silurian series. Below Thebes no trace of this bed was seen, and the blue limestone was succeeded by heavy beds of mottled red and gray limestone, that usually form the base of the Upper Silurian system in this portion of the State. The blue limestone outcrops also on Sexton's creek, and an exposure of it was met with on the road from Thebes to Jonesboro, on the waters of Miller's creek. All the outcrops of this rock met with in this county are in the vicinity of the river bluffs.

Thebes Sandstone and Shale.—This formation, which underlies the limestone above described, is well exposed in the vicinity of Thebes, and the lower portion of it forms the sandstone bluff on which the old court house was built. The lower portion only is a true sandstone, and is about thirty feet in thickness, and passes upward into a sandy shale of a dark brown or chocolate color, which we found exposed two and a-half miles below Thebes, forty feet in thickness. A half mile below Thebes we found a yellowish-brown shale, apparently not above five of six feet in thickness, that evidently formed the base of this group. It was filled with fragments of *Trilobites*, apparently belonging to *Asaphus canalis*, which, with a *Lingula* found in the upper shale immediately below the limestone, are the only fossils it has afforded. The thickness of this lower division of the group may be estimated at about seventy-five feet, about twenty-five of which is in sufficiently thick beds to be used for building stone and for flags. Some of the sandstone layers are from two to three feet in thickness, and are well adapted for foundation walls, culverts, etc., and it has been extensively quarried at this point and transported to Cairo for building purposes. The only outcrop seen of the beds that are adapted to building purposes, is in the immediate vicinity of the town of Thebes, and as they dip in opposite directions over the underlying Trenton limestone, which forms the centre of an anticlinical axis just below Thebes, they soon pass below the water level in each direction. The shaly upper portion, however, outcrops for a distance of about six miles from north to south, commencing about one mile above Santa Fe, and extending to section 27, township 14 south, range 3 west, and forms a narrow belt, nowhere exceeding a mile in width.

Trenton Limestone.—This is the oldest formation known in Southern Illinois, and its only outcrop on the east bank of the Mississippi, in this county, is just below Thebes, where it forms the obstruction to river navigation known as the "*Grand Chain.*" It projects across the river in a narrow belt, forming the center of an axis which elevates the limestone to the height of about seventy feet above the low-water level of the river. The whole thickness of the group is much greater where fully exposed on the Missouri shore, but only the upper part of the mass is elevated above the river level on the eastern bank of the river, and its outcrop scarcely exceeds a half mile in width, by about two miles in length, along the river shore at the lowest stage of water. It is a light gray or bluish-white crystalline limestone, in heavy beds, generally free from siliceous matter, cuts readily, and is susceptible of a high polish, and is adapted to general use as a very fine building stone or marble. It has been extensively quarried for many years in the vicinity of Cape Girardeau, in Missouri, and has become favorably known on the lower Mississippi, as the "*Cape Girardeau marble.*" It also makes a very fine white lime, and is extensively quarried on the Missouri shore for this purpose. An analysis* of this limestone from Cape Girardeau, by Dr. A. Litton, of St. Louis, gave 99.57 per cent. of carbonate of lime, which is a remarkable degree of purity for an unaltered limestone. The upper portion of the bed, which is the part best exposed in Illinois, is that from which the finest building stone is obtained in Missouri. The center of the axis which has elevated these lower Silurian strata above the surface in this county, is about a mile below Thebes, and over this nucleus the overlying beds bend in a saddle-shaped form, with a rapid dip in opposite directions. The principal fossils afforded by the Trenton beds in this county are, *Receptaculites Oweni*, *Strophomena alternata*, *Orthis lynx*, *Rhynchonella capax*, *Illenus crassicauda*, *Lichas cucullus*, *Comarocystites Shumardi*, and a large bivalve shell like *Cypricardites*, and fragments of *Orthoceratites*. The granular character of this rock is not favorable to the preservation of delicate organic forms, and consequently the embedded fossils are not obtained in as good condition in this locality as they often are where the limestones are more argillaceous, and the strata separated by partings of shaly material. In the bed of the river just below the town of Thebes, there are some beds exposed which appear to contain considerable

---

*See Dr. Shumard's Report on the Mississippi river section in the Missouri Report, page 155.

siliceous matter in the form of chert, and also nodules of a black bituminous substance, which ignites when heated, and burns to ashes. As this is the most southerly point on the Mississippi where good building stone, or limestone suitable for lime, can be obtained, these outcrops must eventually become valuable as a source of supply to the country bordering the Mississippi below Cairo, as well as for the building up of that city.

Before closing our descriptions of the rocks of this county, we will mention a bed of very hard quartzite that we found in the hills some two miles back of Santa Fé. Only a single exposure of the rock was seen, not above ten feet in thickness, and having apparently a gentle dip to the northward. No other beds were seen in connection with it that would give any clue to its probable age, but from its color, texture and general appearance, I am inclined to believe that it is a portion of the Thebes sandstone which has undergone metamorphism at this locality, though it presents no signs of metamorphic action at any other locality where we have seen it exposed. In the hillsides above this outcrop we found an exposure of a few feet of soft quartzose sandstone belonging to the Tertiary beds of this region, but this did not appear to correspond exactly in dip or lithological appearance with the quartzites below. This outcrop of quartzite appeared to be exactly on the trend of the axis by which the Lower Silurian beds are elevated above the surface in this county. One of the specimens of quartzite obtained here contains some small pebbles of quartz, and as none were seen in the Thebes sandstone, while they were observed in the Tertiary sandstone of this vicinity, it may be that these altered strata belong to the newer, rather than the older sandstones, and if so, we have the curious anomaly of metamorphic strata of Tertiary age overlying beds of Silurian limestone that are unaltered at their nearest outcrop.

Economical Geology.

Metallic Ores.—No considerable quantity of metallic ores have been found in this county, nor any indications seen that would lead to the conclusion that such deposits will be discovered hereafter. A small amount of galena has been found in the cherty limestones of the Oriskany group, but in too small quantities to be of any economical importance. Brown hematites, or the hydrous oxide of iron, also occurs in small quantities, especially in the ferruginous conglomerate of the Tertiary, but the siliceous pebbles which constitute the greatest portion of the mass, renders it worthless as an iron ore. The seams of smut and lignite in the Tertiary also excite expectations of finding valuable deposits of coal, but no such deposits exist in the county, and time and money spent in search of coal in this region will be spent in vain.

Building Stone and Marble.—Alexander county has an abundant supply of superior building stone, and when the quarries are properly opened, and the amount and quality of the material they will afford is better known, this will prove a very important branch of industry to the county. First in importance, perhaps, not only from the thickness of the formation, and consequently the large amount of material it will afford, is the Trenton limestone, the principal outcrop of which is in the river bluff just below Thebes. This formation is about seventy feet in thickness above the low-water level of the river, and consists of white and bluish-gray limestones, partly in heavy beds of from two to three feet in thickness. It is generally free from siliceous or ferruginous matter, can be easily cut into any desired form, and is susceptible of a high polish, and is adapted to various uses as a marble. It has been extensively quarried at Cape Girardeau since the earliest settlement of the country, both for lime and for the various purposes for which a fine building stone was required, and is already well known and highly appreciated as the "Cape Girardeau marble" along the whole course of the lower Mississippi. For the construction of fine buildings, and the display of elaborate architectural designs, this rock has no superior in this portion of the State.

The mottled beds of the Upper Silurian series consist of hard compact limestone, and are susceptible of a very fine polish, and make a very beautiful marble. The prevailing colors are red, buff, and gray, varying somewhat at different localities. The rock is somewhat siliceous, and consequently harder to work than the white limestone of the Trenton group, but it will no doubt retain a fine polish much longer than a softer material, and the variety of colors which it affords renders it well adapted to many uses as an ornamental stone, for which the other would not be required. These mottled layers vary from ten to twenty feet in thickness, and can be most economically quarried where the overlying strata have been removed by erosion. For table tops, mantles, etc., this is one of the handsomest rocks at present known in the State.

The *Thebes Sandstone* affords an excellent dimension stone, and material adapted to the construction of foundation walls, culverts, etc. It dresses well and is durable, but it would hardly be selected by the architect when in competition with the more beautiful material from the Trenton group. Some of the beds are of suitable thickness, and make good flagstones. All these beds outcrop in the vicinity of the uninterrupted navigation of the Mississippi, and consequently can be made available at a moderate cost to all the lower country bordering on the river that is destitute of such material, which is the case with the whole region from Cairo to New Orleans. This consideration alone adds much to the value of these southern outcrops of building stone, and will surely lead, ere long, to their thorough development.

Clay and Sand.—These materials are abundant, and of varieties suited to the various economical uses to which they are usually applied. The clays of the Tertiary formation are valuable for the manufacture of potter's ware, and one variety has been in use at Santa Fé for some years, and produces a ware of excellent quality. That principally used at Santa Fé, in the manufactory of Mr. Charles Kock, is of a gray color, and is sufficiently mixed with sand to be used without any further addition of that material. Before burning, the ware receives an outside washing of the white clay found near by, to improve its color, and an inside wash of Mississippi river mud, to improve the glazing. The white clays of this vicinity appear to be well adapted to the manufacture of ordinary white ware, but have not been thoroughly tested. The white clays resulting from the decomposition of the siliceous beds of the Devonian series seem also to be suitable for the same purpose. Sand abounds in the Tertiary beds of this region, and also more abundantly in the alluvial beds of the creek and river bottoms. The Devonian sandstone, common in the northeast part of the county, is often quite pure and free from coloring matter, and is well adapted to the manufacture of glass. Although not in close proximity to the coal beds, yet the facilities afforded by the Illinois Central Railroad would secure the required fuel from DuQuoin or Murphysboro at a very reasonable cost.

Road Material.—An inexhaustible amount of the very best material for the construction of turnpike or common roads abounds on all the water-courses that intersect the uplands of this county, and is derived from the cherty limestones of the Upper Silurian and Devonian age. It consists of a brown flint or chert, finely broken for use, and occurs abundantly, filling the valleys of the small streams that intersect the limestones above named. This flint has been used at St. Louis for the manufacture of "concrete stone," and has been found fully equal to the best English flint for this purpose. The material with which this experiment was made was obtained in Union county, but it differs in no way from the flint so abundant in this county, and is derived from the same beds.

Agricultural Resources.—As we have already observed, the uplands of this county are generally broken into steep hills or ridges, and the arable land is mainly confined to the alluvial lands of the rivers and smaller streams. There is, however, a small area in the northeast part of the county that is underlaid by the Devonian sandstone, and the striped shales associated with it, where the surface is not so abruptly broken, and affords some good farming lands. The soil is mostly a yellow clay. The uplands are covered with timber, where the surface is not too rocky, consisting of black and white oak, hickory, beach, yellow poplar, or tulip tree, etc.

On Sexton's creek the bottom is narrow along its upper course, and is heavily timbered with walnut, maple, beech, oak, etc., until it leaves the cherty limestones, and in range 3 the bottoms become wider, averaging perhaps a quarter of a mile in width. On Miller's fork, east of Thebes, the arable land begins at the foot of the breaks on the outcrops of Upper Silurian limestone, but is too narrow for cultivation down to section 14, where it widens for a mile or more, and then becomes low and wet, and so continues to its outlet into the Mississippi. Mill creek bottom, south of the Union county line, averages about a half a mile in width, and has fine sloping lands on either side, which are heavily timbered. Below the last bluff on the creek, east of Ullin, the bottom is very heavily timbered with swamp white oak and yellow poplar, many of the trees reaching a diameter of from four to six feet. The branches of Caney creek, in the northeast part of the county, where they traverse the outcrops of the Devonian slates, have fine arable bottoms and slopes. On the southeast quarter of section 18, township 14, range 1, the creek bottom is about a quarter of a mile in width, and below this it becomes gradually wider until it joins the flats of Mill creek.

From these topographical features it will be seen that the amount of arable land in this county is limited, and restricted to the higher portions of the river bottoms, and the narrow valleys of the small streams. But wherever these bottom lands are dry enough to admit of cultivation, they are very productive, having a light, warm, sandy soil, that yields large crops of corn, cotton, tobacco, and most other products suited to the climate. Small fruits and peaches will also do well on the dryest bottom lands, and grapes, apples, pears, etc., may be successfully cultivated on such of the highlands as are not too steep for cultivation. The advantages of climate in this extreme southern portion of the State, which enables the fruit-grower to put his fruit in market in advance of that raised in any other section north of the Ohio, will always make this a desirable region for the cultivation of such fruits as are most desirable for the early markets.

These rich bottom lands are equally desirable for the market gardener, and Cairo, Chicago and St. Louis could be supplied with early vegetables from this portion of the State several weeks earlier than from Central Illinois.

CHAPTER XIX.

UNION COUNTY.

Union county is situated immediately north of Alexander, and is bounded on the north by Jackson and Williamson counties, on the east by Johnson county, on the south side by Alexander and Pulaski counties, and on the west by the Mississippi river. It embraces the western end of the summit or dividing ridge which crosses Southern Illinois from Bald Rock, on the Big Muddy, to the mouth of Saline river, on the Ohio, and contains an area of little more than eleven townships, or about 400 square miles, of which about one-fifth is bottom and the remainder upland. It is for the most part heavily timbered, except on some of the most rocky hills and ridges. It comprises one of the best timbered districts of the State, and although very broken and hilly along its western borders, presenting a topography quite unlike the central and northern portions of the State, it nevertheless has a large proportion of excellent soil, well adapted to the growth of corn, cotton, tobacco and all varieties of fruit adapted to the climate.

The surface configuration of the different portions of the county is mainly dependent on the character of the underlying strata, and the amount of disturbance to which the rocks have been subjected. The general trend of the line of uplift in this county is from northwest to southeast, and the dip, with some local variations, is to the northeastward. Hence the escarpments on the south and west sides of the ridges are steeper and more rugged than those to the north and east. The river bluffs are high and rocky, and are frequently cut up into rugged declivities and sharp summits, and are formed by the cherty limestones of upper Silurian and Devonian age, which constitute the more southern extension of the same bluffs into Alexander county. In the northeastern portion of the county we find the sandstone ridge already alluded to, which forms the water shed between the streams running northward into the Big Muddy, and those running south into the Mississippi and the Ohio. This ridge presents a perpendicular escarpment on its southern face, similar to the bluffs of our large rivers, although its course is nearly at right angles to the present water courses. Its summit is formed by the Conglomerate sandstone, and its base by the lower Carboniferous limestones and sandstones of the Chester group. South of this chain of bluffs, and extending along the line of the Illinois Central Railroad from Cobden to the south line of the county, there is a broad belt of country underlaid by the lower Carboniferous limestones, in which the ridges are less abrupt, and the surface so gently rolling as to be susceptible of the highest cultivation.

The country north of this sandstone ridge is also underlaid by the Conglomerate sandstone, and is generally broken and hilly. The creeks run in narrow gorges, with scarcely any breadth of bottom land, but the ridges, unlike those formed by the cherty limestones, are susceptible of cultivation, and are heavily timbered. These ridges are now regarded as the best fruit lands in the county, and command a higher price than the more gently rolling slopes of the limestone region further south.

The river bluffs in the northwest township in this county are known as the "Pine Hills," and are exceedingly rugged. These bluffs form ridges from four to five hundred feet in height, and so sharp that on their summits there is scarcely breadth enough for a road, while the slopes are very precipitous, and in places rocky. On the summit there are a few stunted pine trees, growing on cliffs of nearly naked chert rock, but where the soil is better, these ridges sustain a growth of black and white oak, hickory, black gum, yellow poplar, etc. Back of the river bluffs there are a series of similar ridges, covering all the western portion of township 11 south, range 3 west, and the southwestern part of township 11, range 2 west. In this portion of the county the ridges are too much broken for cultivation, and the farms are restricted to the creek bottoms and the more gentle slopes of the hillsides.

The soil and timber of the uplands in this county, except in the very broken region above mentioned, present a general uniformity of character. The soil is a light-brown clay loam, with a subsoil of similar character, and was originally covered with a magnificent growth of white, red and black oak, pignut, scaly-bark and barren hickory, yellow poplar (tulip tree), black gum, beech, black walnut, sugar maple, etc. The post oak, which is the prevailing timber in some portions of Southern Illinois, was seen but rarely here along the north line of the county, and the barren oak was also occasionally met with on the ridges underlaid by the Chester sandstone north of Cypress creek.

The bottom lands of this county comprise a belt of about four miles in width along the eastern bank of the Mississippi, and extending to the river bluffs. These lands, where they are not too wet to admit of cultivation, are exceedingly fertile, and are the best corn lands in the county. The growth of timber on the bottom lands is even heavier than upon the uplands, and comprises several varieties of oak, among which are blue-bark oak, scarlet oak, bur oak and swamp white oak, that are not met with on the uplands; also, sycamore, horn-beam, elm, cottonwood, bald cypress, tupelo gum, white maple, willow, ash, hackberry, pecan, persimmon, red birch, pawpaw, etc. A good deal of this bottom land is too wet for cultivation, and is covered with water, forming ponds, sloughs, etc.

Geology.—The geological structure of this county comprises a wide range of formation, extending from the base of the Upper Silurian to the top of the Conglomerate sandstone of the Coal Measures, through a vertical range of about 2,000 feet of strata. The following section will serve to illlustrate the thickness and relative position of the palæozoic rocks of this county.

In addition to the rocks represented in this section, there are the recent deposits of alluvium which form the bottom lands, and the beds of marly clay, sand, etc., occurring in the creek valleys, which may be referred, most properly, to the *Loess*, and the brown clays which overlie the older rocks on the uplands, all belonging to the Quaternary system.

Section of the Rocks in Union County.

Carboniferous.	200 feet.	Conglomerate sandstone. Massive quartzose sandstone with siliceous pebbles, passing into more finely grained and thin bedded brown sandstone.
	800 feet.	Chester group of the Lower Carboniferous series, consisting of alternations of dark gray argillaceous and ferruginous limestones, alternating with brown sandstones, in regular beds, and argillaceous and sandy shales, the latter inclosing locally a thin seam of coal. The limestones are often bituminous, and emit a fetid odor when struck with a hammer.
	200 to 250 feet.	St. Louis Group: Compact gray limestones, partly light-colored and oolitic in texture, and sometimes dark-blue and cherty.
	80 to 100 feet.	Kinderhook Group; Siliceous shales and chert.
Devonian.	40 to 60 feet.	Black slate, and blue and green shales.
	60 feet.	Hamilton Group: Gray limestone and brown calc. shales.
	25 feet.	Dark fetid limestone. Corniferous.
	20 to 30 feet.	Onondaga limestone: Light gray massive siliceous limestone.
	40 to 60 feet.	Quartzose sandstones and striped siliceous shales.
	200 to 250 feet.	Clear creek limestones of the Oriskany period, consisting of light gray thin-bedded limestones, alternating with layers of chert, passing locally into an irregularly bedded chert rock.
		Band of brown arenaceous shale.
Upper Silurian.	250 feet.	Lower Helderberg limestones: Arenaceous and magnesian limestones, in thin beds, alternating with chert, and at the base passing into a mottled, siliceous limestone in heavier beds.
L. Sil.		Cincinnati Group?

Lower Helderberg Limestones.—This formation is similar in its appearance here to the outcrops of it already described in the foregoing report on Alexander county, and it may be described as a thinly-bedded, grayish-colored, close-textured, siliceous and cherty limestone, sometimes argillaceous and shaly, and, again, so flinty that it is difficult to say whether the flint or the limestone predominates. Hence, it is so intimately related to the cherty Devonian limestone which overlies it in this region, that it is difficult to say, when no fossils are found, to which bed an outcrop belongs. This limestone forms the base of the river bluffs throughout the county, except for a short distance, where the Jonesboro and Cape Girardeau road intersects the bluff, four miles west of Jonesboro. Here, by the down-throw of the strata, the result, probably, of a fault, we find the quartzose sandstone of the Devonian, extending down to the creek level, and overlaid by the massive beds of Onondaga limestone. For several miles in this vicinity, and mostly through township 12, the bluffs are composed of the cherty limestones of the Oriskany group, but in township 11, range 3 west, and in township 13, range 2, the base of the bluffs consist of the lower Helderberg limestones, and the upper part of the cherty Devonian limestones, often capped with the sandstone. Beyond the immediate vicinity of the river bluffs they do not appear in this county. Along the bluffs these beds form bold and picturesque cliffs, that present a peculiar wall-like appearance, from the uniform thinness of the strata, and are seen to the best advantage in the smooth vertical cliffs, and turreted projecting ledges that are frequent along the outcrops of this formation. No fossils have been obtained from this bed in Union county, but on the opposite side of the river, just below Bailey's Landing, where the beds are much better exposed, the following species have been obtained: *Orthis subcarinata*, *O. hybrida*, or *O. oblata*, a *Cœlospira*, scarcely distinguishable from *C. concava*, *C. imbricata*, *Spirifer perlamellosus*, and *Acidaspis hamata*. These were associated with forms closely resembling, if not identical with, *Merista lævis*, *Platyceras pyramidatum*, *P. unguiforme*, *P. incile*, and *P. multistriatum*. As these are all species common in the lower Helderberg limestones of New York, there can be but little doubt that these beds may be properly referred to the same horizon, and are the western representatives of that group.

Seven miles southwest of Jonesboro, on the southwest quarter of section 9, township 13, range 2, near the Cape Girardeau road, we observed a bed of limestone, of which about twenty-five feet in thickness was exposed, that exactly resembled the glass-rock of the Trenton series in Northern Illinois. From its lithological characters alone, we should not hesitate to place this rock in the lower Silurian series, and to regard it as the equivalent of the compact siliceous limestone that forms the upper member of the Cincinnati group, in Alexander county, but as we failed to find any fossils in it that would enable us to decide positively as to its age, it may be possible that it is an intercalated bed of the upper Silurian series. However, we place it at the bottom of the section, with a query, until further examinations can be made. I find no mention of this outcrop in Mr. ENGELMANN's notes, or any intimations that a similar rock was met with in the upper Silurian limestones of this county.

From Wolf lake to the north line of the county, the upper Silurian limestones form the entire bluff, often reaching a height of 200 feet or more, in smooth, vertical faces or turreted walls. Fine springs of beautifully limpid water issue from the base of these bluffs at numerous points. Near the head of Wolf lake, and not far from the northwest corner of section 22, township 11, range 3 west, is one of the highest points in this part of the county; the lower limestone reaches an elevation of 200 feet above the Mississippi bottoms, and is capped by 100 feet of the rough chert rock of the Oriskany group, which stand out in bold relief, with a strong easterly dip. These bluffs continue southward, along the eastern borders of Wolf lake, to the northwest quarter of section 3, township 12, range 3, where, in consequence of the easterly trend of the bluffs, or perhaps a break in the strata, these limestones disappear, and the bluffs are formed by the Devonian beds. Following down the river bluffs a distance of about eight miles by the section lines, this limestone again appears, near the north line of section 9, township 13, range 2, and from this point they continue to form the main portion of the bluffs to the Alexander county line.

Clear Creek Limestone.—This cherty limestone, or chert formation, as it might very properly be called, occupies the upper portion of the river bluffs in township 13 south, range 2 west, and township 11 south, range 3 west, where the upper Silurian limestones form the lower part, and in township 12 south, ranges 2 and 3 west, where these Silurian rocks are below the surface, the bluffs are composed mainly of this cherty rock and the overlying Devonian beds. This formation forms an irregular belt of outcrop along the line of river bluffs, ranging from two to six miles in width. This belt is narrowest in the southern portion of the county, becomes gradually wider in township 12, range 2 west, and attains its maximum width in the south part of township 11, ranges 2 and 3 west, and from this point gradually becomes narrower to the north line of the county. Its greatest development is on the upper course of Clear creek, and on Higgins creek, in the northern portion of the county. It also outcrops on all the forks of Caney creek, in the central part of township 12 south, range 2 west, and south of this its outcrop is restricted to a narrow belt along the river bluffs.

Although generally cherty, it presents considerable variety in its lithological characters. Portions of the mass appear as a porous or compact chert, sometimes massive, and again quite evenly stratified, and these cherty beds pass into silico-magnesian limestones of compact texture, and these, again, into chalky, white limestones, filled with nodules and concretionary masses of compact flint. Some of these changes are probably due to atmospheric or aqueous agencies, by which the calcareous matter has been dissolved and removed; or else the silica has replaced the limestone by a slow chemical action, analogous to that by which, in certain strata, the calcareous shells of Mollusks are changed into siliceous fossils. On sections 12, 13 and 14, in township 11, range 2 west, Mr. Engelmann notices the occurrence of massive limestones, that assume the appearance of a white marble. On the northeast quarter of section 12, he describes the rock as a delicate grayish-colored and white limestone, of a crystalline or sub-crystalline texture. The exposed surface is very hard and full of flaws, from long exposure, but by quarrying into the bed beyond the influence of surface agencies, an excellent material might be obtained, that would be adapted to various kinds of ornamental work, of uniform quality and texture, and susceptible of a high polish.

Bald Knob is a very prominent inland bluff or promontory, that lies a little to the west of the center of township 11 south, range 2 west, and appears to be mainly composed of the siliceous limestones and chert of this formation. The cherty beds outcrop along its lower slopes, but the summit was so covered with soil and detritus that the highest rocks could not be seen. On its sides were seen tumbling masses of white quartzose sandstone, that appeared to belong to the bed usually overlying the Oriskany group in this portion of the State. It is said to be the highest elevation in the county, and it is probable its altitude is due to some local disturbance and uplift of the strata. Although the strata of the knob, itself, seem to lie nearly horizontal, we find the lower Carboniferous beds, on its north side, dipping at a high angle to the northeastward. In the banks of Seminary Fork, on the southeastern side of the knob, we found the characteristic fossils of this cherty limestone quite abundant, and about half a mile further east, on the same branch, we found the overlying sandstone extending down to the creek level.

The characteristic fossils of this group, obtained from the exposures of the strata in this county, are as follows: *Leptocœlia flabellites, Leptæna nucleata, Rhynchonella speciosa, Platyceras tortuosum, Rensselæria Condoni, Spirifer arctus* (?), and *Stricklandinia elongata*, var. *curta.*

Quartzose Sandstone and Striped Shales.—These beds, which have been considered as forming the uppermost strata of the Oriskany series, more probably belong to a higher geological level. They directly overlie the cherty limestones just described, but owing to the comparatively small thickness of strata, and the readiness with which the rock yields to the influence of atmospheric agencies, good exposures are rarely seen, and it exerts but little influence in modifying the topographical features of the surface of this county. The shales are much thinner here than in Alexander county, and in the central and northern portions of the county they were not met with at all. Four miles west of Jonesboro, on the road to Willard's Landing, the sandstone is exposed near the foot of the bluff, and is directly overlaid by a massive gray limestone, equivalent to the Onondago limestone of New York, without any intervening shales, so far as could be seen. The sandstone was not fully exposed at this point, but was at least thirty feet or more in thickness. We found at this locality a good many fossils, among which are the following: A small, undetermined *Zaphrentis, Pleurodictyum problematicum*, an *Orthis*, like *O. musculosa*, a finely striated *Stophodonta*, like *S. magnifica*, but smaller, and fragments of a large *Odontocephalus*, similar to, but much larger than, that from the overlying limestone. About two miles and a half southwest of Jonesboro, on the middle fork of Caney creek, the lower part of this sandstone is exposed, resting directly upon the thin-bedded, siliceous and cherty limestones of the Clear Creek group, without any indications of shale between. The thin-bedded limestone was full of the characteristic fossils of this group, at this locality, and a few were also obtained from the sandstone. The latter is most commonly met with on the summits of the chert hills, or in tumbling masses on their slopes.

Three and a half miles southwest of Jonesboro, it outcrops on the south fork of Caney creek, and at one locality in this neighborhood, where it is of a pure white color, it has been mistaken for marble. It is usually more or less stained with the red oxide of iron, the colors being similar to those of the striped shales that are sometimes associated with it.

The striped shales, or "Calico rock," occur in the south part of the county, especially on Miners' creek, where, according to Mr. Engelmann, there is a thickness of about fifty feet of these shales exposed, passing upward into chert. It is quite probable that the sandstone and shale replace each other, as the shales are sometimes seen below the sandstone, and at other localities above it, these changes being due to the fine or coarse character of the sediment, the finer giving origin to the shales, and the coarser to the sandstone.

Onondaga Limestone.—Above the sandstone and shale just described there is a massive gray limestone, usually about twenty feet in thickness, which, from its peculiar group of fossils, we regard as the equivalent of the Onondaga limestone of the New York Reports. It is lighter colored, more massive and less cherty than the overlying limestones of the Hamilton group, and may be thus readily distinguished from them, even in the absence of characteristic fossils. This limestone outcrops two miles west of Jonesboro, on the road to Willard's Landing, in the bed of the creek, and four miles west, on the same road, it is found directly overlying the sandstone and shale, which has already been described as forming the base of the bluff at this locality. This rock was supposed to form the base of the Hamilton series, until the fossils which it contained were critically examined, when it was found to be quite distinct from that, and more closely allied to the older divisions of the Devonian series. Its line of outcrop through this county is determined by the overlying Hamilton limestones, with which it is intimately associated. Its most characteristic fossils are *Centronella hecate*, *Spirifer acuminatus*, *S. fimbriatus*, several undetermined *Spirifers* with greatly extended hinge lines, *Atrypa reticularis*, a small *Productus*, like *P. subaculeatus*, and a species of the curious group of *Trilobites*, that also occurs in the underlying sandstones, resembling the *Odontocephalus selenurus* of the Corniferous limestone of New York, and it may be that this is the western representative of both the Onondaga and Corniferous limestones of the eastern States. At the most northerly outcrops of this limestone, in Jackson county, it becomes locally quite arena-

—31

ceous, and consists, in part, of alternations of thin beds of limestone and sandstone, showing, by its lithological as well as its palæontological characters, a more intimate relation with the underlying than the overlying formation.

Corniferous limestone.—This is a dark-gray, fetid limestone, from twenty to twenty-five feet in thickness, which was found outcropping about two or three miles west of Jonesboro, where about twenty feet in thickness was exposed above the bed of the creek. It is strongly impregnated with bituminous matter, as shown by its dark color, and the strong, fetid odor emitted from it when struck with the hammer. It contains several species of corals, among which the *Zaphrentis* is a common form, together with *Microcyclus discus, Phacops rana, Rhynchonella,* etc. This limestone no doubt represents the oil-producing horizon of Canada West, but no oil springs are known to occur in it in this State.

Hamilton Group.—This group consists of two well-marked divisions in this county, comprising, first, a bed of chocolate-brown and buff calcareous shale, filled with crushed specimens of *Leiorhynchus limitaris,* associated with *Pterinea muricata;* and second, a bed of gray, semi-crystalline or granular limestone, containing *Tropidoleptus carinatus* in abundance, associated with *Spirifers,* and other characteristic Hamilton forms. The thickness of the group here is about eighty or eighty-five feet, and it is immediately overlaid by the Black Slate.

Black Slate.—This division of the Devonian series is very well developed in this county, and attains a thickness of fifty to seventy feet, though it is seldom exposed in its full thickness. On Caney creek, about two miles northwest of Jonesboro, where the above section was observed, the bed was pretty well exposed, and on one of the ravines in this vicinity a drift had been carried into the hill, where it outcrops, in search of coal. From its close resemblance to the bituminous shales of the Coal Measures, it is not very surprising that those who are entirely ignorant of the fact that the workable coal beds are restricted to a certain geological horizon, and that this slate is far below that horizon, should suppose that its outcrop indicated the proximity of coal, and consequently be led into a useless expenditure of time and means, in a vain search after coal in regions remote from the true coal-bearing strata. Only a portion of the bed presents the color, the highly bituminous characters, and slatey cleavage, which suggested the name by which it is generally known in the west, and the remainder consists of green and blue, or chocolate-colored argillaceous shales, often so closely resembling the next succeeding formation that no exact line of division can be drawn between them at the partial exposures usually met with in this county. Its most northerly outcrop in this county is at what is called the Iron Mountain, where it forms the southeastern slope of the hill on the northeast quarter of section 34, township 11 south, range 2 west. From this point the trend of its outcrop is a little to the east of south to the southeast corner of section 36, township 13 south, range 2 west, making an easting of about two miles in a distance of thirteen miles from north to south. Besides the localities already given, the black slate outcrops on the north fork of Caney creek, on the southwest quarter of section 11, township 12 south, range 2 west. In the exposures of this horizon, west and south of Jonesboro, the bed becomes mostly argillaceous, and the black laminated slates were not seen, and are probably replaced by argillaceous shales. A single species of fossil shell was obtained from the slate at the point where the tunnel was carried into the hill, a mile or more west of Jonesboro. This was a *Lingula* apparently identical with the *L.* spatulata* of the Genessee slate, of which these beds are supposed to be the western representative. This fossil is exceedingly abundant in Ohio and Tennessee, wherever this strata is exposed, but it has as yet been found nowhere in Illinois except at the locality above named. This shell is figured on plate 13, figure 1, Vol. 3 of the original Reports.

Siliceous Shales.—The black slate formation is succeeded by a series of siliceous and partly argillaceous shales, with some intercalations of chert, which are variously colored, sometimes striped, but usually brown, and attain a thickness of a hundred feet or more. Owing to the soft character of the material of which these shales are, for the most part, composed, good exposures are rarely met with, and the strata are generally covered up in the slopes of the hills. They have afforded no fossils to aid in the determination of their true horizon, but from their lithological characters, and their stratigraphical position, I regard them as the probable equivalents of the Kinderhook group of the lower Carboniferous series. Their line of outcrop is almost exactly parallel with that of the underlying black slate, and commencing at the so-called Iron Mountain, it runs a little to the east of south, forming a narrow belt, scarcely more than a mile in width, extending to the southwest

---

* NOTE.—This *Lingula* was found, on critical comparison, to be specifically distinct from the New York species, and has been described under the name of *L. sub-spatulata.* This formation is probably the equivalent of the Erie shale of Ohio.

corner of township 13 south, range 1 west, where it intersects the north line of Alexander county. The shale passes upwards into cherty beds and siliceous limestone, which is nowhere well exposed, and probably belongs to one of the limestone divisions, perhaps the Keokuk group of the lower Carboniferous series. The cherty beds form the summit of the so-called Iron Mountain, and contain ferruginous matter in the form of a brown hydroxyd of iron, from which the hill derives its name. This iron ore was probably derived from a limestone formation that once extended over the summit of this hill, and from which the calcareous portions have been removed by long exposure to surface agencies, or the more rapidly denuding forces of water currents, leaving only the cherty portions remaining. At what time and by what agency the ferruginous matter by which the cherty mass is now permeated was introduced, can only be conjectured. Perhaps the limestone from which the material has been derived was the source of chalybeate springs, the waters of which may have dissolved the lime and precipitated in its place the iron ore, by which the cherty material is now cemented into a highly ferruginous mass. At our first visit to this locality, in 1858, we measured about thirty feet of chert and iron ore overlying the shales which form the slope of the hill. At this time we saw some imperfect fossils in the chert, which led us to suspect that it had been derived from a limestone, probably the equivalent of the Keokuk group of the lower Carboniferous series. No indications of the existence of beds equivalent to the Burlington limestone were seen in this county, although this formation has been recognized in the adjoining county of Jackson, on the north, and it seems probable that that is the most southerly outcrop of the bed, for in this county, and in Hardin, although the junction of the Devonian with the lower Carboniferous limestone is well exposed, no representative of that limestone with its peculiar group of fossils has been seen. It seems most probable that the siliceous cherty limestones and beds of chert that immediately underlie the St. Louis limestones here, are referable to the Keokuk group rather than to any older formation.

St. Louis Limestone.—This important limestone is well developed in this county. Commencing on the north side of "Bald Knob," in the southeast quarter of section 17, township 11 south, range 2 west, it forms a triangular belt to the south line of the county. Its western line of outcrop is parallel with that of the subordinate Devonian strata, and its trend is a little to the east of south, while its eastern boundary is a line running southeast from "Bald Knob," so that, from a mere point at its northern extremity, it gradually widens to the southern line of the county, where its outcrop covers an area of about twelve miles in width. Its most northerly outcrop is on the Seminary fork of Clear creek, near the center of township 11 south, range 2 west, and on the head-waters of Clear creek, in the southeastern part of the same township. In township 12 south, range 1 and 2 west, it outcrops on all the head-waters of Caney creek and on Little creek, and over the whole of township 13 south, range 1 west, except a small area in the southwest corner of the township, on Big creek, throughout its whole course in this county, and on Add's branch, and Cypress creek, below the middle of section 23, township 12 south, range 1 east.

This limestone presents considerable variation in its lithological characters in the different parts of the formation, and also at different localities in the same stratum. The lowest portion of the group, which is tolerably well exposed a half mile west of Jonesboro, forms what is known in that region as the Jonesboro limestone. It is a massive, light gray, or nearly white, sub-crystalline, or earthy limestone, that breaks regularly into rectangular blocks, and forms a good and durable building stone. Most of it, at the outcrops we examined, is quite free from chert, but, locally, it becomes somewhat cherty, the siliceous material being disseminated through it in concretions, or in fine particles, which, when the lime is dissolved, leaves a skeleton of porous chert. The thickness of this part of the group, exposed near Jonesboro, is about thirty feet, but probably in the aggregate it is much more. It has afforded no well defined fossils, and its true age is only determined by its stratigraphical position and its lithological characters, which appear to be more nearly related to the St. Louis group than to any other division of the lower Carboniferous series. The principal outcrops of this rock in this county, besides the one just named, immediately west of Jonesboro, are on Caney creek, near the centre of section 11, township 12, range 2, at the German meeting-house, in the centre of section 1, township 13, range 2 west, thence up the branch in the southeast quarter of section 1, the northeast quarter of section 12, and through the south half of the adjoining section 6. On the branches of Mill creek it outcrops near the southeast corner of section 13, township 13, range 2 west, and in the southwest corner of section 18, township 13, range 1 west, in the southeast quarter of section 17 and the northeast corner of section 19, and through the southwest quarter of section 20, from whence it probably extends southward to the county line. The curious forms known under the names of *epsomites*, *crystalites*, *stylotites*, *lignilites*, etc., are frequently met with in this part of the St. Louis group, near Jonesboro. They consist of portions of the rock that are separated from the surrounding mass by a series of parallel columns, or flutings, which penetrate the strata at right-angles to the plane of stratification, and give to the enclosed mass, when broken out, a vertically striated surface. Their origin has been explained in various ways, and as fossil shells are often found, forming one extremity of the *lignilite*, determining to some extent their size and form, it has been suggested that they are due either to the embedded shells or some other hard substance, which was forced upward by the pressure of escaping gases, before the hardening of the strata, and leaving a tubular shaped hole beneath, which was subsequently filled from below with the soft sediments, by the pressure of the superincumbent strata, thus forming the *lignilites*. As fossil shells are exceedingly scarce in these strata, while the *lignilites* are abundant, it seems that they must be due, in this instance, at least, to something besides the presence of organic forms.

Above these massive beds just described, we find a series of bluish-gray or light gray siliceous and cherty limestones, in thinner beds than the rock below. Some of the beds are crystalline, others are argillaceous, and, when decomposed, leave a profusion of reddish chert, that is found in abundance in all the ravines that intersect this limestone. Fossils are not abundant in this division of the group in Union county, but a few siliceous corals are found, among which are the two common forms of Lithostrotion, the *L. proliferum* and *L. mamillaris*, with one or two species of *Zaphrentis*, not yet determined. This division comprises the outcrops north and south of Jonesboro, and between the latter and Anna. It is succeeded by a series of light and bluish-gray massive limestones, usually close textured and sub-crystalline, some beds of which are purely calcareous, while others are siliceous and magnesian. Many of the layers are locally oolitic, as at the lime quarries east of Anna, and this oolitic character will probably be found characteristic of this portion of the group throughout the county.

The St. Louis limestone in this county attains an aggregate thickness of two hundred feet or more, and the surface over which it outcrops may readily be defined by the numerous sink-holes which everywhere abound where this is the underlying rock. It is the well-known "Cavernous limestone" of the west, and most of the large caves of this and the adjoining States are in this formation.

The fossils of the upper division at the quarries east of Anna are mostly siliceous, and consist in part of the following species: *Pen-*

tremites Koninckiana, P. Grosvenouri, plates of a *Platycrinus* like *P. plenus, Athyris ambigua, A. Royissii, Platyceras acutirostris, Terebratula formosa, T. hastata, Rhynchonella mutata, Retzia Verneuiliana,* and several undetermined corals. Above the massive oolitic limestones just described, Mr. ENGELMANN mentions the occurrence of a bed of fine-grained, ripple-marked sandstone, eight feet in thickness, outcropping on the northwest quarter of section 7, township 13, range 1 east, and succeeded by twenty feet of white or light gray oolitic and flinty limestone, which may be considered as the very highest beds of the St. Louis group, or perhaps forming beds of passage to the next succeeding formation.

Chester Group.—This is by far the most important subdivision of the lower Carboniferous series in this portion of the State, and attains a maximum thickness, where fully developed, of at least a thousand feet. It consists of four or five different bodies of limestone, separated by sandstones and shales, and is characterized by a distinct group of fossils, which serve to distinguish it at once from any of the subordinate groups of limestone. Eight divisions of this group have been recognized in Union county, four of which are limestones, and the remainder sandstones and shales, and we have numbered them consecutively from the top downward; the odd numbers, 1, 3, 5, 7, being applied to the limestones, and the even numbers, 2, 4, 6, 8, to the sandstones.

The limestones of this group are usually argillaceous, sometimes siliceous and ferruginous, and are readily distinguished from the other calcareous divisions of the lower Carboniferous series, even in the absence of characteristic fossils, by their lithological characters. The sandstones are more evenly and thinly bedded than the overlying Conglomerate, and are locally ripple-marked. The lowest division of this group is a thick bed of sandstone, to which the name of ferruginous sandstone has sometimes been applied, from the ferruginous matter which it contains at certain localities. This character predominates more or less in all the sandstones of this series, the brown oxide of iron being generally disseminated through it in specks, giving a mottled appearance to the rock when freshly broken. Locally the upper sandstones of this series are replaced by shales, either argillaceous or sandy, and as they readily decompose when exposed to atmospheric action, they are usually covered up in the slopes of the hills. The thickness of the lower sandstone, No. 8, of this series, is about 150 feet in this county, and commencing on the head waters of Huggins creek, in the northwest part of the county, its line of outcrop extends in a nearly due southeast course to the middle of the east line of township 13 south, range 1 east, where it crosses the county line into Johnson county. On the Seminary fork of Clear creek, in the northwest quarter of section 22, township 11 south, range 2 west, it may be seen rising abruptly to the surface, with a strong dip to the northeast, and forming the base of a heavy limestone series. It may be seen capping the St. Louis limestone near the northwest corner of section 26, and on the main fork of Clear creek, above the Iron Mountain, and probably crosses the dividing ridge in the northeast quarter of section 6, township 12 south, range 1 west. On a branch of Cache river, on the southeast quarter of section 8, it was traced for some distance, until the creek turns east, when it dips below the water level, and is succeeded by the higher members of the series. On Big creek, as far as it runs southeastward, this sandstone caps the ridge to the northeast, and continues in that course by the head of Add's branch, and crosses Cypress creek, striking the Johnson county line at the southeast corner of section 24, township 13 south, range 1 east.

It is better exposed on Cypress creek than anywhere else in the county, and beginning in the breaks at the head of the creek, on the southeast quarter of section 23, township 12 south, range 1 west, it outcrops along the creek for some distance, forming not only its banks, but the slopes of the adjacent hills. A portion of it here is thinly bedded, and separates into thin, even slabs, suited to various building purposes. On the northeast quarter of section 31, township 12 south, range 1 east, it crops out along a small branch of this creek, and is fine-grained, white with brown spots, purely quartzose, and rather soft when first quarried, but hardens on exposure. It is obtained here in fine, even slabs, from one to twelve inches in thickness, which dress easily, and appear to possess a suitable grit for grindstones, and is also suitable for foundation walls, and many other uses for which building stones are required. These evenly-bedded layers are not confined in their outcrop to this locality, but have been observed at several points in this county. In the northwest quarter of section 32, the upper shaly strata of this division are exposed at the foot of hills on the north side of the creek, while the overlying limestone outcrops higher up on the slope. In the south part of section 33, the sandstone reaches a height of sixty or seventy feet above the creek, and is overlaid by the succeeding limestone. From thence down the creek it forms high cliffs a hundred feet or more in height, down to section 3, township 13, range 1 east, where the course of the creek changes more to the eastward, and the sandstone dips below the creek level, except some shaly layers that form the top of this division, and continue near the creek level lower down, even where the overlying limestone forms the main portion of the bluff. The sandstone rises again on section 12, and from thence down it forms a continuous and gradually rising bluff to section 24, where it leaves the creek in consequence of the southwesterly direction of its course.

The outcrops of the upper members of this series cannot be so accurately traced, in consequence of the general resemblance which the different beds bear to each other, and for the lack of continuous exposures along the line of trend of the strata. The area which they occupy in this county may be briefly described as follows: Commencing in the southeastern portion they outcrop in the northeastern corner of township 13 south, range 1 east, over the whole of township 12 south, range 1 east, except the southwest corner. The southern part of township 11 south, range 1 east, and 11 south, 1 west, extending up Bradshaw's creek, to within a mile of the northern line of the county, and outcropping on Drury's creek, nearly as far north; and in township 11 south, range 2 west, they form a belt about two miles in width, extending diagonally from the southeast to the northwest corner of the township. They also outcrop on the north side of the dividing ridge in this township, on the head-waters of Clay-lick, Cedar and Cave creeks, to the north line of the county. From these remarks it will be seen that the general trend of these strata corresponds very nearly with that of the St. Louis limestone below, and is very nearly from northwest to southeast.

The following section of the lower portion of the group was made by Mr. Engelmann, on Cypress creek, on the south part of section 33, township 12 south, range 1 east:

Covered slope at top of the hill, not measured	
Massive sandstone, partially exposed	20 feet
Close textured gray limestone, with *Archimedes* and other fossils	40 "
Hidden slope, probably underlaid by limestone or shale	18 "
Limestone, similar to that above	21 "
Limestone, close textured and crystalline, bluish or brownish gray, with *Archimedes*, *Productus elegans*, etc	19 "
Sandstone, mostly fine grained and quartzose, some of it thin bedded, and in the upper part shaly	70 "

It is probable that all these limestones, including the hidden slope between the two limestones, belong to the lower limestone division, No. 7, of the Chester series; and if so, it is about one hundred feet in thickness in this part of the county. This limestone forms the principal part the bluffs on Cypress creek, in sections 2 and 12, and near the mouth of Dry fork, in the west part of section 2, it forms a prominent bluff, where a hundred feet in thickness of the limestone is exposed. The same strata outcrop on the Vienna road, near the bridge, in the southeast quarter of the same section, where the limestone shows intercallations of argillaceous shales. Near the middle of section 12, township 13, range 1 east, the limestone is overlaid by forty feet of sandstone. The only point where this limestone was seen extending to the southwest, beyond Cypress creek, is on section 11, and it is no doubt the lower limestone, or No. 7, of the Chester series, reckoning from the top downwards. This limestone also outcrops to the northwestward, on a branch of *Cache* creek, northeast of Anna, on the southwest quarter of section 9, township 12 south, range 1 west, where from sixty to eighty feet in thickness of it may be seen, and it extends across the hills into the southwest quarter of section 9, and thence diagonally across section 16, dipping strongly to the northeast. The exposed portions are mostly gray and crystalline, with numerous fossils, and especially *Pentremites godoni*, *Productus elegans*, *Spirifer lineatus*, *Athyris ambigua*, and *Archimedes*. Beyond this point, on the west half of section 9, we find the overlying sandstone, No. 6, forming a bluff about forty feet in height, and at another point in the northwest quarter of the same section, the following section was made, where nearly the whole thickness of this sandstone was exposed:

Vertical cliff of sandstone	10 feet
Slope, underlaid with thin beds of sandstone	24 "
Hard sandstone, in thin beds, alternating with shales	10 "
Gray and purple argillaceous shales	10 "

The underlying limestone, No. 7, crops out near by, and this section probably shows very nearly the whole thickness of the sandstone No. 6, which is here not far from sixty feet. In section 34, township 12 south, range 1 east, there is from twenty to thirty feet of this sandstone exposed in thin and evenly stratified beds. Continuing up the eastern branch of this creek to the northeast quarter of section 34 and the northwest quarter of section 35, we find the overlying limestone, No. 5, capping the ridge. It is also exposed on the northeast quarter of section 1, township 13 south, range 1 east, and the adjoining section, 36, on the north. In the northern part of township 12 south, range 1 west, these rocks are also well exposed in numerous outcrops, on the branches of Cache river. On the southwest quarter of section 4, the sandstone No. 6 appears, dipping rapidly down the creek, and soon disappears and is succeeded by the limestone No. 5, and that by the overlying sandstone, No. 4. The limestone No. 5 may be traced to section 9, where it is much better exposed. The overlying sandstone caps the ridge in the northeast quarter of section 9, and in the west part of section 10, and forms the bluffs of the creek on the southeast quarter of section 4, and through sections 3 and 2. On the southwest quarter of section 3, it is exposed from the water's edge to the height of forty feet, mostly in thin beds, suitable for building material.

On a sharp southward bend of the creek in section 2, near the east line, and just above the crossing of the Jonesboro and Saratoga road, this limestone No. 5 outcrops on the south branch of the creek, forming a bluff twenty feet in height, above a sloping bank of twelve feet, and it is here overlaid by twelve feet of sandstone, above which was a ledge of brown limestone (containing the remains of *Fishes and Trilobites*), which appeared to be a local intercalation in the sandstone, loose masses of which covered the slope above. In the northwest quarter of section 1, the sandstone forms the banks of the creek, and the stratum of intercalated limestone is again seen, two feet in thickness, containing the fossils common to this group. The sandstone No. 6 also appears on Cache river, on section 17, township 12 south, range 1 east. The lower part, about twenty feet in thickness, is thin-bedded, fine-grained, and of a dark-brown color, and some portions of it are very hard, approaching a quartzite in texture. The upper part is best exposed a short distance farther east, in the northeast quarter of section 20, where the creek runs over thin beds of ripple-marked, brown, compact, flinty sand-rock, that splits regularly into rhomboidal slabs, and show a strong dip to the north-northeast. Above it there are about ten feet of gray argillaceous shales, the upper eight inches of which are dark-colored and bituminous, and contain, in the upper two inches, some thin streaks of coal. This stratum has been observed at several other points in this and the adjoining counties, and indicates the earliest period when the coal-forming conditions began to prevail in Southern Illinois.

Sandstone No. 4 is only exposed on Cache river, on the southeast quarter of section 14, where it is seen as a finely-grained, compact, brown, slightly micaceous sandstone, capped by the limestone No. 3, and it also appears on the lower course of Bradshaw's creek, in the northeast quarter of section 16. Except at the point above named, the Chester limestone No. 3 was not seen on Cache river, except near the Johnson county line, on the southeast quarter of section 13, where ledges of it cross the creek, and the water has worn a narrow channel through the rugged masses of limestone. It is of a bluish-gray color, close-textured, with an uneven fracture. Half a mile to the northeast of this point, on the southwest quarter of section 13, it is again exposed in the lower part of the bluff, about thirty feet in thickness, while the sandstone No. 2 caps the bluffs, which are abruptly broken. To the northward the sandstone extends to the lower part of Lick creek.

On Bradshaw's creek, which heads in the dividing ridge that traverses the northern part of the county, there are numerous outcrops of this limestone, beginning a half mile above its junction with Cache river, and extending northward nearly to the township line. It is usually of a dark, bluish-gray color, fetid, hard and subcrystalline, and contains the common fossils of the group. The overlying sandstone No. 2 crops out on sections 2 and 3, township 12 south, range 1 east, while in the northwest quarter of section 3, the upper limestone No. 1 is seen. On the northwest quarter of section 32, township 11 south, range 1 east, the limestone No. 3 is seen rising from twenty-five to thirty feet above the water level, and is here overlaid by ten feet of shales, and a heavy body of sandstone, which forms prominent cliffs in the bend of the creek on the north part of section 31. Extending thence westward, it caps the highest ridges northeast of Saratoga. On the northwest quarter of section 30, the sandstone dips below the creek level, and is succeeded by the upper limestone, which outcrops along the upper course of the creek, nearly to the north line of the county. On Lick creek and Conneway branch this limestone is well exposed, and on the former creek reaches nearly the head, attaining a thickness of a hundred feet or more, and is succeeded by the Conglomerate.

West and northwest from Saratoga, on the branches of Cache river, these two upper divisions of the Chester series form the principal outcrops, extending to Cobden, and on the head waters of Drury's creek to within about a mile and a half of the north line of the county.

On the head waters of Clear creek, west and northwest of Cobden, the lower divisions of the Chester series appear, forming prominent bluffs on section 25, township 11 south, range 2 west, and they also appear on some of the head branches of Huggins creek, and on Cave creek, Cedar creek, and Clay-lick creek, on the northern side of the dividing ridge. The aggregate thickness of the group in this county probably will not exceed seven or eight hundred feet, and as it is somewhat irregular in its development, it would be found to vary considerably in its thickness at different points.

The upper limestone division, which reaches an aggregate thickness in this county of more than a hundred feet, according to the measurements and sections of Mr. Engelmann, includes beds which, in some of the adjoining counties, probably constitute two or three distinct divisions of the series. The prevalence of quartzose sandstones through the group seems to ally it somewhat closely to the overlying Conglomerate, and indeed the whole series was included by Dr. Owen with the Conglomerate, as constituting the series equivalent to the Millstone-grit of England. But the presence of *Pentremites, Archimedes,* and many other fossils which are usually considered to be characteristic lower Carboniferous forms, has caused it to be recognized latterly by nearly all American geologists as the upper division of the lower Carboniferous limestone.

Conglomerate.—This sandstone, which forms the base of the true Coal Measures, and, locally, contains some beds of coal that reach a thickness of two or three feet, and are consequently of some commercial value, outcrops over a considerable area in the northwestern portion of the county, and its southern limit is pretty nearly defined by the dividing ridge which we have already mentioned as traversing the northern portion of the county, and forming a distinct water-shed across the southern portion of the State. The base of this formation consists of a massive quartzose sandstone, usually coarse-grained, and, locally, containing embedded pebbles from the size of a pea upward to several inches in diameter. Its outcrop often presents, at the base, a perpendicular face of concretionary or imperfectly stratified sandstone, fifty feet or more in thickness. Above this, the beds become more evenly stratified; and are sometimes shaly, or interstratified with shales. Its thickness has not been accurately measured, but it probably reaches an average of two hundred feet or more. The most westerly outcrop of this formation in Union county is in the south part of section 9, township 11 south, range 2 west, a little northeast of *Bald Knob.* From there it trends southeast to Cobden, where it is intersected by the water-courses of the South Pass, beyond which it continues to the southeast, nearly to the middle of section 33, township 11 south, range 1 west, where it bends abruptly to the northward, around the heads of Bradshaw's creek and Little Grassy, to within about a mile of the north line of the county, where it turns again rapidly southeastward, in a narrow tongue, occupying the hills between Bradshaw's creek and Lick creek, as far south as the southwest quarter of section 28, township 11 south, range 1 east.

On the north and east of Lick creek, it occupies the whole remaining area of the township, intersecting the Johnson county line at the southeast corner of township 11 south, range 1 east. Its outcrop in the county covers an area of a little more than one and a half townships, and is confined to the northern and northeastern portions of the county. A few plants, such as *Sigillaria*, *Stigmaria*, *Lepidodendron*, etc., have been found in the evenly-bedded sandstones of this group, on Drury's creek, and these are the only fossils it has thus far afforded.

Superficial Deposits.—The surface deposits upon the uplands in this county consist mainly of a yellow, loamy clay, mixed, locally, with flinty gravel, derived, no doubt, from the underlying limestones, by the decomposition of the calcareous portions, through atmospheric agencies; but no evidences were seen of the presence of anything like true Northern Drift in the county. The Loess formation was recognized at a single locality only, on the road from Jonesboro to Willard's Landing, where the road intersects a ridge of this material on the eastern side of the Mississippi bottom, and the cut through it exposes from 20 to 30 feet of light, buff-colored, finely arenaceous silt, *in situ*, and presenting the usual appearance of the arenaceous beds of this formation. And it is worthy of remark, that in this region no deposits of this kind cap the highest hills, as at more northerly localities, but they occupy the valleys, showing that the hills in this part of the State were already elevated far above the water level at the time the Loess beds were deposited. These beds extend downward very nearly or quite to the present level of the Mississippi bottoms.

Economical Geology.

Coal.—From what has already been said in the foregoing pages, it will be seen that there are no true coal-bearing rocks in this county, and hence, that no reasonable expectation of finding extensive deposits of coal can be entertained. As has already been said, considerable labor has been expended west of Jonesboro, in digging for coal in the Black Slate of the Devonian series; but as this slate lies more than a thousand feet below the horizon of any true coal-bearing strata, the labor and means so expended can only result in disappointment. There are some thin streaks of coal appearing locally, interstratified with the shales of the Chester series; but they have never been found so developed as to be of any practical value. One of the thin coals, occurring in the Conglomerate, has been found just over the county line, in Williamson county, and may, possibly, extend into Union, and if so, will be found near the north line of the county. This is the only portion of the county where coal may be looked for with any prospect of success, and it is but seldom that the Conglomerate coals are sufficiently developed to make them of any practical value, except to supply the immediate neighborhood where they outcrop.

Iron Ore.—The brown hematite ore exists in this county in considerable quantities, though to the present time no deposit has been discovered that appears to be sufficiently extensive, and free from extraneous matter to justify the erection of a furnace. The principal deposit of this kind, and the only one that promises to be of any practical value, is that already partially described as forming the summit of the ridge known as the Iron Mountain. This ore is a good, compact variety of brown hematite, which, in its purest state, affords from fifty to sixty per cent. of metallic iron, but it is here more or less intermingled with chert, the latter often forming the greater portion of the mass. No considerable body of ore was seen during our examinations of this region, that was entirely free from siliceous matter, and this would necessarily very much deteriorate the value of the ore for the manufacture of metallic iron. It is quite possible, however, that a more careful search, by digging into the cherty mass at the most prominent points, would bring to light an accumulation of the ore so free from chert as to be successfully smelted for the production of iron. The ore and chert with which it is associated, forms the summit of the ridge, while the slope of the hill is formed by the shales and slates of the Kinderhook group, and Devonian limestones. As these beds are nowhere highly ferruginous, it is not probable that the iron originated in them, but rather from some limestones of lower Carboniferous age, which, no doubt, originally extended over the ridge. These limestones may have been the source of chalybeate springs, from which the iron was precipitated as the water reached the surface and dissolved the lime, leaving the chert to be embedded as we now find it, in a ferruginous mass. The dip of the lower Carboniferous limestones now found to the northeastward of this ridge, is such, that any considerable extension of their beds to the southwestward would carry the strata to the summit of this ridge, of which they no doubt once formed a part, and from which they have been removed by erosion at some comparatively recent period. In some respects this deposit resembles the ferruginous Conglomerate of the Tertiary that occurs along the Ohio river, in Pulaski and Massac counties, and it is possible that it may be of the same age, and owes its origin to a similar cause.

Near the top of the ridge excavations have been made before the present settlement of the country, perhaps by the Spaniards or the old French inhabitants, who no doubt carefully explored such portions of the country as seemed likely to afford valuable deposits of metallic ores. This iron ore shows itself on the southern extension of the Iron Mountain ridge in the northeast quarter of section 3, township 12, range 2 west, and also on the north side of Clear creek, in section 27, township 11, range 2, thus showing that it originally extended over a considerable area.

Lead Ore.—The sulphuret of lead, or *galena*, has been found in small quantities in the cherty limestones of the Devonian series. On Huggins creek, on the southwest quarter of section 1, township 11, range 3 west, it has been found near Mr. Gregory's. The galena occurs here, associated with calc-spar, filling small pockets in the rock. Altogether about one hundred pounds of the mineral was obtained at this locality. It is possible that a pocket might be found that would yield a considerable quantity of ore, but the prospect is not encouraging for successful mining operations.

Potter's Clay.—Good potter's clay occurs at several localities in Union county. On the northwest quarter of section 2, township 12 south, range 2 west, a very fine white pipe clay is found, which is used at the pottery in Anna, for the manufacture of common stoneware, by mixing with a common clay found near the town. This pipe clay is nearly white in color, with streaks of purple through it, and appears from its colors to have been derived from the striped shales known locally in this part of the State as "Calico Rock." Except for the coloring matter which it contains, this clay seems to be of a quality suited for the manufacture of a fine article of white ware. On the eastern slope of *Bald Knob* a fine siliceous clay is found, similar in appearance to that forming what is known as the *Chalk Banks*, on the Mississippi, which has resulted apparently from the decomposition of the cherty beds of the Oriskany group. The striped clay first mentioned has been found at several localities in this county, and will no doubt prove to be a valuable deposit. Specimens have been collected for analysis, and its constituents will soon be accurately determined.

Building Materials.—Building stones of excellent quality and in great variety abound in this county. Sandstones of excellent quality occur abundantly in the arenaceous division of the Chester group, and especially in the lower division, which is here more than a hundred feet in thickness. The rock is generally firm in its texture, and the oxide of iron which it contains acts as a durable cement, and renders it a very reliable stone, not only for dry walls, but for culverts and bridge abutments, where it will be subject to the combined action of frost and water. It is sometimes thin bedded, and affords slabs suitable for flags. At other localities it is more massive, and readily splits into blocks suitable for dimension stone. But all sandstones required for heavy masonry, and especially where they are required to resist the combined action of frost and water, should be selected with care, and always from that portion of the quarry where the exposed ledges are not seriously affected by exposure to atmospheric agencies. The Conglomerate sandstone is generally less coherent in structure than the sandstone of the Chester series, and is far less reliable as a building stone, but occasionally it is found in regular beds, and sufficiently firm in texture for ordinary building purposes.

The St. Louis limestone affords a good building material, especially the upper and lower divisions. At the quarries a half mile west of Jonesboro, the rock is a massive, nearly white limestone, free from chert, and dresses well, and in a dry wall will probably prove to be durable, but splits when used for curbing, or wherever it is subject to the action of frost and water. The middle of this division is a dark gray, cherty limestone, that might answer well for rough walls, but would not dress well in consequence of the cherty matter so generally disseminated through it. The upper division, quarried east of Anna, is a light gray, massive limestone, tolerably free from chert, and in quality similar to the quarry rock a half a mile west of Jonesboro. The Chester limestone, when not too argillaceous in their character, afford good building stones, and the dark blue, semi-crystalline limestone in the vicinity of Cobden which forms the upper division of the series, affords a good material for heavy work, and has been used for culverts at several points along the Central railroad.

Limestone for Lime.—The best limestone for the manufacture of quick lime, is found in the upper portion of the St. Louis group, and is extensively quarried a half mile east of Anna, where several kilns are constantly in operation. The rock is a crystalline, and partly oolitic, light gray limestone, nearly a pure carbonate of lime in its composition, and makes a fine white lime, similar in quality to the Alton lime, made from the same formation. The Cairo market,

—32

and the several towns along the Illinois Central railroad, are mainly supplied with lime from this locality. This vicinity could easily supply the whole of Southern Illinois with the indispensable article. It is probable, also, that some of the limestones of the Devonian series might be made available for the manufacture of lime; but they seem to be more siliceous in their composition than the limestone near Anna, and are, furthermore, not so easily accessible. The limestones of the Chester group, at many points, are suitable for the manufacture of good lime, and there are many localities in that portion of the county where they outcrop, where lime can be conveniently and cheaply made. The lime made from these beds, however, is not equal to that obtained from the St. Louis limestone, being of a yellowish color, and some of the beds do not slack well when burned.

Marbles.—The variegated limestones occurring at the base of the lower Helderberg series have already been described in the report on Alexander county, and their adaptation to the various uses for which an ornamental stone is required, has been briefly discussed. These limestones, presenting similar lithological characters, were observed at the base of the bluff near the point where the road from Clear creek, leading to Jonesboro, strikes the river bluff, not far from the south line of the county, and they will no doubt be found at many points in this vicinity. The variegated beds appeared to attain a thickness of about twenty feet at this locality, and pass gradually into the siliceous limestones above. The Clear creek limestone, of the Devonian series, also affords, at some localities, heavy beds of nearly pure white, or delicate grayish-white, crystalline limestone, that is susceptible of receiving and retaining a high polish, and seems to be well adapted to the use of the marble-worker. These occur on *Huggins creek*, on sections 12 and 14, and also on the northwest quarter of section 13, township 11 south, range 3 west. The rock weathers somewhat unevenly, giving a flawed appearance to a long exposed surface; but by quarrying into the bed beyond the influence of surface agencies, a sound and excellent marble would no doubt be found. These outcrops are from eight to ten miles distant from Cobden, on the Central railroad, and three or four miles from the Big Muddy river. The beds are no doubt the equivalent to those at *Bald Rock* and the lower end of the *Backbone*, in Jackson county, to be described in the following chapter.

Clay for brick and *Sand* for mortar can be found in almost any neighborhood in the county. The common brown clays of the sub-soil in this county make good brick, and sand is found in all the alluvial deposits along the streams, and especially where sandstone is the prevailing rock.

Mill-stones.—The enormous masses of chert rock contained in the Clear Creek limestones afford, at some points, a burr-stone that appears to be nearly, if not quite equal in quality to the celebrated French burr-stones so extensively used for mill-stones in this country. Some of the specimens obtained here seem to possess the requisite hardness and porosity, and some mill-stones have been obtained from the chert beds at *Bald Knob* that are said to have answered a good purpose, and were used in the neighboring mills. But these were made from the rock that had been long exposed at the surface, and perhaps were not taken even from the best part of that; while the beds lying beyond the reach of atmospheric influences have not been tested. For grinding corn, these home-manufactured stones have answered a good purpose, doing their work rapidly and well. For grinding wheat, their value has not yet been fairly tested.

Grind-stones.—Some of the evenly bedded sandstones of the Chester group, and especially the lower bed of the series, is frequently developed in thin, even layers, that could be readily manufactured into grindstones. The rock has a fine, sharp grain, and if too soft when freshly quarried, would probably harden sufficiently on exposure to give them the necessary durability. Some beds of the Conglomerate sandstone also have a sharp grit, and when sufficiently compact in texture and even bedded, will make good grind-stones.

Mineral Springs.—At *Western Saratoga*, in this county, there is a mineral spring in the Chester limestone, which has attained some celebrity in the surrounding country for its medicinal properties. It is located in the northeast corner of section 1, township 12 south, range 1 west, and appears to be a tolerably strong sulphur water, and contains, besides sulphuretted hydrogen, a small quantity of sulphate of lime, carbonate of soda, chloride of sodium, and perhaps a little alumina and magnesia. The water is said to be a specific for dyspepsia and chronic diseases of the skin. It is also said to be beneficial in cases of scrofula. The water is strongest during the dry season of the year, being then less affected by the admixture of surface water.

Near Seminary Fork of Clear creek, on the southwest quarter of section 22, township 11 south, range 2 west, a strong spring boils up, from which bubbles of gas, probably carbonic acid gas, rise continually. The water does not appear to possess any decided mineral properties, but evidently originates from a deep source, as it preserves an even temperature throughout the year. The strata are strongly tilted in this vicinity, and this spring appears to rise to the surface through the fissures, formed by the disturbing cause that elevated the underlying rocks.

Agriculture, Soils, etc.—The topographical features of this county are quite varied, and are determined by the outcrops of the different geological formations within its limits. A tract of alluvial bottom land, from two to three miles in width, stretches along the western borders of the county through its whole extent, and some quite narrow bottoms are also found on the lower courses of some of the largest creeks. In the very broken region where the lower Helderberg and the Clear Creek limestones outcrop, the arable land is restricted almost entirely to the creek valleys. The region underlaid by the lower Carboniferous limestone series, although somewhat hilly, is nevertheless generally susceptible of cultivation, and constitutes the best grain-growing section of the county. The sandstones, limestones and shales forming this series, from the decomposition of which the soil has been formed, contain all the essential mineral ingredients necessary to the production of a soil physically and chemically well proportioned, and we find these lands productive in cotton, tobacco, wheat, corn and all the products of a temperate climate. The sandstones and arenaceous shales have furnished sufficient sand to make the soil warm and mellow, the argillaceous shales have furnished clay to make it attract and retain moisture and ammonia, the limestones the necessary lime to decompose the organic matter, and to set at liberty the alkaline bases, and to supply the phosphates and other salts which are the indispensable ingredients of a productive soil. The soil and subsoil are very similar to each other, except that the former is a little more disintegrated, and contains more vegetable matter or humus. Both are finely arenaceous, but less so than the post-oak soils of the country farther north, and is sufficiently coarse to make it light, and to produce a natural drainage by the absorption of surplus water, where the surface is too level to turn the water readily. The magnificent growth of timber, consisting mainly of deep-rooted species, which originally covered the surface of this limestone region, is due mainly to the physical and chemical characters of the soil above mentioned, which render it also admirably adapted to the growth of fruit trees, and the production of all varieties of fruits suited to the climate.

One of the finest fruit regions in the State is the summit of the sandstone ridge already described as traversing the northern portion of this county, and forming the water-shed separating the streams running north into the Big Muddy, from those running south into the Ohio and Mississippi. The ridge has an elevation of five or six hundred feet above the level of the Ohio at Cairo, and on its southern face presents a series of perpendicular cliffs like those bordering our present rivers. Towards the north it sends off spurs along the courses of the small streams by which it is intersected, or is joined by more gentle slopes to the adjacent highlands. It was originally covered with a heavy growth of timber, consisting mainly of oak and hickory, but has recently been transformed from a wilderness into fruitful farms, with orchards and vineyards, such as delight the eye and gladden the heart of all true worshippers at the shrine of Pomona.

In the spring of 1852 I undertook to make a reconnoissance of this ridge, from the Big Muddy to the Ohio, through what was then an almost unbroken wilderness, and on foot and alone, with hammer in hand, I traversed this wild and picturesque region, reaching the Ohio in eight days after leaving Big Muddy. The only signs of civilization to be met with then, in this region, was a log cabin now and then, occupied by some squatter's family from East Tennessee or North Carolina, who imagined themselves entirely secure in this wilderness from the encroachments of a higher civilization. But the squatter planted a few peaches about his cabin, and when the Illinois Central railroad was built, and settlers began to flock into this long neglected region, they observed that when the peach failed everywhere else north of the Ohio river, the orchards on this sandstone ridge always produced an abundant crop. Hence, the attention of fruit-growers was naturally drawn to this region, now brought within a day's travel of the Chicago market; and the result has been that these lands, which, in 1852, were not considered worth the government price of a dollar and a quarter an acre, are now readily sold at from $150 to $200 per acre, and are owned and occupied by the most intelligent and refined rural population that can be found in the West. This is undoubtedly the finest fruit region in the State, and more fruit is annually shipped from Cobden than from any other station on the road, and the annual products of the orchards and vineyards of this county must steadily and rapidly increase for years to come.

CHAPTER XX.

JACKSON COUNTY.

This county lies immediately north of Union county, which forms its southern boundary, and on the east it is bounded by Williamson and Franklin counties, on the north by Perry county, and on the west by Randolph county and the Mississippi river. It embraces an area of about five hundred and eighty square miles, of which something over one hundred is alluvial bottom land on the Mississippi. The county line which separates this county from Randolph on the northwest, runs from northeast to southwest, along the dividing ridge between Kinkaid creek and Mary's river. This county reaches northeastward to the borders of the prairie region, and embraces two or three small prairies within its limits, while the remainder of the county was originally covered with a heavy growth of timber.

The bottom lands along the Mississippi are in part low and wet, while other portions as sufficiently dry to admit of cultivation, and are very productive, though subject to overflow during the annual spring floods. Some of the low lands are too wet for the growth of arboreal vegetation, and are covered with coarse grass and ponds of water. The higher parts of the bottoms are covered with a heavy growth of timber, among which we observed the following species: Willow, sweet-gum, tupelo-gum, sycamore, cotton-wood, honey locust, hackberry, box-elder, red birch, white ash, black ash, red oak, swamp or pin oak, swamp white oak, bur oak, white walnut, pecan, horn beam, persimmon, red haw, mulberry, scaly-bark hickory, red and white elm, white and sugar maple, red bud, dogwood, pignut hickory, scarlet oak, linden, beech, white oak, black oak, black gum, yellow poplar, or tulip tree, etc.

The country adjacent to the river bluffs is roughly broken and hilly, and the bluffs themselves often present high rocky precipices, rising in bold relief from the river bottoms to the height of two or three hundred feet, and form a bold picturesque scenery. The main chain of bluffs is about five miles from the river, with a broad belt of bottom land intervening, but in the extreme southwestern part of the county there is another range of bluffs immediately at the river bank, formed by some isolated hills that have successfully withstood the denuding forces which excavated the broad valley now in part occupied by the Mississippi river. These hills are known as "Fountain Bluff," "Devil's Bake Oven," and "Back-bone," and the two latter are formed by an uplift of Devonian strata, which are here tilted to an angle of about 25°, dipping to the northeastward, while the former consists in part of Chester limestone and sandstone, overlaid by the Conglomerate, with a very moderate dip in the same direction.

Fountain Bluff or *"Big Hill,"* as it is sometimes called, is an oval-shaped eminence, about three miles in length, from north to south, and about one mile and a half in width. Its base is formed of the lower Carboniferous limestone of the Chester series which outcrops around its western and southern slope, and its upper part by the Conglomerate, the lower layers of which, at the northern extremity of the hill dip below the level of the adjacent bottom, while the higher beds form an elevation of two hundred feet or more above the river level. Between the lower end of this hill and the "Bake Oven," there is an interval of half a mile or more of bottom land which, before the erosion of the river valley, was no doubt occupied by the lower Carboniferous and Devonian strata that properly intervene between the beds now outcropping at the "Bake Oven" and the southern extremity of Fountain Bluff.

Between these hills which now skirt the eastern shore of the Mississippi, and the regular chain of river bluffs which skirt the bottom lands on the east, there exists a broad belt of low, wet bottom, five miles in width, and mostly covered with ponds of water, except in the very dryest portions of the season, and over which for countless ages rolled the mighty currents that formed the valley in which the turpid waters of the Mississippi now find their way to the gulf. From the fact that the waters of the Mississippi are restricted to an area much less than its average width, at what is called the *Grand Tower*, and are hemmed in by precipitous limestone bluffs on either side, the theory has been entertained that at a former period these limestone cliffs extended quite across the river, forming an immense fall which has been gradually cut away by the current of the river; but the ingenious author of this apparently plausible theory was probably not aware of the existence of a valley five miles in width, within a half mile of the eastern bank of the river, through which the surplus water of the river now flows during every period of high-water, and into which the whole current of the river would be turned by the introduction of any considerable impediment into its present channel. The whole valley, including the narrow gorge in which the river now runs, was formed long before the existence of the present river, and by causes far more potent than an ordinary river current, and was probably effected during a former submergence of the entire region, by the combined force of water currents and moving ice; the same agencies which have excavated all our principal river valleys.

The main chain of bluffs in the southern part of the county is on the eastern side of the Big Muddy, which enters the Mississippi bottom in the northern part of township 9 south, range 3 west, and from this point the river winds along the eastern borders of the bottom, near the bluffs, to the south line of the county, in a direction nearly south, in accordance with the general trend of the bluffs. To the northward of the point where the Big Muddy enters the bottom, the trend of the bluffs is northwestward to the Randolph county line.

Geological Formations.

The geological structure of this county includes a wide range of formations, embracing an aggregate thickness of about two thousand seven hundred feet of strata, and ranging from the top of the lower Coal Measures down through the Conglomerate, the lower Carboniferous and Devonian, to the base of the upper Silurian series, and thus affords a wide and varied field for exploration, such as is afforded by few counties in the State. The Devonian beds at the "Bake Oven" were the first recognized rocks of this age in the State, and the disturbed condition of the strata, and the bold and picturesque scenery on both sides of the river, at this locality, have rendered this one of the most attractive localities for the tourist, as well as the geologist, to be met with in the southern portion of the State.

The *Grand Tower*, which is an isolated cliff of limestone, standing out and forming an island in the river nearly a hundred feet above the low-water level, has long been a conspicuous land-mark for the traveler on the Lower Mississippi.

The following section will illustrate the geological structure of this county, and the order of sequence and thickness of the different groups of rocks found within its limits:

Perpendicular Section of the Rocks in Jackson County.

Quaternary.	200.	Alluvium, Loess and Drift.
Conglomerate and Coal Measures.	500 to 600.	Lower Coal Measures, consisting of sandstones, shales, slates, thin beds of limestone, with three or more seams of coal, ranging from two and a half to four feet in thickness. Conglomerate: Quartzose sandstone, often massive, and including pebbles of quartz, passing upward into thin-bedded, soft, micaceous sandstones; the whole series ranging from five to six hundred feet in thickness, including the Coal Measures.
Lower Carboniferous Limestone.	800.	Chester Group: Gray and brown argillaceous limestones, alternating with sandstone and sandy or argillaceous shales.
	250.	St. Louis Group: Light gray limestone.
	150.	Keokuk Group: Cherty gray limestone.
	100.	Burlington Limestone; Brown crinoidal limestone.
	?	Kinderhook Group? Not exposed.
Devonian.	?	Black Slate? Not exposed.
	40 to 75.	Hamilton Group: Gray limestone, with intercalations of calcareous shales.
	20 to 30.	Corniferous limestone.
	60.	Onondaga Limestone: Light gray siliceous limestone, sandstone, and striped siliceous shales.
	250.	Oriskany Group: Clear Creek limestone, consisting of alternations of limestone and chert, passing locally into a complete chert rock.
Upper Silurian.		Band of brown shale.
	200.	Lower Helderberg Limestones; Buff and gray magnesian limestones, in thin beds, alternating with chert.

The lower divisions of the foregoing section outcrop only over a very limited area in the southwestern corner of the county, where they are elevated above the surface level by the uplift which crosses the river about three miles above the south line of the county, with a trend from northwest to southeast.

We will now describe the general character, thickness and extent of outcrop of the formations that are developed in this county, beginning with the lowest:

Lower Helderberg Limestone.—This formation outcrops only in the river bluff near the south line of the county, commencing near "Bald Rock," and extending south from there into Union county. It has been fully described in the foregoing chapter on that county, and the description need not be repeated here.

Oriskany Group.—This group consists of a series of cherty, siliceous limestones, and light gray, massive crystalline limestone, the whole attaining an aggregate thickness of at least two hundred and fifty feet. It forms the prominent hill known as "Bald Rock," on the Big Muddy, and from that point it forms the upper part of the bluffs to the south line of the county. "Bald Rock" is a bold, rocky precipice, rising abruptly from the water level to a height of at least two hundred feet, on the eastern bank of the Big Muddy, the waters of which wash its base. The upper part of the exposure, for a thickness of a hundred feet or more, consists of heavy beds of limestone, partly cherty and siliceous, while other portions are composed of white, or light gray and drab crystalline limestone, quite hard, and apparently susceptible of receiving a high polish, and adapted to the ordinary uses of the marble worker. It is only a limited thickness of strata, however, that are of this character, while the most of the layers are too hard and siliceous, not sufficiently uniform in texture, and rather cherty to work well, except for rough walls. The lower part of the exposure here consists of a loose, porous chert rock, similar in all respects to that so fully described as belonging to this horizon in Union county. At the lower end of the "Back-bone" these beds are also exposed, and consist, in part, of massive crystalline limestone, variously colored, and streaked with pink, yellowish and blue, and when polished, they form a beautiful marble. These massive beds attain a considerable thickness, but from the disturbed condition of the strata, could not be accurately measured. They are here underlaid, also, by a porous, cherty rock, a hundred feet or more in thickness. The calcareous beds abound in fossils, among which the remains of *Crinoidea* were abundant, consisting mainly of columns and plates. These beds are equivalent of the Clear Creek limestone, of Union county, and present very similar characters to the outcrops already described in that county, except that the massive calcareous beds form a more conspicuous feature at the "Bald Rock" than at any point observed farther south, though they are no doubt represented in Union county by the white and bluish-gray limestones on Huggins creek, already described in the foregoing chapter.

Onondaga Group.—The arenaceous beds which succeed these cherty limestones in the ascending order occur at the "Bake Oven" forming the base of the bluff, and at the bottom they constitute a true quartzose sandstone, while above they consist of alternate layers of sandstone and siliceous limestone, attaining altogether a thickness of thirty-five to forty feet. The fossils from this bed are crushed and in a poor condition for determination, so that it is difficult to say positively whether they are most nearly allied to the beds below or above. From the fact that it becomes more and more calcareous towards the top, and finally passes into the light gray limestone of the Onondaga period above, it would seem probable that these arenaceous beds also might with equal propriety be considered as belonging to this higher division of the Devonian series. This sandstone is succeeded by a massive light gray semi-crystalline limestone which forms the middle portion of the perpendicular cliff at the "Bake Oven," and attains a maximum thickness of about twenty-five feet. Its only outcrops are in the river bluffs at the "Back-bone" and the "Bake Oven," and possibly at "Bald Rock," on the east side of the Big Muddy river. The fossils characteristic of this limestone have already been enumerated in the foregoing chapter.

Corniferous and *Hamilton Groups.*—The beds exposed both at the "Back-bone" and "Bake Oven" consist of dark gray, siliceous, fetid limestones, with intercalations of calcareous shales, attaining altogether a thickness of a hundred feet or more. These limestones are well exposed at the "Bake Oven," where they form the upper part of the perpendicular escarpment, and also at the upper end of the "Back-bone," where they form the northern extremity of the ridge. On top of the ridge, about one-third of the distance from the upper to the lower end, there is a bed of calcareo-argillaceous shale, mostly buff-colored, and from ten to fifteen feet in thickness. It is probably about the middle of the series, though the exposures were too incomplete to give us an entire section. The lower beds contain comparatively few fossils here, but have afforded several species, among which are a large *Gomphoceras*, of which several specimens were obtained, *Nautilus* (*Discites*) *ornatus*, a large *Strophomena*, a *Para-*

cyclas, like *P. elliptica* and *Chonetes Littoni*. The upper beds contain the following species: *Chonetes carinata*, *C. Martini*, *C. pusilla*, *Tropidoleptus carinatus*, *Atrypa reticularis*, *Strophomena rhomboidalis*, *S. demissa*, *S. fragilis*, *Orthis Iowensis*, *Spirifer fornacula*, *S. formosa*, *Phacops bufo*, and several undetermined species of *Zaphrentis*, with a few fragments of fishes. These limestones have only been seen at the two localities above cited, and at the lower extremity of Walker's Hill, immediately east of the lower end of the "Back-bone" ridge, where only a few feet in thickness of these Hamilton limestones are exposed; and on the east side of the Big Muddy, where we might naturally expect to find them overlying the lower Devonian strata that are so well developed there, they have not been seen, and appear to have been crowded under the superincumbent limestones of the lower Carboniferous series, the result probably of the disturbance which has elevated the Devonian strata above the surface at this point.

All the limestones above decribed are limited in their outcrop to a very small area, and are strictly confined to the river bluffs in the southwest corner of the county, and although they attain an aggregate thickness of between six and seven hundred feet, their outcrop does not cover an area of more than two miles square. Above the Hamilton limestone we should expect to find the usually succeeding *Black Slate*, but no exposure of it was found in this county, though at the lower end of Walker's Hill we find a covered slope of considerable thickness immediately above the limestone, that is probably underlaid by the shaly beds of this series, and perhaps in part also by the siliceous shales of the Kinderhook group.

The beds forming this hill dip rapidly to the northward, and between its northern and southern extremities we find the local outcrops of partially exposed beds that appear to represent the whole lower Carboniferous series, from the Kinderhook group to the top of the St. Louis limestones inclusive.

Burlington Limestone.—The outcrop of this formation already cited is the only one met with in this county, and the most southerly one known in the State. It occurs on the western slope of Walker's Hill, nearly opposite to the lower end of the "Back-bone" ridge, and exhibits only a part of the formation, consisting, so far as seen, of brown and brownish-gray crinoidal limestone in tolerably regular beds, and in part in tumbling masses on the top of the hill. This exposure was not sufficient to afford an accurate measurement, but the formation appeared to be at least fifty feet in thickness, and is possibly considerably more.

Keokuk and St. Louis Groups.—The upper end of Walker's Hill is composed of gray limestones, which are but partially exposed in the outcropping strata, or in tumbling masses on the hill-side, but which are easily identified as belonging to the groups above named. The hill is about half a mile in length from north to south, and these limestones occupy the upper or northern end of the hill, with a strong dip to the northward, which carries the whole series underground in a distance of about a quarter of a mile. The whole thickness of the lower Carboniferous limestones outcropping in this hill is probably not less than four or five hundred feet. North of this hill there is a valley of about a half a mile in width, separating it from Fountain Bluff, the lower end of which, as we have already stated, is formed by the upper beds of the Chester series, while the lower beds of that series were worn away by the denuding forces which excavated the intervening valley. None of the limestones above mentioned, except those of the Chester group, have been identified anywhere in the county, except in the river bluffs near the southern extremity of the county, and at Walker's Hill, which is but a half mile to the eastward of the river bluff. Their outcrop in this county is entirely due to the axis of elevation which crosses the river at this point, with a general trend from northwest to southeast, and intersects only the southwest corner of this county, and on the eastern side of the Big Muddy all the lower Carboniferous series below the Chester group, as well as the upper part of the Devonian series, were apparently crowded under the Chester beds, which here immediately succeed the lower Devonian strata, though they are not found resting upon them. Their outcrop covers an area in this county of scarcely more than two square miles.

Chester Group.—This group, though not fully exposed in Jackson county, nevertheless occupies a much greater area than the subordinate groups, and outcrops over a surface of about twenty-five miles square, but is confined to the river bluffs and the valleys of some of the adjacent streams. Commencing on Digognie creek, at the northwest corner of the county, its upper divisions form the river bluffs, capped, in part, by the Conglomerate, nearly down to where Kincaid creek enters the Mississippi bottom, and on the last named creek, commencing on the northwest quarter of section 28, township 8 south, range 3 west, they extend thence along the valley of the creek, through township 8 south, range 4 west, and on to some of its head branches in the adjoining township on the west. They also form the valley of Digognie creek, as far as it runs in this county, and the outcrops on Reed's creek and Cochran's creek, nearly to their heads. Through township 9 south, range 3 west, the trend of the bluffs is so far to the eastward that these limestones are not seen, and the bluffs are formed by the Conglomerate sandstone; but on section 14, township 10 south, range 3 west, they again come to the surface and continue along the bluffs to within about two miles of the county line, from whence they trend off to the southeastward into Union county. They also appear on two or three of the southern branches of Cedar creek, and for a short distance, also, on the main creek on section 13, township 10 south, range 3 west. At *Fountain Bluff*, on the Mississippi, they form the base of the hill, which is capped with Conglomerate at the lower extremity, while the latter formation forms the entire elevation at the northern end of the hill. The following section, made by Mr. Engelmann, at the county line near the northwest corner of the county, probably exhibits as great a thickness of strata as can be found at any locality in the county:

Section of the River Bluffs near Digognie Creek.

No. 2.	Fine-grained quartzose sandstone, partly exposed	35	feet
No. 3.	Dark bluish-gray limestone, siliceous and cherty, probably the second limestone in the series from the top	40	"
No. 4.	Slope, partly underlaid with sandy shales	20	"
	Massive quartzose sandstone	40	"
No. 5.	Limestone, upper part of the bed, only, exposed	20	"

The lower limestone in the above section is probably the equivalent of the upper bed at Chester, and its position is consequently near the middle of the series. It is the lowest division exposed in the northwestern portion of the county, and perhaps the lowest that appears above the surface in the county.

The following is a section of the river bluffs at Mr. Wright's place, on the west part of section 35, township 8 south, range 4 west, and gives a good idea of the character and thickness of the upper division of the group in this county:

	Quartzose and ferruginous sandstone (Conglomerate)	5	feet
No. 1.	Limestone, upper part only partly exposed	40	"
No. 2.	Slope, hidden, probably underlaid with sandstone	20	"
	White quartzose sandstone	46	"
	Slope, underlaid with shales, interstratified with limestones	41	"
No. 3.	Dark gray siliceous limestone	8	"
	Slope, with masses of siliceous limestone	38	"
	Compact brown siliceous limestone, not in place	3	"
	Slope, to high-water mark	18	"

This section appears to include the three upper divisions of the Chester series, with an aggregate thickness of a little more than two hundred feet. A mile and a half below this point, on the northeast quarter of section 1, township 9, range 2, a seam of carbonaceous shale, with streaks of coal, may be seen in the shales of the upper division of the Chester series. This carbonaceous shale is here about eight inches thick, and is intercallated in argillaceous shales, as seen in the following section:

	Conglomerate sandstone, capping the bluff	30 to 40 feet
No. 1.	Siliceous limestone, partly exposed	28 "
No. 2.	Sandstone and sandy shales	21 "
	Argillo-arenaceous shales, passing into argillaceous shale	22 "
	Carbonaceous shale, with streaks of coal	⅔ "
	Argillaceous shale	6 "
	Massive sandstone	53 "
	Slope, hidden to river level	55 "

This is undoubtedly the representative of the small seam of coal that has been observed in these limestones in Union, Johnson and Pope counties, and is nowhere of any practical value, but only interesting from the fact that it is the first evidence presented in the development of the lower Carboniferous series, of the existence of true coal-bearing conditions. This thin seam of coaly matter occurs at several points, both in this county and Randolph, and has given rise to reports of the existence of workable beds of coal in this group of rocks, which are without any true foundation.

The upper sandstone of the Chester series is fully one hundred feet in thickness, and is in part massive and partly thin-bedded and shaly, and frequently presents lines of false stratification, or apparent lines of bedding inclined at a considerable angle to the true stratification of the rock. The black shale and coal mentioned above occurs in the same relative position at Dr. Hodges' on the northeast quarter of section 11, town 8, range 4, and also a mile further south in the northwest quarter of section 14. The upper limestone, or No. 1 of the series, numbering them from the top downwards, outcrops at several points near the summit of the ridge, at the head of Digognie and Reed's creeks. It is also exposed at Mr. Gordon's, on the breaks of Reed's creek, near the county line, and is here highly siliceous and interstratified with cherty arenaceous strata, and is directly overlaid by the Conglomerate.

Kincaid creek heads in the Conglomerate, not far from the head of Reed's creek, but on the eastern part of section 12, township 8 south, range 5 west, the creek valley intersects the upper limestone which has here been burned for lime, and it continues thence down the creek for several miles through sections 5, 4 and 9, and into section 10. There are some small caves in the limestone here, and numerous sink holes, and it is intersected with veins of calcareous spar. Lower down on the creek, on the southeast quarter of section 3, blue argillaceous shales outcrop above the limestone, in which are embedded numerous concretions of carbonate of iron. This shale appears to be at the base of the Conglomerate. On section 24, township 8 south, range 3 west, a bed of highly ferruginous sandstone occurs which changes locally into a brown hydrous peroxyd of iron, somewhat mixed with flint and sand, and about a foot in thickness. This appeared to occupy about the same position in the strata as the iron carbonates above mentioned, that is, near the base of the Conglomerate.

Fountain Bluff or "Big Hill, as it is sometimes called, is formed by the upper division of the Chester series and the Conglomerate. The former beds occupy the entire elevation at the lower end of the hill, but the strong northerly dip soon carries them below the river level, and the upper or northern portion is composed entirely of the Conglomerate. At the base of the hill, on the south and southeastern side, siliceous limestones, interspersed with shales, are seen, and these are overlaid by a massive sandstone, forming a cliff eighty feet in height. Still higher up are partial outcrops of shaly limestone, with *Archimedes* and other characteristic fossils of this series, and still higher the sandstones of the Conglomerate. From these observations it would seem that we have at the lower extremity of this hill the three upper divisions of the Chester group, embracing two limestones and a sandstone. At the upper end of the hill the Conglomerate forms the entire exposure, and rises in towering cliffs 120 feet at least above the adjacent river bottoms.

Below the mouth of Cedar creek, at Herald's old mill, a few feet in thickness of the upper limestone of this series was seen overlaid by heavy beds of Conglomerate, and from this point it gradually rises in descending the bluffs, in consequence of their more western trend. Approaching Bald Rock the dip increases, and near the mouth of Rattlesnake creek the beds dip northeast at an angle of thirty degrees. This is the most southerly outcrop of these limestones in the river bluffs, and from this point they trend off to the southeast into Union county.

The most easterly outcrop of these limestones in Jackson county is on the upper course of Cedar creek, near Williams' mill, on the southwest quarter of section 35, township 10 south, range 2 west. At this point the lowest strata exposed, consist of a dark gray, uncrystalline, hard and brittle limestone, which are succeeded by brownish-gray, argillaceous and sub-crystalline limestone, the whole forming a bed forty feet or more in thickness. The fossils observed here were: *Productus elegans*, *P. pileiformis*, *Athyris ambigua*, an *Orthoceratite*, etc. The mill is driven by a spring which issues from the limestones near the top of the exposure, and it appears to have a subterranean connection with the western branch of the creek, as the flow of water from the spring is apparently governed by the amount of water in this branch.

It is probable that all the outcrops of Chester limestones observed in this county belong to the upper divisions of the series, and that the lower members are now entirely hidden in the valleys that intervene between these outcrops and the older formations. From their general similarity in lithological characters and the wide range of the characteristic fossils of the group through the whole series, it is difficult to decide to what part of the series an outcrop of limestone belongs, unless the associated beds are also well exposed, so that its position can be determined by the sequence of the strata.

Conglomerate.—The term Conglomerate Sandstone, or Millstone-grit, is used to designate a thick bed of sandstone that lies at the base of the Coal Measures, and as it also contains local developments of coal sufficiently important to be worked profitably at some points, it may properly be considered as the base of the true coal-bearing rocks. Through all the counties that border the Illinois coal field south of Randolph, this formation is largely developed, attaining a thickness of two, or sometimes, perhaps, as much as three hundred feet. It consists of quartzose sandstone, mostly nearly white, but sometimes colored by ferruginous matter, and frequently contains rounded pebbles of quartz rock, from the size of a pea to those three or four inches in diameter. When ferruginous, it weathers very unevenly, and leaves a hard brown crust upon its surface, formed of sand, cemented by the brown oxide of iron. Where the quartz pebbles are abundant, the finer materials disintegrate from around them on the exposed surface, and leave them projecting from the perpendicular walls of sandstone, like partly embedded cannon balls. Locally it passes into shales or thin bedded limestones, and it contains thin beds of argillaceous shales. The sandstones are sometimes soft, and decompose readily on exposure to the atmosphere, and again are more compact and harden slightly on exposure, and such outcrops form towering cliffs and bold escarpments in agreeable contrast to the usual monotony of the more level landscapes.

The *Abneyville Rock* is a prominent cliff of this sandstone, about a mile in length, situated on the eastern side of the Big Muddy river, which washes its base. It is situated in sections 23 and 26, township 9 south, range 3 west, and is only about thirty feet in height above the river level. *Swallow Rock* is another prominent bluff of the Conglomerate on the Big Muddy, beginning near the center of section 35, and extending for some distance to the southward. At its northern extremity it forms an overhanging cliff of sandstone sixty feet high, increasing in elevation to the southward, until on section 2, township 10 south, range 3 west, it attains a perpendicular height of more than two hundred feet above the river. *Figure House Rock* is a cliff of sandstone on Cedar creek, about half a mile above its mouth, remarkable only for the rude figures carved on it by the former inhabitants of the country. These consist for the most part of rude figures of the human form, with others resembling bird tracks, arrow heads, etc.

At the top of the Conglomerate there is usually a seam of coal that averages about eighteen inches in thickness, and forms an easily recognized horizon in tracing the sequence of strata, scarcely to be distinguished otherwise by any change in their lithological characters. This formation caps the river bluff throughout the county, except at a few localities in the extreme southwestern part already mentioned, where they are composed of Silurian and Devonian strata, and through the more northern part of township 10 south, range 3 west, and nearly the whole of 9 south, range 3 west, this sandstone forms the entire elevation of the bluffs, and also covers a belt of country immediately to the eastward of them, averaging from three to six miles in width.

In the extreme southern portion of the county it outcrops from Cave creek to the county line of Williamson county, and forms the valley of both branches of Drury's creek, to the middle of township 10 south, range 1 west, and on Cedar creek it occupies the valley of that stream through the northern and eastern portions of township 10 south, range 2 west. It extends up the valley of the Big Muddy, above the mouth of Lewis creek, and outcrops on the lower course of Kinkaid creek, from the northwest quarter of section 28, township 8 south, range 3 west, to the river bluffs. It caps the highlands between the upper course of Kinkaid creek and the river bluffs, and also forms the valley of North Fork and Little Kinkaid. It forms the valley of the north fork of Mill creek, at the county line of Randolph county, underlying a belt of country about three miles in width, trending northeastward into that county. The outcrops of coal at the top of this formation will be mentioned under the head of Coal Measures.

Lower Coal Measures.—The lower Coal Measures, as they are developed in this county, cover an area about equal to one-half of the county, and if a line is drawn diagonally from the southeast to the northwest corner, it would define very nearly the western boundary of the coal field in this county. These lower measures include a thickness of about two hundred and fifty, or possibly three hundred, feet of strata, consisting mainly of sandstones and shales, with some thin beds of limestone, and three or four seams of coal, probably including all the beds, from the horizon of the DuQuoin coal to the base of the measures. The lowest persistent seam in this series is the one outcropping just at the top of the Conglomerate. It is usually from sixteen to twenty-four inches in thickness, and affords a coal of fair quality, but is too thin to be worked with profit, except by stripping at its outcrop. The next coal in the series, of a workable thickness, are the Murphysboro coals, which are well exposed on the Big Muddy, near that town, where the rocks show the following section, from the top downwards:

Micaceous sandstone, with partings of shale	20	feet	
Coal, upper seam	3	"	
Dark-blue clay shale	12	"	
Brown areno-argillaceous shale, with iron nodules	15	"	
Coal	3	"	
Clay parting, from two to eight inches	0	"	8 inches
Coal	2	"	
Shale, with nodules of iron ore	20	"	
Sandstone, extending below the river level	?	"	

Extensive mining operations have been carried on here for many years, and formerly the coal from these mines was floated down the Big Muddy on barges, and across the Mississippi to the highlands on the west side, in Missouri, where a coal depot was established when the mines were first opened. Recently these mines have passed into the hands of some eastern capitalists, a joint stock company has been formed under the title of the "Mount Carbon Coal and Railroad Company," and a railroad has been constructed from the mines to the Mississippi river, at the lower extremity of the "Backbone," where a coal depot has been established.

The lower seam, or, rather, the two lower seams, though they are worked as one, is mainly wrought here, and the lower part of it, below the clay parting, affords a coal of excellent quality, and sufficiently free from the sulphuret of iron to be used in a raw state for smelting iron, a quality which greatly enhances its value from its proximity to the St. Louis market, and the immense iron deposits of Missouri. The upper part of the seam also affords a good quality of coal, but contains more sulphuret of iron than that below. The seam of clay shale is variable in thickness, ranging, in the vicinity of the shaft, from two to six inches, and appears to increase in thickness towards the south, so that in a distance of less than a mile in that direction it is ten feet thick, and the lower division of the seam has thinned out altogether. The thickness of the top coal varies from thirty to forty-two inches, and the bottom from twenty-two to thirty-two inches.

Very little has been done here towards mining the upper seam in the foregoing section, and its maximum thickness in this vicinity may be set down at about three feet, and from this it ranges down to a mere streak of bituminous matter. At the Mount Carbon mines, where it had been opened and drifted on for some distance, it ranges from twenty-four to thirty inches in thickness, with a sandstone roof. The quality of the coal does not appear to be equal to that from either division of the lower seam. On the north side of the Big Muddy, around Murphysboro, these coals have not yet been found, and it seems probable that they were cut away in the erosion of the river valley, which was subsequently refilled with Quaternary deposits, but they will probably be found wherever borings are made beyond the northern limits of this valley, at a depth of less than one hundred feet from the surface.

It is possible that the foregoing section represents the three lower coals, and that the lowest one with the clay parting is really two distinct seams, which are here only separated by a thin parting of shale, but it seems more probable that the seam usually developed at the top of the Conglomerate really holds a lower position, and is not represented here. These seams outcrop also about a mile southeast of Carbondale, holding about the same relative position, and the section here is very nearly an exact repetition of that at Murphysboro, except that the lower coal seam is four feet thick and has no clay parting. Seven miles south of this point, near Makanda, a thin seam of coal is found about eighteen inches thick, which must underlie those at Carbondale. These coals appear on Pond creek and Camp creek, and also on both branches of Rattlesnake creek, but presenting at their various outcrops considerable diversity in thickness, and in the character of the enclosing strata. On the northwest quarter of section 15, township 7 south, range 3 west, coal occurs, associated with sandstones, as shown in the following section:

Slope of the hill covered with loose masses of sandstone and some of the lower strata in place, not measured	?
Carbonaceous shale with coal in fragments	1 foot
Soft sandstone with particles of coal	3 feet
Coal	2 feet 6 inches
Sandstone extending below the creek level	?

At another exposure, near by, the carbonaceous shale above the coal was wanting, and the coal was directly enclosed between the sandstones. Near the center of section 22, in what is known as the "Killian Settlement," coal is found from five to six feet in thickness. It contains some sulphuret of iron, but appears to be of fair quality. It is said to rest on sandstone, and the roof, where it has not been removed by surface agencies, appears to be also sandstone, which outcrops near by, just above the level of the coal. The same coal, retaining about the same thickness, was found by Mr. Killian, in digging a well near the southeast corner of section 16. It was overlaid here by drift clay, and rested directly on sandstone. The character of the strata accompanying this coal would seem to ally it to the upper seam at Murphysboro, but no attempt has been made in this neighborhood, so far as we know, to determine whether there was a workable coal below this or not.

The shales associated with the lower coals of the foregoing section abound in fossil plants, and, where the shales are argillaceous, the plants may be obtained in a very fine state of preservation. The shales above the lower coal also contain numerous nodules of impure iron ore, exactly like those from Mazon creek, in Grundy county, and contain many of the same species of plants; and hence we infer that these seams belong to about the same horizon, and are probably also the equivalents of the Colchester coal in McDonough county, the roof of which contains similar nodules enclosing plants.

One mile and a half southeast of Carbondale, on Dr. Wm. Richart's place, coal has been opened by a shaft, while another and higher seam outcrops in the hill above, affording the following section:

Micaceous sandstone and sandy shale	15 feet
Coal	3 "
Fire clay and clay shale, partly hidden	35 "
Coal	4 "
Fire clay	5 "
Sandstone	15 to 20 "

These coals and the beds associated with them appear to be the stratigraphical equivalents of the Murphysboro coals, and most probably represent the upper seam and upper division of the lower coals at that point. The blue shale above the coal contains traces of coal plants and *Lingula mytiloides*. A half mile farther to the southeast, the lower seam in the above section is opened on Dr. Storer's land by drifting into the southeastern slope of the hill at its line of outcrop. It presents no marked variation in its appearance here from what was observed at Dr. Richart's. The base of the upper sandstone in the foregoing section is said to be sixty-nine feet above the railroad grade at the depot in Carbondale. To the northward of the range of low hills in which these coals outcrop, there is a broad valley about five miles in width, extending to Crab Orchard creek, and in the bluffs of this creek a seam of coal outcrops, which is probably the upper coal in the foregoing section. In the intervening valley this upper seam, and probably the lower one also, has been entirely cut away by the erosion of the strata, as no coal has been met with in sinking wells in this valley, except at one point, where a coal, representing the lower seam probably, was reached.

About four miles southeast of Carbondale, on the northeast quarter of section 36, township 9 south, range 1 west, just on the county line of Williamson county, two coal seams outcrop, probably the same as those in the foregoing section, but occurring under different conditions.

The following is the section here:

Massive sandstone, not measured	
Compact, siliceous gray limestone	3 feet.
Gray shale, with nodules of iron ore	4 "
Coal, varying in thickness from	4 to 4 " 4 inches
Slope, with partial outcrops of shale	31 "
Coal, variable in thickness from	1 to 2 " 6 inches
Blue shale, underlaid by sandstone	? "

While we have, in the sections given above, as many as three distinct coal seams developed around the extreme borders of the coal field in this county, yet towards the northwest they decrease in number, so that there is probably but one in the western part of the county that is thick enough to be of any practical value.

About a mile northwest of DeSoto, at Mr. Farner's, on a high point on the northwest quarter of section 17, township 8 south, range 1 west, the following strata were passed through in a well:

Soil and drift clay	20 feet
Siliceous limestone	7 "
Siliceous shales, hard	20 "
Hard black slate	3 "
Coal	4 "
Shale	8 "

The limestones in this vicinity are hard, close-textured, siliceous and rather light-colored, gray or brown, and contain the following species of fossils: *Productus longispinus, Spirifer cameratus, S. Kentuckensis, S. lineatus, Athyris subtileta, A. Royissii, Retzia Mormoni,* *Chonetes mesoloba*, etc. This group of fossils would seem to indicate a close proximity to the DuQuoin coal, No. 5 of the general section of the Coal Measures in the valley of the Illinois river (see Chapter I, p. 5), and it may be that this is an outlier of that seam. At DeSoto a shaft was sunk to the depth of eighty-two feet, and a boring was carried down 105 feet farther, without finding any coal of any practical importance. This shaft was probably commenced below the horizon of the seam in Farner's well, which is located on ground considerably higher than the level of the town.

On the elevated land between the Little Muddy and Beaucoup, limestones similar to those already mentioned at Farner's are found at various points, as on Little Muddy, two miles north of DeSoto, and at Elk Prairie, near the northeast corner of section 19, township 7 south, range 1 west, where the bed appears to be as much as eight feet in thickness. On the southwest quarter of the same section the limestone was struck at a depth of twenty feet, and below this a sandstone with a thin seam of coal. On Span's creek, just over the line in Perry county, a coal seam has been opened which will be described in the report on that county, and farther up the creek, on section 4, township 7 south, range 2 west, fragments of limestone are found in the creek, and at Mr. Porter's, in a well dug on section 3, large masses of limestone were found at a depth of twenty-five feet. The limestone was separated into large masses with crevices between, through which the augur passed unimpeded. This limestone closely resembles that at Farner's, near DeSoto, and on the Beaucoup, and contains the same fossils, and probably belongs to the same bed. In another well a few rods distant, no limestone was found, but coal was struck at a depth of twenty-nine feet. It is probable this well was sunk through a wide fissure in the limestone, that had subsequently been filled with clay. The underlying sandstone on Six-mile creek, below Mr. Wilson's, contains a streak of coal two inches thick, which seems to be an exact repetition of the strata at Elk Prairie. It is probable that the limestone mentioned above, with its associated coal and sandstone, forms the highest portion of the Coal Measures developed in this county, and the dip, which along the Illinois Central Railroad is to the northward, is changed in the northwestern part of the county to a more easterly direction, and becomes slight and undulating. As no reliable boring has been made in the northern part of the county, where the whole series would probably be found, it is not possible to give a connected section of the strata belonging to the Coal Measures in this county, but the following tabular statement, prepared by Mr. ENGELMANN, gives the locality, thickness and depth below the surface of all the coals found in the county:

Localities of Coal in Jackson County.

Number.	Name.	Township.	Range.	Section.	Quarter.	Thickness *Inches.*	Depth of Coal.	Remarks.
1	O'Donnell	10	1	32	S. of S.W.	24	Outcrop	Nos. 1 to 9 are the most south-
2	Ben Wiley	10	1	28	S.W	30 (?)	"	erly outcrops of the coal at
3	Stonefort	10	1	27	N.E.	12	"	the top of the Millstone-grit.
4	On Clay-lick creek	10	1	30	S. line	10 or 12	"	
5	Near Drury's cr'k.	10	1	17	S.E. (?)	3 or 4	"	
6	Judge W. Hagler.	10	2	24	N. half	2	"	Near Cedar creek.
7	Frank Robinson	10	2	10	S.W.	4	"	" "
8	Th. Etherton	10	2	3	S.E. N.W.	3	"	On Sugar creek.
9	Conner	9	2	32	S.E.	8 (?)	"	" "
10	Sam Etherton	9	2	32	W. side	18 or 22	"	Head of Bear creek.
11	Osburn	9	2	30	S.E. N.W.	18	"	Head of Shoal creek.
12	Hooker	9	2	20	S.W.	18	"	On Lewis' creek.
13	Town creek	9	3	13	S.E.	18	"	Nos. 10 to 27 are the most west-
14		9	2	18	N.E.	16	"	erly outcrops of coal at and
15	Hanson	9	2	17	N.W.	16	"	near the top of the Millstone-
16	Indian creek	8	3	36	S.E.	20	"	grit.
17	Breaks of Kincaid	8	3	34	N. line	6 or 8	"	
18	Jungman	8	3	26	W. line	16	"	
19	Hipel	8	3	23	N.W.	30 (?)	20 feet	
20	W. W. Worthen	8	3	8	W. line	20	Outcrop	Breaks of Kincaid.
21	Sterling Smith	7	3	32	W. half	3 to 5	"	Breaks of Rattlesnake creek.
22	Jim Smith	7	4	36	S.W.	36	"	Breaks of Kincaid.
23	Downen	7	4	10	S.W.	48 to 72	"	Head of Brushy Fork.
24	Jesse Ward	7	4	20	E. half	?	26 feet	
25	W. Bradley	7	4	7	N.E.	26 (?)	Outcrop	
26	Underwood	7	4	10	N.W.	24	"	
27	Koke	7	4	4	N.E. N.W.	0 to 18	"	
28	Frank Crane	7	3	11	N.W.	?	"	Near Columbo.
29	Don Morrison's	7	3	15	N.W.	30	"	On Little Rattlesnake creek.
30	Killian	7	3	16	S.E.	60 to 72	38 feet	" " " "
31	Killian	7	3	22	Center	60 to 72	Outcrop	" " " "
32	Jesse Nicholson.	7	3	23	S.W.	?	50 feet	" " " "
33	Robert Smith	7	3	35	N.W.	36	Outcrop	Near Big Rattlesnake creek.
34	Hughes McMillen	8	3	12	S.E. S.W.	36	"	On Camp creek.
35	Near Pond creek	8	2	20	S.W.	12	40 feet	
36	Upper vein	9	2	9	W. half	0 to 36	Outcrop	Near Murphysboro.
37	Cen. vein top coal	9	2	9	W. half	30 to 43	"	" "
38	Cen. vein bot'm c'l	9	2	9	W. half	22 to 32	"	" "
39		9	2	10	W. side	12 to 16	"	" "
40	Muddy river	8	2	34	S.W.	?	"	In the bed of the river.
41	Jux	9	2	16	S.E.	18 to 30	"	
42	Jenkins	9	2	22	S.E.	Thin	12 feet	On Mud creek.
43	Edwin Hanson	10	1	8	N.E.	24 to 42	Outcrop	Breaks of Drury's creek.
44	Jones	10	1	3	S. line	24 (?)	"	Near Indian creek.
45	Henry Hanson	9	1	27	S. line	?	22 feet	This bed at an intermediate
46	Brooks	9	1	27	N. E. S.W.	48	Outcrop	point is only 18 inches
47	Carbondale	9	1	27	S.W. N.W.	24 to 32	"	thick.
48	Upper bed	9	1	36	N.E.	48 to 52	"	Near Sycamore branch.
49	Upper bed	9	1	36	E. line	42	"	" " "
50	Lower bed	9	1	36	E. half	12 to 30	"	" " "
51	On Crab Orchard	9	1	25	N.E.	36 (?)	"	
52	Fish Trap	9	1	23	S.E.	20 or more	"	On Big Crab Orchard creek.
53	Snyder	9	1	24	S.E. N.E.	16	"	" " " "
54	Old Bridge	9	1	2	Center	20 to 36	"	" " " "
55	Meyer	9	1	1	S. line	42 (?)	"	Breaks of Crab Orchard creek.
56	Snake Den	8	1	34	N.E.	24 to 36	"	On Big Crab Orchard creek.
57	Fish Trap	8	1	14	S.W.	1 to 6	"	On Little Muddy.
58	Farner	8	1	17	N.W.	48	50 feet	Near DeSoto.
59	On the railroad	8	1	8	S.E.	12 (?)	40 feet	" "
60	DeSoto	8	1	20	N.E.	?	70 feet	Reported to have been struck
61	DeSoto	8	1	20	N.E.	Thin	(?)	by boring.
62	DeSoto	8	1	20	N.E.	?	170 feet	
63	Swartz	7	1	19	N.E.	2	15 feet	In Elk Prairie.
64	Porter	7	2	3	Center	?	29 feet	Near Span's branch.
65	Taylor	7	1	5	N.W.	3	Outcrop	On Six-mile creek.
66	Daviess	7	1	7	N. line	Over 12	16 feet	In Elk Prairie.

Localities numbered from 1 to 27, inclusive, Mr. Engelmann refers to the lowest coal in the series, the seam immediately above the Conglomerate, but we think he is certainly mistaken in referring No. 23 to that horizon, and most likely all the outcrops in the northern part of township 7 south, range 4 west, may be referred to a higher position in the series. The lower coals are less developed in Randolph and St. Clair counties than in the southern part of Jackson, and it is probable that this change is effected, in part, at least, before reaching the Randolph county line. Above this lower seam we have the two seams at Murphysboro and Carbondale, and above these the coals north and northwest of DeSoto, some of which may be the equivalents of the DuQuoin coal, though they are somewhat thinner than the average thickness of that coal farther north.

Quaternary Deposits.—The uplands in this county are covered by a deposit of clay and sand, with gravel, and a few boulders of granite, trap, and other metamorphic rocks, showing that it may properly be referred, in part, at least, to what is usually called the Drift period, and this county appears to mark its southern limits, for no well marked deposits of this kind have been observed south of the dividing ridge that crosses the State through the south part of Jackson and the north part of Union counties. These drift clays probably do not average in this county more than about twenty feet in thickness, and are passed through almost everywhere on the uplands in sinking wells. Below these beds of clay and gravel, a deposit is often met with in this county, which has also been observed at many localities in different portions of the State, consisting of a dark blue or black mud, containing branches of trees, and sometimes trees of large size. This deposit varies in thickness from a few inches to ten feet or more, and has been observed in this county at the following localities: On the northeast corner of town 7 south, range 5 west, near the Randolph county line, where it was found in wells twenty-five to thirty feet below the surface; at the town of Shiloh or Steuben, in Randolph county, it is eight to ten feet thick, under twenty feet of drift deposits; on the southwest quarter of section 24, township 7 south, range 4 west, it was found eight feet thick, thirty-five feet below the surface, and was underlaid by gravel and sand, and at Jesse Ward's, on the southeast quarter of section 20, township 7, range 4, and on section 16, it was found from twelve to fifteen feet thick. It has also been noticed two miles west of Carbondale, where it was struck in several wells, but its thickness was not ascertained. It was from twenty-five to thirty feet below the surface, and above a water-bearing stratum of sand.

The *Loess* formation in this county consists mainly of comminuted siliceous silt, usually of a light brown or buff color, and locally it becomes a yellowish loam with calcareous concretions. At some localities the mass is slightly cemented, so as to form high perpendicular escarpments on the summits of the hills, and presents but slight traces of stratification. It occupies only a narrow belt on the top of the river bluffs from the west line of the county to the vicinity of the Pine hills near the south line. These hill were probably above the level of the water during the deposit of this formation, and hence they are not covered by it. On the east side of Fountain Bluff this formation extends down to the level of the river bottoms, and probably once filled the valley between this and the main chain of bluffs. The soil over the highest portions of the river bluffs appears to be derived, in part, at least, from this formation, and the yellow poplar or tulip tree flourishes best where the soil is underlaid by beds of *Loess*.

Economical Geology.

Bituminous Coal.—Although the coal seams outcropping in this county are for the most part rather thin, and are therefore not extensively worked at the present time, and the thickest and most profitable beds outcrop at points remote from railroads, and where the local demand is limited, yet the supply of this indispensable requisite to the industrial interests of the country is abundant, and will be developed in the future as the demand for it increases. There are at least three, and perhaps four, seams outcropping within the limits of this county, ranging in thickness from a few inches to six feet. The thickest coal is that outcropping in the northern part of the county at the head of Brushy Fork, and at Killian's, on the waters of Rattle-snake creek, and at Farner's, near DeSoto, where the coal ranges from four to six feet in thickness. These may be the equivalent of the upper seam at Murphysboro and Carbondale, but more probably belong to another horizon. The seams below this, except at Murphysboro, where two seams appear to run together so as to be worked as one, do not usually exceed three feet in thickness, and are often found too thin to be mined to advantage, except where they outcrop so that they can be worked by stripping.

About one-half of the superficial area of this county is underlaid with coal, embracing all the northeastern portion, and a line drawn from the southeastern to the northwestern corner of the county would very nearly define the southwestern limits of the coal-field.

The lowest seam in the series is that occurring usually at the top of the Conglomerate, and its most southern outcrops are numbered from one to ten in the foregoing tabular statement, and its thickness in this portion of the county ranges from three to thirty inches. Its character is variable; at some localities it affords a coal of excellent quality, and at others it is quite poor, and mixed with slate and sulphuret of iron. It is doubtful if this seam extends into the northwestern portion of the county at all.

The next coals in the series are those of Murphysboro and Carbondale, of which a section is given on a preceding page. At the first named point three seams are developed, the two lower ones being so near together that they can be worked as one seam. This is an excellent coal, one of the best known in the State, and has been successfully used in its raw state for smelting iron. These mines are said to have been opened as early as 1810, and a flat boat load of coal from this point was shipped that year to New Orleans, and in 1822 Gov. Joseph Duncan loaded several boats here with coal for the same market. More recently these mines were wrought for several years by the Jackson County Coal Company, the coal being loaded on flat boats and then towed down the Big Muddy to their depot on the west bank of the Mississippi. This, however, proved to be an uncertain mode of transportation, because during a considerable portion of the year the Muddy river was too low to allow the boats to run at all, and at best they could only run a small part of the season. About the year 1865, the Mount Carbon Coal Company built a railroad from these mines to the Mississippi, making their terminus and depot at the lower end of Back-bone ridge, thus giving themselves an easy and certain access to the river markets at all seasons of the year. This road, which is only about fifteen miles in length, is now in successful operation for the transportation of coal, and is being extended to Carbondale, on the Illinois Central railroad, which will give an outlet for this coal in that direction also. Nearly all the coal mined at this point has been taken from the lower seams, which are here separated by a parting of clay shale from a few inches to two feet in thickness.

The upper division of the seam averages about three feet in thickness, and the lower about two feet. The coal from both divisions is good, though that from the lower seems to be the freest from sulphuret of iron. The coal is hard and bright, and the layers separated by carbonaceous clod or "mineral charcoal." An analysis of this coal by Mr. Henry Pratten, formerly Assistant Geologist and Chemist of the Survey, gave the following result:

	Specific gravity	1.2933
	Loss in coking	37.7
	Total weight of coke	62.3—100
Analysis—	Moisture	6.5
	Volatile matter	31.2
	Carbon in coke	60.8
	Ashes	1.5—100

The northern limit of this seam has not been determined, and the next outcrops in that direction on Pond and Indian creeks reveal only a thin seam of coal, from six to twelve inches thick, and it is probable that the Big Muddy coal, as it appears in the vicinity of Murphysboro, is a local development of limited extent. At Carbondale the lower division of the main Murphysboro seam is not found at all, and the upper division is about four feet thick, while the upper seam, thirty-five feet above the lower, is three feet in thickness. If we are right in our supposition that the lower division of the main Murphysboro coal may be a distinct seam, the two being brought so near together here by the thinning out of the intervening strata that they can be worked as one, then that lower seam may be the eighteen-inch coal outcropping near Makanda, at the top of the Conglomerate, and this supposition is strengthened by the fact that the clay parting which divides the lower seam at Murphysboro increases in a southerly direction so rapidly that a mile distant in that direction the divisions are too widely separated to be worked as a single seam.

The coals outcropping in the northern part of the county, which seem to hold a higher position than those of Murphysboro, have been so little worked that no decided opinion can be given as to the average quality of the coal which they afford, and although they may be inferior to the Murphysboro coal in quality, yet they are no doubt good enough for ordinary steam-producing and heating purposes, and will eventually prove an important addition to the mineral wealth of the county.

Building Stone.—The southwestern portion of this county contains an inexhaustible supply of excellent building stone of various kinds, including marbles that are susceptible of receiving a high polish, and suited to the construction of elegant and costly buildings. The massive layers of siliceous sub-crystalline limestone, that are intercalated in the cherty beds of the lower Devonian series at "Bald Rock" and "Back-bone," afford some layers that are delicately colored, sometimes nearly white, or streaked with pink, yellow and blue, these colors being so blended as to have a pleasing effect on a highly polished surface. Some of these layers contain considerable chert in small nodules, but others are quite free from this pernicious material, and will dress evenly and receive a high polish. These beds have never been worked for building material, but recently a commencement has been made at "Bald Rock," and quarries will be opened, so that the extent of these marble beds may be fully determined. Specimens from this locality, brought to this city, and polished by the marble workers here, proved to be susceptible of receiving a very high polish at a moderate cost of labor.

The Onondaga and Hamilton limestones at the "Bake Oven," afford a durable material for foundations, culverts and rough walls, and some of the lower beds would probably dress well, and are so situated that they can be conveniently quarried for shipping from their outcrop at the water's edge.

The limestones of the lower Carboniferous series, at Walker's hill, will afford an inexhaustible supply of limestone suitable for all ordinary building purposes, and those belonging to the St. Louis group, at the upper end of the hill, will furnish material for the manufacture of a quick lime of superior quality; and as this is the only locality in the county where this limestone is found, and being in close proximity to the railroad, by which the products of lime-kilns established here could be sent into the central portion of the State, where no limestones are found, and the facility with which fuel could be obtained from the coal mines of the Big Muddy, are considerations that point to this as a very desirable locality for the establishment of extensive works of this kind.

The limestones of the Chester series are generally siliceous and cherty, but they are for the most part durable, and may be used for foundation walls when no better material is at hand. Some beds of this rock are so siliceous as to form a very refractory fire-stone, and it has been used in the construction of fire-places and chimneys by the early settlers of the country. It is probable that some of the beds are also pure enough to be burned for lime, but they would make an article quite inferior to that from the St. Louis limestone, except for cement.

The sandstones of the Chester series, and the Conglomerate, afford some good building stone to supply the local demand in the vicinity of their outcrops. Locally, they are thin-bedded and afford a good flag-stone. On Drury creek, the Illinois Central Railroad Company has opened an extensive quarry in the Conglomerate sandstone, on the northeast quarter of section 9, township 10 south, range 1 west, where the rock is quarried for building stone and for ballast for the road. About fifty feet in thickness of the sandstone is exposed here, in a bluff close to the road, about thirty-five feet of which is thinly bedded, while the lower fifteen feet is in tolerably heavy beds, and afford some good dimension stone. The rock is finely grained, somewhat micaceous, and of a brownish-yellow color. It is rather soft when just quarried, but hardens considerably on exposure, and makes a durable building stone. In the northeastern portion of the county, good building stone is comparatively scarce, but some of the sandstones and the limestones of the Coal Measures, which outcrop on the streams in this portion of the county, may be made available to supply the local demands for such material.

Iron Ores.—Iron ore in the form of a hydrous peroxide of iron, also known as *brown hematite* or *limonite*, and the impure carbonate of iron, known as *clay iron ore*, and *kidney ore*, abound in this county; the former associated usually with the sandstones, and the latter with clay shales of the Chester series, Conglomerate and Coal Measures. The *limonite* occurs most abundantly at the base of the Conglomerate, and was especially noticed in this position at several points in section 24, township 8 south, range 4 west, and at some other points in the same vicinity. The argillaceous shales in all the groups above named contain more or less *clay iron ore*, or *kidney ore*, disseminated through them, either in nodules or bands of septaria, crossed with veins of calcareous spar. Overlying the upper coal at Murphysboro, they form a layer in the shale from six to eight inches thick. It was nowhere seen in this county, however, in sufficient quantity to become valuable for the manufacture of iron.

Lead Ore.—Galena or sulphuret of lead occurs in small quantities in the lower Devonian limestones in the southwestern corner of the county. It was found at the lower extremity of the Back-bone ridge in cutting down the hill for the railroad grade, occurring in nodular masses, from one to three inches in diameter, and coated with a thin crust of calcareous matter. It did not appear to belong to a regular vein and probably occupied pockets in the cherty limestones. The quantity found here was too small to make the discovery a matter of any economical importance.

Saltpetre.—This article has been obtained in Jackson county in small quantities by lixiviating the earth at the bottom of certain caves. The largest cave of this kind in the county is situated on the lower course of Cave creek, near the north line of section 21, township 10 south, range 2 west, where the Conglomerate forms the greater part of a ridge three hundred feet high. The cave is on the east side of the creek, and is formed by an opening into the sandstone, about three hundred feet in width at the mouth of the cave, and gradually narrowing backwards for about two hundred feet to the rear end. In the central part of the cave the roof is about sixty feet in height, gradually becoming less towards the rear, where the gradual rising of the floor and the depression of the roof forms the terminus of the cavern. This cavern has no doubt been the resort of wild animals for ages, seeking shelter there in summer from the scorching rays of the sun, and in winter from the cold, just as the domestic animals do at the present day, and in this way the earth at the bottom of the cave became impregnated with the animal matter from which the saltpetre is ultimately obtained.

Chloride of Sodium.—Salt was formerly manufactured in this county near Brownsville, the old county seat. The well was on the bank of the Big Muddy river, three and a half miles below Murphysboro, on the southeast quarter of section 2, township 9 south, range 3 east, and was three hundred feet in depth. There was formerly a salt-lick at this point, and after finding more indications of salt by sinking a well a few feet in depth, Mr. Pierce obtained a charter in 1824, and commenced operations by boring to the depth of 300 feet, when he obtained a plentiful flow of brine. A copper tube was inserted to keep out the fresh water which filtered through the sandstones, but as the boring had not been carefully made, the hole was not perfectly straight and round and considerable difficulty was experienced in keeping the well free from surface water, which weakened the brine. Notwithstanding the defective tubing, the well yielded one bushel of salt to one hundred and seventy-five gallons of brine, and with the best tubing that could be put in under the circumstances, the yield was increased to one bushel of salt to one hundred and twenty-five gallons. The salt was said to have been quite free from foreign mineral substances, leaving scarcely any insoluble matter in the pans. In 1830 or 1832, operations were stopped in consequence of the weakening of the brine from the defective tubing. About 1830 a new well was commenced a mile lower down the river, and at a depth of two hundred and twelve feet a strong brine was obtained, but only a small quantity. The boring was continued to the depth of three hundred and sixty-seven feet and then abandoned. The report states that this depth was entirely through sandstones, but this statement seems hardly probable, for a boring to that depth at this point must have penetrated to the limestones of the Chester series. A spring of weak brine is still running near the opening of the old well at the rate of two hundred gallons an hour.

The salt wells at Syracuse, New York, which supply a large portion of the trade of the western country, yield a bushel of salt to the hundred gallons of water, and we see no reason why, with a proper tubing, the Brownsville salt well could not be profitably worked, considering the abundance and cheapness of fuel, both wood and coal, in this vicinity. The geological horizon from which the brine is obtained here, appears to be at the junction of the Conglomerate sandstone with the lower Carboniferous series, which is probably the principal brine-producing horizon in this State. Salt-licks also occur on the Columbo, in this county, and experiments should be made to determine if they indicate the existence of a valuable brine at this locality. With the recent improvements in boring, an experimental well could be sunk to the depth of from three hundred to five hundred feet, or down to the lower Carboniferous limestones, at a comparatively moderate cost, as nearly the whole distance would be through soft sandstones and shales, and if properly conducted would thoroughly test the question as to the value of the brine at either of the above named localities.

Sand and Clays.—Sand and clay for the manufacture of brick is abundant, and may be found in almost every neighborhood where such building material is required. A good potters' clay, or a clay suitable for the manufacture of fire brick, is more rarely found, and none such was met with during our examinations in this county, but as such beds frequently occur in the lower Coal Measures, it is quite probable that they will hereafter be found as the workable coals are more generally developed, and the clays associated with them are better known.

Agricultural Resources.—The general character of the bottom lands in this county has already been alluded to, and we will proceed to describe briefly the uplands, commencing with the river bluffs and region immediately adjacent thereto, that is underlaid by the Conglomerate sandstone and subordinate limestones.

This region includes a belt of country from six to eight miles in breadth, running parallel with the river bluffs, in a general direction from northwest to southeast, and comprises about one-fourth of the whole area of the county. It is for the most part exceedingly broken and hilly, with very little arable land, except on the narrow ridges, where small farms have been opened, extending frequently into the more broken lands on either side. Along the river bluffs the soil is formed in part of the sandy loam of the *Loess*, and is deep and rich where the surface is tolerably level, and farther back, where this formation is wanting, the ridges are covered with a light brown sandy soil, derived mainly from the decomposition of the underlying sandstones. Farther back from the river bluffs the soil is underlaid by a subsoil of stiff clay, succeeded by sand and gravel of the Drift period. These ridges are heavily timbered with yellow poplar or tulip tree, white and black oak, pignut and scaly-bark hickory, barren hickory, black walnut, sugar maple, black gum, sassafras and hazel, and a few post-oaks are also found in this region, where the soil is thin. The wheat and corn crops on these ridges are generally less in their yield per acre than along the foot of the bluffs on the high bottoms, but the grain is heavier and the crop less subject to failures, and it is quite probable that with a better and more thorough system of cultivation, these lands would prove to be quite as productive as any of the uplands in the county. Fruit trees and vines grow finely on these broken lands, and the fruit is less liable to be killed by the late frosts in spring than that planted in the valleys, and the peach never fails entirely on the high ridges in the southern portion of this county, and its cultivation has come to be one of the most important pursuits of the agriculturist in this region. Chicago and other northwestern markets are now mainly supplied with this delicious fruit from this and the adjoining counties, and the favorable position of this region in regard to climate, and its accessibility to the northwestern markets, renders it an exceedingly desirable locality for the practical fruit-grower. Grape culture has already been commenced here, and although partial failures have resulted from planting Catawbas, and some other varieties that are peculiarly liable to mildew, yet it must eventually succeed with the more hardy varieties.

The northeastern part of the county, embracing the region north of Murphysboro and Carbondale, and east of the dividing ridge which runs in a due northwest course from Murphysboro to the northwest corner of the county, is underlaid by the Coal Measures, and has a comparatively level or gently rolling surface. At some points the country assumes the "barren" character more conspicuous farther north, and which will be more fully discussed in the report on Perry county. This "barren" soil is an extremely fine, whitish, arenaceous loam, and the characteristic timber is post-oak. The regular post-oak flats of Perry county extend also into the northern part of Jackson county, but they only occupy a limited area, and the adjacent lands are more undulating, and the timber consists in part of black-jack, black oak, barren hickory and hazel, and on the more broken portions we find white oak, hickory and black gum. These lands are apt to suffer more from drouth than the white oak and poplar lands of the hilly region above described, but a more thorough and deep cultivation of the soil will probably remedy this defect, and render these lands quite productive.

Between Muddy river and Carbondale there is a wide stretch of flat land forming a level valley several miles in width, which is quite wet in consequence in part of its level surface, but more from the fineness and retentive character of the soil, which prevents a free drainage of the surface. This land is now generally neglected, and considered too wet for cultivation, but when once thoroughly broken with the plow it soon becomes dry by allowing the surface water to pass down into the more porous sub-soil below. These flat lands are heavily timbered with swamp white oak, scaly-bark and other hickories, black walnut, red, blue-bark and water oak, ash, horn-beam, red-bud, pawpaw, etc.

This county lies upon the extreme southern border of the prairie region, and some small prairies are found within its limits, among which are the following: Virgennes prairie, Cox's prairie, Manny's prairie, Elk prairie, and a part of Six-mile prairie, which is mostly in Franklin county. The prairie soil consists of a finely-comminuted, chocolate-colored, arenaceous material, which, in consequence of its fineness, assumes the appearance of clay. It is usually of a yellowish-gray or chocolate color, according to the amount of vegetable humus it contains, and from one to two feet deep. The sub-soil consists of a reddish-yellow clay stratum or hard-pan, tough and very hard to break up, almost impervious to water, and decomposes slowly when exposed at the surface, but does not form a good soil. The hard-pan is not found everywhere near the surface, but at some points there is a yellowish clay sub-soil beneath the prairies, which forms a fertile soil when fully exposed to atmospheric influences.

At many points the prairies, without any change of surface level, are surrounded by post-oak flats, which gradually change into "barrens" and post-oak hills. Some of these flats have the white, impalpable, arenaceous soil which characterizes the post-oak and black-jack flats, and are exclusively timbered with these two varieties. Northeast of DeSoto we find some similar lands, although the soil is not generally quite so white, and the post-oak becomes more vigorous in growth and less numerous, or is entirely superseded by hickory, black oak and other varieties of timber, when the surface becomes more undulating. On the whole, the agricultural resources of this county will compare favorably with any of the adjoining counties, and but for the prevalence of the milk-sickness, which has always prevailed to some extent in this portion of the State, this county would now be one of the foremost in Southern Illinois in wealth and population. But this much dreaded disease will probably disappear as the surface of the country is brought under cultivation, and settlers even now find but little difficulty in protecting their cattle from its ravages, by confining them to cultivated pastures, instead of allowing them to range at will through the forests.

GLOSSARY

OF GEOLOGICAL AND OTHER SCIENTIFIC TERMS,

USED IN THIS VOLUME.

Acervularia. A genus of fossil corals.

Actinocrinus. A genus of fossil Crinoidea, or lily-shaped marine animals.

Adipocere. A substance resembling spermaceti, into which the muscular fibre of dead animals is changed, by long immersion in water or moist places.

Agaricocrinus. Agassizocrinus. Genera of Crinoidea.

Agelacrinites. A genus of marine animals allied to the Crinoidea.

Allorisma. A genus of fossil marine bivalve shells.

Alluvium. Accumulations of earth, sand and gravel, washed down by rivers or floods upon land not permanently submerged.

Alveolites. A genus of fossil corals.

Amorphous. Bodies devoid of regular form, not stratified.

Amygdaloid. A rock in which crystalized minerals are scattered in almond-shaped cavities.

Analogue. Corresponding bodies. A living shell of the same genus as a fossil shell, is the analogue of the latter.

Annularia. A genus of fossil plants.

Anthracite. Coal, in which the volatile matters have been expelled by subterranean heat, metamorphic coal.

Anticlinal axis. A point of upheaval from which the rocks dip in opposite directions.

Anvil-rock sandstone. A sandstone overlying coal No. 12 of the Kentucky series.

Arragonite. A simple mineral, a variety of carbonate of lime.

Archæocidaris. A fossil genus, allied to the living sea eggs or sea urchins.

Archimedes. A screw-shaped fossil, the axis of a Bryozoan.

Arenaceous. Sandy, containing sand.

Argillaceous. Clayey, composed in whole or in part of clay.

Asaphus. A genus of fossil Crustacea (Trilobites).

Asterophyllites. A genus of fossil ferns.

Asphaltum. A partly hardened bitumen.

Athyris. A genus of fossil marine bivalve shells.

Avicula. A genus of living bivalve shells, some of which are found in a fossil state.

Aviculopecten. A genus of fossil shells, resembling Avicula and Pecten.

Azoic rocks. Rocks formed before the existence of animals or plants, and consequently destitute of fossil remains.

Bellerophon. A genus of marine univalve shells.

Birdseye limestone. A limestone in New York, of lower Silurian age.

Bitter spar. A sparry mineral, consisting of carbonate of lime and carbonate of magnesia. The crystallized variety of dolomite or magnesian limestone.

Bituminous shale. Shale, impregnated with bitumen, usually of a dark brown or black color.

Black river limestone. A lower Silurian limestone of the New York series.

Botryoidal. Resembling a bunch of grapes.

Boulder. Rounded or other masses of rock that have been transported from more or less distant localities by currents of water, or on floating masses of ice, during the Drift period.

Brachiopoda. A class of marine Mollusks with two fleshy, ciliated arms, developed from the sides of the mouth, that serve to create currents to bring them food.

Breccia. A rock composed of angular fragments cemented together.

Brown spar. Crystallized dolomite.

Bryozoa. The lowest type of Mollusca.

Calamites. A genus of fossil plants, allied to the rushes.

Calcareous. Containing lime.

Calc. spar. Crystallized carbonate of lime.

Calymene. A genus of fossil Crustacea (Trilobites).

Carbonate. A combination of carbonic acid with other substances.

Cephalopoda. A class of marine Molluscous animals, having thin organs of prehension arranged around the head.

Ceraurus. A genus of fossil Crustacea (Trilobites).

Chalcedony. An uncrystallized siliceous mineral.
Chalybeate springs. Mineral springs holding iron in solution.
Chætetes. A genus of fossil coral-building polyps.
Chert. A siliceous mineral allied to chalcedony and flint.
Chonetes. A genus of fossil bivalve shells, of the class Brachiopoda.
Cincinnati group. The upper division of the lower Silurian system.
Coal basin. Coal-bearing strata, deposited in a depression formed in older rocks.
Congeners. Species that belong to the same genus.
Conformable. Rocks are said to be conformable when the strata are parallel.
Conglomerate. Rounded pebbles and grains of sand cemented together.
Conularia. A genus of fossil marine shells, usually cone-shaped.
Cosmogony. Speculations in regard to the creation of the earth.
Cretaceous. Chalk formation.
Crinoidea. An order of lily-shaped marine animals, belonging to the sub-kingdom Radiata. They generally grow attached to the bottom of the sea, by a jointed stem, analogous to the mode of growth of plants, though some are free.
Crustacea. A class of animals, such as the lobster and cray-fish, with a crust-like shell covering the body, legs, etc.
Crystalline. Having the texture of broken crystal, or an assemblage of ill-defined crystals. Loaf-sugar has a crystalline texture.
Curlew limestone. Limestone above coal seam No. 3, of the Kentucky series.
Cyathophylloid corals. Corals having a cup-shaped depression in their summits.
Cyclonema. A genus of fossil marine univalve shells.
Cyrtia and Cyrtina. Genera of fossil bivalve shells (Brachipods).
Cyrtolites. A genus of chambered univalve shells.
Dalmania. A genus of fossil Crustaceous animals (Trilobites).
Debris. Fragments of rock removed by the action of water or frost.
Dendrocrinus. A genus of fossil Crinoidea.
Denudation. Wearing away by the action of running water or other agencies.
Detritus. Matter worn off from rocks.
Devonian. The geological system next above the Silurian.
Dichocrinus. A genus of fossil Crinoidea.
Dip. The inclination of strata in any particular direction.
Diluvial. Effects of floods of ice and water, in comparatively modern times.

Discina. A genus of fossil marine shells.

Dolomite. A limestone composed of the carbonates of lime and magnesia.

Drift. A formation made up of sands, clays, gravel and boulders, and spread over the more solid rocks.

Escarpment. The abrupt face or steep slope of a rock, hill or ridge.

Euomphalus. A genus of fossil marine univalve shells.

Exuviæ. The hard crust or shell cast from the bodies of animals, or what remains after the decomposition of the fleshy parts.

Favistella. A genus of fossil corals.

Fault. A sudden interruption of the continuity of strata in the same plane, caused by a crack or fissure.

Fauna. The various kinds of animals peculiar to a country constitute its fauna.

Favosites. A genus of fossil corals.

Ferruginous. Containing iron.

Fissile. Easily cleft, dividing readily into parallel laminæ, like slate.

Flora. The various kinds of trees and plants in a country constitute its flora.

Fluviatile. Belonging to rivers.

Fluor Spar. A crystal composed of lime and fluorine.

Foraminifera. An order of usually microscopic shells.

Formation. A group of strata referred to a common origin.

Forbesiocrinus. A genus of fossil Crinoidea.

Fossil. An animal or plant found embedded in the earth by natural causes, usually applied to the remains of extinct types.

Fossiliferous. Containing fossils.

Fucoides. Fossil sea weeds.

Galena. A metallic ore, composed of lead and sulphur.

Gangue. The mineral substance that encloses or accompanies the metallic ore in a vein.

Gasteropoda. A division of the Mollusca in which the foot of the animal is attached to its belly.

Genus. Species of animals or plants possessing certain characters in common.

Geode. A rounded nodule of stone, containing a cavity lined with crystals.

Glyptocrinus. A genus of fossil Crinoidea.

Gomphoceras, Goniatites, Gonioceras. Genera of fossil marine chambered shells, allied to the living Nautilus.

Granatocrinus. Graphiocrinus. Genera of fossil Crinoidea.

Granite. A rock composed of quartz, mica and feld spar.

Granular. Composed of distinct grains.

Gypsum. A mineral composed of lime and sulphuric acid.

Hade. A deviation of a mineral vein or crevice from the vertical.

Halysites. A genus of fossil corals.

Heavy spar. A combination of baryta and sulphuric acid.

Heliolites. A genus of fossil corals.

Helodus. A genus of fossil fishes.

Hemipronites. A genus of fossil bivalve shells.

Hornstone. A siliceous mineral, resembling flint.

Heterocrinus. A genus of fossil Crinoidea.

Humus. A dark-brown substance, formed usually in the soil, by the decomposition of vegetable matter.

Hydraulic limestone. An earthy limestone, that, when calcined and ground, has the property of setting or hardening under water.

Hymenophyllites. A genus of fossil plants.

In situ. Rocks remaining in the place where they are formed.

Isotelus. A genus of fossil Crustacea (Trilobites).

Joints. Fissures or lines of parting in rocks, often at right angles to the planes of stratification.

Knorrhia. A genus of fossil plants.

Laminated. Formed in thin layers.

Lenticular. Having the form of a lens.

Leperdita. A genus of small fossil Crustacea.

Lepidostrobus. Cones of Lepidodendron.

Lepidodendron. A genus of fossil cone-bearing trees.

Leptæna. Leptocœlia. Genera of fossil marine bivalve shells.

Lignite. Wood converted into a kind of coal.

Lithological. The stony structure of a mineral mass.

Lithostrotion. A genus of fossil corals.

Lituites. A genus of coiled chambered shells.

Lingula. A genus of fossil bivalve shells.

Loam. A mixture of sand and clay.

Lode. A metallic vein.

Loess. A division of the Quaternary system.

Lucina. A genus of bivalve marine shells.

Lyropora. A genus of fossil Bryozoa.

Maclurea. A genus of fossil univalve shells.

Mahoning sandstone. The sandstone overlying coal No. 4, in Kentucky.

Mammoth. An extinct animal, belonging to the same genus as the living Elephant.

Mammillary. Minerals having convex concretions.

Marl. A mixture of clay and lime.

Mastodon. An extinct animal, allied to the Elephant.
Matrix. The substance in which another is embedded.
Megaphitum. A genus of fossil trees.
Melonites. A genus of fossil marine animals, allied to the sea urchin.
Meristella. A genus of fossil bivalve shells.
Metamorphic rocks. Rocks that have been altered from their original condition by heat or other causes.
Micaceous. Containing mica.
Millstone grit. The Conglomerate sandstone at the base of the Coal Measures.
Mollusca. Animals (shell fish) which have soft bodies and are without bones, but usually protected by a shell.
Mountain limestone. The lowest division of the Carboniferous system. Lower Carboniferous limestone.
Murchisonia. A genus of spiral univalve shells.
Myalina. An extinct genus of bivalve marine shells.
Naticopsis. A genus of fossil shells, allied to the living Natica.
Nautilus. A living genus of marine shells, also found fossilized in the rocks.
Neuropteris. A genus of fossil plants.
Niagara group. A division of the upper Silurian system.
Nodule. A rounded, irregular-shaped lump or mass.
Nucleus. A solid central piece, around which other matter is collected.
Odontopteris. A genus of fossil plants.
Oolitic. A limestone composed of rounded particles, like the roe or egg of a fish.
Organic remains. Remains of animals or plants found in a fossil state.
Orodus. A genus of fossil fishes.
Orthis. A genus of marine bivalve shells.
Orthoceras. An extinct genus of long, straight-chambered shells.
Outcrop. An exposure of rock at the surface.
Outlier. A portion of a stratum or formation left detached from the general mass by the removal of the surrounding portions.
Ovate. Egg-shaped.
Paleontology. The science which treats of fossil remains.
Paleozoic. A name given to the older fossiliferous rocks.
Pecopteris. A genus of fossil plants.
Pentremites. A genus of fossil Blastoids, the bodies of which resemble petrified nuts.
Petroleum. Rock oil; a liquid hydro-carbon.

Plastic clay. Soft, tough clay, such as is used for pottery.
Platycrinus. A genus of fossil Crinoidea.
Platyceras. A genus of marine univalve shells.
Pleurodictyum. A genus of fossil corals.
Pleurotomaria. A genus of marine univalve shells.
Phillipsastrea. A genus of fossil corals.
Pinna. A genus of marine bivalve shells.
Polyphemopsis. A genus of univalve shells.
Porocrinus. A genus of fossil Crinoidea.
Porphyry. An unstratified or igneous rock, containing crystals of feld spar.
Polyzoa. The lowest group of the sub-kingdom Mollusca. The same as Bryozoa.
Poteriocrinus. A genus of fossil Crinoidea.
Precipitate. Substances that, having been dissolved in a fluid, form a solid by chemical combination, and fall to the bottom of the solution.
Productus. A genus of extinct marine bivalve shells.
Pyrites. A compound of copper or iron with sulphur.
Pyritiferous. Containing pyrites.
Quartz. A simple mineral, composed of pure silex.
Quartzite. Sandstone that has been changed, by metamorphic action, to a hard quartz rock.
Quaternary. The newest of the geological systems, in which nearly all of the organic forms belong to living species.
Radiata. One of the great sub-kingdoms into which the animal kingdom is divided, including star fishes, corals, crinoids, etc.
Receptaculites. A genus of fossils, supposed to belong to the Foraminifera.
Retzia. A genus of fossil bivalve shells.
Rhodocrinus. A genus of fossil Crinoidea.
Rhynchonella. A genus of marine bivalve shells.
Saccharoidal. Having the color and texture of loaf sugar.
Schizodus. A genus of fossil bivalve shells.
Schœnaster. A genus of fossil star fishes.
Sedimentary rocks. Those which have been formed of materials that have been thrown down from a state of suspension in water.
Semi-coscinium. A genus of fossil Bryozoa.
Septaria. Lenticular masses of clay, impregnated with iron, traversed by veins of calcite or other minerals. (Turtle stones.)
Shale. An indurated clay or sandstone, in thin layers.
Sigillária. A genus of fossil trees.

Siliceous. Composed mainly of silex.

Silicified. Changed into siliceous material.

Silurian. One of the older systems of rocks.

Sphenophyllum. A genus of fossil plants.

Sphenopoterium. A genus of fossil sponges.

Spirifer. Spiriferina. Genera of fossil marine bivalve shells.

Stalactite. A rock formed by the dripping of water, holding lime or other mineral in solution, from the roof of a cavern or fissure in the rock.

Stalagmite. Deposits formed at the bottom of a cavern or fissure by the dripping of water holding lime or other mineral in solution.

Stigmaria. Stem-like plants, often traversing the under clays of the coal, supposed to be the roots of Sigillaria.

Strata. The different layers of a rock formation.

Stratified. Formed in regular beds or layers.

Streptelasma. A genus of fossil corals.

Stricklandinia. A genus of fossil marine shells.

Strike. The direction of the line of bearing of the strata, which is always at right angles to the prevailing dip.

Stromatopora. A genus of fossil sponges (?)

Synchronism. Formed at the same time; of the same age.

Syringopora. A genus of fossil corals.

Taxocrinus. A genus of fossil Crinoidea.

Talus. Slope of broken fragments accumulated at the foot of a steep rock.

Tellinomya. A genus of marine bivalve shells.

Tentaculites. Little tubular fossils, with encircling ring-like ridges. Affinites doubtful.

Terebratula. A genus of marine bivalve shells.

Tertiary strata. The newest, or latest formed, of the great systems of stratified rock anterior to the Quaternary.

Testacea. Molluscus animals, having a shelly covering. (Mollusca.)

Thermal springs. Springs of hot water.

Thin out. Beds, growing gradually and constantly thinner in one direction, until they entirely disappear, are said to thin out in that direction.

Trap rock. Volcanic rocks, composed of feld spar, augite and horn blende.

Trenton limestone. A division of the Lower Silurian system.

Trilobite. An extinct order of animals, of which the body is three lobed, belonging to the class Crustacea.

Tropidoleptus. A genus of fossil marine shells.

Tuffa, calcareous. A deposit of lime from springs, forming a porous carbonate of lime.

Veins. Cracks in the rocks, that have been subsequently filled by other substances, either earthy or metallic.

Zaphrentis. A genus of fossil corals.

Zeacrinus. A genus of fossil Crinoidea.

Zinc blende. Sulphuret of zinc.

Zoophite. An animal, like the coral or sponge, that, being attached to the ground, has the form of plants.

INDEX.