REPORT.

The geological history of Indiana appears tame and devoid of the marvelous interest which attaches to those regions of country where the forces generated in the earth's laboratory have made themselves conspicuous by the metamorphism of the rocks, and the tilting, folding and fracturing of its crust. Here the elements concerned in the building up of strata leave no trace of violent cataclysms, and the rocks presented to view lie regularly bedded at an inclination or dip, to the westward and northward, so gentle that its existence can only be made known by observations extended to points that are far distant from one another. Not a single true fault, or upward or downward break and displacement of the strata has yet been discovered. From this, then, one might be led to suppose that the geologist would have but little trouble in tracing and making up a complete and accurate record of the geological history of the State. But this very monotony of action and uniformity of strata is, perhaps, more perplexing and defiant to deal with and read correctly, than where turbulence prevailed and marked the pages of geological time with bold and well-defined characters. There is also another great drawback to investigations in Indiana, due to an immense deposit of glacial clay, sand, gravel and boulders which spread over so large a portion of the State, and cover up the beds of stratified rock to a depth of several

hundred feet in the counties north of the Wabash river, fifty to a hundred feet in the central part of the State, and twenty to sixty feet in the southern part.

The oldest and first-formed rocks in Indiana are to be seen in the southeastern part of the State, and extend along the Ohio river, from the mouth of the Fourteen-mile creek, in Clark county, to the eastern boundary line.

From the mouth of Fourteen-mile creek, the western boundary of these rocks runs in a northeasterly direction through Ripley county, keeping a little west of Versailles, nearly through the central part of Franklin, western part of Union to Cambridge and Richmond in Wayne county. It may be followed a few miles north of Richmond, on the middle fork of White Water river, and from thence east into Ohio. This group of paleozoic rocks received the name of Hudson River group in the geological reports of New York, where they were first studied and assigned to the position which they hold in geological sequence. The Hudson River group, in New York, forms the upper division of the Trenton period and the upper member of the Lower Silurian formation. Going east from the western outcrop of the Hudson River group through Ohio to its eastern boundary, the width of the exposure is about ninety miles. But by far the greater area of these beds is to be found in Kentucky, on the south, where the breadth is over one hundred miles, and the southward prolongation reaches beyond Nashville, in Tennessee. Altogether, the exposure from its northern outcrop in Ohio to its southern crop in Tennessee is about three hundred and twenty miles long. In Kentucky these rocks received the name of "Blue limestone." Professor Safford, in his geological report on the rocks of that State, gave them the name of "Nashville group." Worthen and Meek, in the geological reports of Illinois, gave them the name of "Cincinnati group," and I

suppose that I might, with the same propriety, add to this confusion by applying to these beds the name of "Madison group," because we find at this city an admirable exposure of the beds, and some striking lithological peculiarities not noticed elsewhere, but I prefer rather to diminish than augment the number of synonyms which are so perplexing to the masses who are trying to acquire a fair knowledge of geological science, but become discouraged on finding so many names applied to a single epoch.

The Lower Silurian rocks being the oldest within the borders of Ohio, Indiana, Kentucky and Illinois, they must necessarily, where not brought to the surface, underlie the formations that follow them in time, so that, go in whatsoever direction you will from their surface exposure, it will be observed that they are lost beneath the drainage, and give place to newer formations. This well-known fact has led the ablest geological observers of this country to attribute their outcrop to a local disturbance, which uplifted and brought them to the surface. The axis of this disturbance was supposed to be in a northeasterly and southwesterly direction, and to pass in the vicinity of Cincinnati, Ohio. Some speak of it as the "Cincinnati axis," or "Cincinnati uplift."

Dr. John Locke and Dr. D. D. Owen believed that this line of axis in Ohio passed near to the Indiana boundary, as they found the Hudson River rocks at a greater elevation here above the Ohio river than they are at Cincinnati. Professor Orton, of the Ohio geological survey, in his very comprehensive and able report on these beds, while he did not undertake to re-examine Dr. Locke's points of observation near the borders of Indiana, finding the Cincinnati beds in Clermont county, sixty miles east of Indiana, seventy-four feet higher than at Cincinnati, and the section to include fifty feet of rocks, which are supposed to underlie

the lowest stratum, exposed in the river at Cincinnati, concluded from these facts, that the axis of uplift is not a sharply-defined line, but a broad arch, and the highest point of that arch lies to the east, and not to the west, of Cincinnati, as indicated by Dr. Locke. "Cincinnati arch," and "Cincinnati dome," have long been common expressions used by geologists in speaking of the dynamics of the strata. The dip of the beds in the vicinity of Cincinnati, according to Professor Orton, is to the northward.

My own opinion is that the Lower Silurian strata in the region above alluded to were not thrust to the surface by a local disturbance, but by an elevating force which acted very slowly and extended over the entire central area of the United States. If we are to judge from the hight of the strata above the sea level, then the seat of greatest force concerned in the elevation was not confined to southwestern Ohio, but should be looked for in Kentucky, where the Lower Silurian has a greater elevation and a much more extended area than to be found in Ohio or Indiana. An examination of the hydrography of the district occupied by the Lower Silurian should at once convince the most skeptical that instead of Cincinnati anticlinal, it would be more proper to say Cincinnati synclinal; and instead of dome, basin. Licking river rises east of south and flows north to find the lowest level at Cincinnati. The Ohio river itself after washing the eastern border of Clermont county, has to turn almost north in order to reach the depression at Cincinnati, then turns nearly due west to the boundary of Indiana, when the general course is directed to the south. The Great Miami and the Little Miami rivers rise to the northward and flow in a southerly direction to reach the low ground at or near Cincinnati. The tributaries of the Ohio river indicate in a measure the topography of the country traveled, and we have only to point out the geological levels to prove our

premises more fully. Professor Orton, in the first volume Geological Reports of Ohio, page 412, says that the heavy stratum of *Orthis biforata* found at Cincinnati four hundred and twenty-five feet above low water, are four hundred and seventy-five to four hundred and ninety feet above the river at Bethel, on the eastern side of Clermont county. Here, then, we have evidence of a dip to the northward of two to three feet to the mile.

If we take the levels of Dr. John Locke near the Indiana boundary, about thirty miles west of Cincinnati, the top of the Cincinnati beds are six hundred and one feet above the river, including a dip of about two to three feet per mile to the eastward. Now my own observations in Indiana go to sustain the accuracy of Dr. Locke's levels. At Morris, on the Indianapolis, Cincinnati & Lafayette railroad, the *Orthis lynx*, or *Orthis biforata* beds, which I take to be the equivalent of the *Orthis biforata* beds at Cincinnati, have an elevation, by railroad levels, of five hundred and seventy feet above the river at the latter place; and at Pierceville, on the Ohio & Mississippi railroad, forty-four miles west of Cincinnati, the Lower Silurian is five hundred and seventy-four feet.

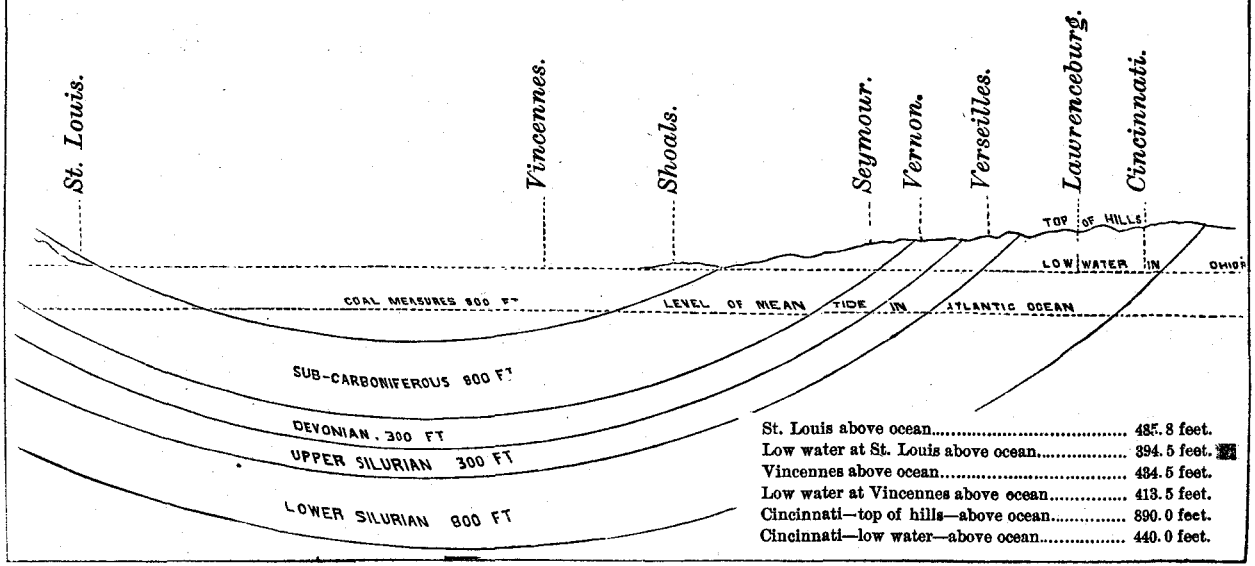
Take the elevation near Bethel, four hundred and seventy-five to four hundred and ninety feet, and the elevation at Morris, five hundred and seventy feet, and one would be compelled, from these levels, to place Cincinnati in a synclinal rather than an anticlinal axis. But I do not attribute the same importance to such slight variations in levels as many of my co-laborers in geology, I prefer rather to refer them to other causes such as arise from an uneven ocean bottom and the effects of subsequent denudation.

The central valley of the United States we find made up exclusively of sedimentary rocks that were laid down on an uneven bottom; of these the Lower Silurian beds are

the oldest in time and were, therefore, formed first. The exposure of these beds in Indiana, Ohio, Kentucky and Tennessee, surrounded as they are on all sides by strata that follow them in regular sequence as you recede from the outcrop, have, therefore, led many geologists to believe that they were thrust up by a local disturbance, of which Cincinnati lies in or near the axis. Now, if this was the case, then we are bound to admit that in the vicinity of Cincinnati there has been a vast amount of denudation, as I have already shown that the Hudson river beds occupy a greater elevation, both on the east, south and west of that city. According to Professor Proctor, to whom I wrote for information, the Hudson river beds, twelve miles west of Frankfort, Kentucky, are eighteen hundred and eighty-five feet above the level of the sea. Immediately at Frankfort the highest points are, according to the same authority, eight hundred and ten feet, and at Lexington nine hundred and fifty feet above the sea. If Mr. Proctor is right in the elevation of the beds twelve miles from Frankfort, and that the upper beds have elsewhere been cut away and removed by denudation, we have here evidence of the exposure of a vast amount of Lower Silurian rocks far in excess of what is known in Ohio and Indiana at the present time; and as such an elevation of the Lower Silurian in Indiana or Ohio would have covered the entire area of these states, no such idea can be entertained for a moment, and their disappearance here can not be due to any very great amount of denudation, but to a northerly dip of the strata. In a paper which I read before the American Association for the Advancement of Science, at the Indianapolis meeting in 1871, I then called attention to the fact that the Lower Silurian rocks were not brought to the surface by a local uplift, but by an upward movement of the continent. The shallow parts of the ocean were first laid bare, and this

PLATE I.

Section from St. Louis, Mo., to Cincinnati, Ohio.



St. Louis above ocean	425. 8 feet.
Low water at St. Louis above ocean	394. 5 feet.
Vincennes above ocean	434. 5 feet.
Low water at Vincennes above ocean	413. 5 feet.
Cincinnati—top of hills—above ocean	890. 0 feet.
Cincinnati—low water—above ocean	440. 0 feet.

gave rise to a Lower Silurian peninsula. I shall not now undertake to give a detailed account of the filling up of the ocean basins which encompassed the Lower Silurian land, but confine myself to what followed in the area comprising the State of Indiana. As the land rose above the ocean, the succeeding strata made their appearance in regular sequence, as shown by the accompanying section (Fig. 1), which is made to scale from Cincinnati, Ohio, to the Mississippi river opposite St. Louis. The elevations are given from the grade of the Ohio & Mississippi railroad. The lower dotted line represents the level of mean tide in the Atlantic ocean. The upper dotted line, low water in the Ohio river at Cincinnati, and the top line indicates the topography. Commencing with the Lower Silurian on the right, it is succeeded near Versailles by the Upper Silurian, this by the Devonian, Sub-carboniferous and Coal-measure strata.

The subordinate strata rise again to the surface in Missouri, so that we have in Illinois and Indiana, between the eastern and western crop of the Sub-carboniferous, a vast shallow basin reaching from shore to shore of the Sub-carboniferous rocks at the close of the latter epoch. After a time this basin, being shut out from the sea, became a fresh-water marsh, and the conditions were favorable for a luxuriant growth of plants which furnished carbon for a bed of coal. To account for a succession of seams of coal, we must now admit a period of submergence.

The low ocean barriers, which protected the basin on the south, were overflowed, and a deposit of sediment gave rise to the overlying shales, sandstones and limestones. The deposit was necessarily continued over long periods, and the stoppage for a time of the movement would cause the outlet to fill up and again shut out the sea, and bring about the conditions for plant growth and the formation of another bed of coal, and so on until the basin was filled or the coal

epoch terminated. This period of comparative rest and subsidence need not have been regular nor violent in its action, but must have been slow and of long duration. A similar basin, and due to like causes, existed on the eastern side of the Silurian belt, giving rise to the Appalachian coal basin; but the beds of coal which it contains need not have been formed at precisely the same time, though they must necessarily be very closely correlated in the upper part of the basins. In the eastern field the formation of coal commenced at an earlier period, and the accumulated strata are at least thicker than they are in the west. In Pennsylvania the coal measures are estimated to be eight thousand feet thick, two thousand in Ohio, seven hundred to eight hundred feet in Indiana, and about twelve hundred feet in the deepest part in Illinois.

In quality, the coals in the respective basins, though formed under such similar conditions, are remarkably distinct when judged by their behavior when charred in ovens or burnt in furnaces or grates. The Allegheny basin coals, as a general rule, contain less water mechanically combined, and the oxygen, hydrogen and carbon are in such relations to one another that the mass is more readily melted or fused into a semi-fluid consistency under the act of combustion, and when the volatile part is expelled by dry distillation in ovens, there will remain a strong and more or less compact coke.

The coals of the Illinois basin become less fluid in burning, and make but a poor coke for metallurgical purposes. There has been much speculation in regard to the cause why coals that approach one another very closely in the amount of fixed carbon and volatile matter, and in the relative proportions of their elementary constituents—carbon, hydrogen, oxygen and nitrogen—act so very differently in the coking oven; one may make an excellent coke, while the product

from the other will be very indifferent. The caking coals of Indiana swell and fuse to a pasty mass when burning, but the coke which is made from them is not strong, and is filled with large cells that give it a sort of honeycomb appearance. The Indiana block coal, on the other hand, does not swell or melt in burning, and coke made from it has the shape and structure of the original mass. Now, if we look at the analyses of fair samples of coal from the Allegheny basin, and caking coal and block coal from Indiana, one will be puzzled to know why the difference above referred to should exist when the coals are subjected to similar treatment. The volatile hydrocarbons, and the oxygen and nitrogen contained in bituminous coal are continually undergoing a change after the coal has been brought to the day. It makes no difference in this respect whether it be left exposed to the weather, or is kept under shelter and away from the direct action of the sun; the total quantity of volatile matter is diminished, and the per cent. of fixed carbon is increased.* By augmenting the temperature the change takes place more rapidly. At a temperature of 212° F. the per centage of coke will, in the laboratory, reach its maximum in about ninety hours, and if left exposed to the air at the same time will have gained in total weight from 4.75 to 5.8 per cent. A slight increase in weight of fixed carbon takes place at a temperature of 212° F. when the coal is placed in an air tight digester and excluded from the atmosphere, and when the temperature was raised in these experiments,* no change was perceived in the quality or quantity of the coal.

From the above I think it possible that time and temperature have had and continue to exert a modifying influence on the character of fossil coal. From the great thickness

*See Indiana Geological Report, 1875, pp. 18 to 29.

of the Appalachian coal basin, we may infer that the formation of beds of coal commenced then at a much earlier date—say thousands of years before their formation in the Illinois coal field began. Indeed the formation of coal beds may have ceased entirely in Pennsylvania before the conditions favorable for coal beds were reached in Indiana.

From what is said here of the physical character of coal in the two great basins, it must not be inferred that the plants themselves have had nothing to do in the matter; but their study would be foreign to the object in view which is to show the effect of time and dynamical causes in modifying and building up the strata.

With the coal measures, all marine deposits terminated within the limits of Indiana and Ohio. The Gulf of Mexico extended a little further north than the present mouth of the Ohio river. At this time, too, the Hudson River group was hardly more than five hundred feet above the sea level. The coal epoch was brought to a close by a change in the movement of the earth's crust, which now commenced to rise. The main seat of the force must have been north of either Cincinnati or Indianapolis, and a large portion of the continent beyond the great lakes was carried to an elevation which kept it clothed in perpetual ice and snow until the close of the Glacial Epoch. The grinding force of this vast field of ice, moving over mountains, valleys and plains, wore away the surface of the rocks and removed immense masses along with finer debris from a higher to a lower plain. The long continuance of a force that was cutting and wearing down the projecting mountain peaks would of itself bring about a change of temperature, and the ice belt would be moved to the north by glaciation, if not otherwise intervened to produce an equilibrium of elevation between the northern and southern portion of the continent; though it is possible that the northern part of the conti-

nent has been depressed since the Glacier Epoch closed in Indiana.

Let us again look at some of the elevations in Ohio and Indiana, and see if we can reconcile them upon the theory of a special uplift in Silurian times in the vicinity of Cincinnati. It has already been shown that Hudson River rocks are found at Bethel, twenty-six miles east of Cincinnati, at an elevation of seventy-five to ninety feet above the equivalent beds at the latter place. They are also about one hundred and fifty feet higher at the same distance northwest of Cincinnati, according to Dr. Locke; at least one hundred and ten feet higher at Sunman, in Ripley county, Indiana, on the Indianapolis, Cincinnati & Lafayette railroad; one hundred and twenty-four feet at Pierceville, on the Ohio and Mississippi railroad, and at other places which it is not necessary to cite now. At nearly all of these elevated places the Upper Silurian rocks make their appearance in thin beds, which thicken as you go to the east, north or west, and all the strata disappear in regular sequence, as shown in the diagram on page 9. Take the elevation of the upper beds of the Hudson river group at Cincinnati to be eight hundred and ninety feet, as determined by surveys, we find the country rising as we go to the north or west. Three miles northeast of Bellefontaine, Ohio, the elevation is thirteen hundred and sixty feet, and the black Devonshire shale at Bellefontaine twelve hundred and eleven feet above the level of the ocean, and four hundred and seventy feet above the hills at Cincinnati. Union City, Indiana, on the Niagara rocks, is eleven hundred and twenty-two feet above the ocean. Following a direction southwest from Bellefontaine, we have a continuation of high land, with lower geological strata, until we pass Shelbyville, when the Niagara disappears and is succeded by the Devonian. At the Weed Patch, in Brown county, the lower member of the Sub-carbonifer-

ous epoch has an elevation of eleven hundred and seventy-two feet above the sea, which is about the same as the elevation at Bellefontaine, two hundred and twenty-two miles to the northeast in an air line. The Weed Patch is about five hundred feet above the Black shale that correlates with the Black shale at Bellefontaine, which difference, without resorting to violent uplifting forces, may be accounted for by a gentle slope of the ocean bottom. The difference in altitude of this shale at the points mentioned will not exceed six hundred feet, and the horizontal distance being two hundred and twenty-two miles, will be represented by a gradient of less than three feet to the mile. From these figures, showing the elevation of the Sub-carboniferous formation in Indiana, and the Black shale at Bellefontaine, it is apparent that the central basin of the continent was elevated by a force which commenced in Silurian times and continued up to the coal epoch, and that the axis of greatest force was not in a north and south direction, passing in the vicinity of Cincinnati, but was in a northeast and southwest direction, and lay between the waters of the Wabash and Ohio rivers. In other words, these two streams run in ancient valleys. The watershed which turns the drainage to the northward and southward does not terminate in Ohio, but may be traced from Bellefontaine, in a northeast course, through Pennsylvania, and into New York to Lake Chatauqua, which forms one of the head waters of the Ohio river.

The accompanying diagram (Plate 2*) of the surface of the country, over nearly an air line from Washington, in Daviess county, Indiana, to a point three miles east of Bellefontaine, Ohio, and passing along the divide between the east and west forks of White river, is given to show the elevations of the respective places through which it passes, above the ocean, low water in the Ohio river at Cincinnati,

*See cut at end of this report.

Lake Erie, Indianapolis, and the top of the Silurian rocks in the hills back of Cincinnati. The Black shale which forms the upper member of the Devonian near Bellefontaine, is thirteen hundred and sixty feet above the ocean, or four hundred and ninety-five feet above the top of the Lower Silurian at Cincinnati. And the geological horizon is fully twelve hundred feet higher than the rocks at Cincinnati.

From Piqua, Ohio, to Centreville, Indiana, where the Hudson river rocks pass beneath the drainage of the country, the strata are nearly horizontal, and everywhere show an elevation considerably higher than at Cincinnati.

At Flat Rock or St. Paul the Niagara rocks have about the same elevation as the hills around Cincinnati. From Edinburg, which is in the same geological formation as the Black shale at Bellefontaine, the land rises rapidly to the Weed Patch, in Brown county, which is eleven hundred and seventy-two feet above the ocean, two hundred and ninety-five feet above the Hudson river rocks at Cincinnati; and more than one thousand feet higher in geological sequence, as the rocks here belong to the Sub-carboniferous sandstone group. The top of the hill is from four hundred to four hundred and fifty feet above the Black shale.

Over the entire distance, along the line of this section, the dip of the strata is so gentle, at any point visible, that one is puzzled to estimate or measure it with the clinometer, and the physical structure of the rocks and the abundance of well preserved fossils which they contain furnish evidence that they were formed in a comparatively quiet and shallow sea. Indeed, the slight inclination of the strata, and the total absence of breaks or faults, all tend to prove that the elevation of this part of the continent was the result of a force acting with remarkable uniformity over the entire basin, and could not have reached its greatest development in Silurian times.

The subsequent disturbance which elevated the Appalachian chain, and tilted and folded the Carboniferous beds of Pennsylvania, did not extend as far west as the central portion of Ohio, if it reached within the borders of that State at all. At all events no traces of it are to be found within the borders of Indiana.

We have no means of knowing the depth of the Lower Silurian beds in this State, as they have never been gone through by any of the bores yet made for Artesian water. The great well at Fort Wayne, Ind., commencing in the drift, reached the Niagara rocks at the depth of eighty feet. This rock may be seen at the crop along Little river and on the main Wabash river in Huntington and Wells counties, and is traced to within twelve or fourteen miles of Fort Wayne. It is not possible to determine the thickness of this formation in the bore by the character of the debris brought up by the sand pump, but I am satisfied from measurements made at exposures to the south that it can not exceed two hundred and fifty feet, and I question if it is so much. After passing through the Niagara* this bore continued in the Lower Silurian to a depth of three thousand feet without reaching artesian water or the bottom of the formation. Another deep bore, at Louisville, Ky., has penetrated these beds to the depth of two thousand one hundred and seventy-eight feet. While it is not possible to speak with certainty from the samples of borings, carefully preserved, of the rocks in the Fort Wayne well, as to what specific division of the Lower Silurian formation they belong, from a strong resemblance standpoint there can be but little doubt that the base of the Hudson river group has not been reached.

* I do not believe it is possible to distinguish the Clinton epoch in Indiana.

Along the Ohio river, going southwest from Cincinnati, but little change is found in the members comprising the crop of the Lower Silurian, and the upper beds maintain about the same elevation above the Ohio river at Cincinnati, until you pass west of Indian-Kentuck creek in Jefferson county. This may be seen on either side of the river. At Madison, according to W. T. S. Cornett, M. D., who has given much attention to the study of the geology of Jefferson county, and especially to the rocks at Madison, the Hudson river rocks have an exposure of three hundred and fifty-one feet above the river, only seventy-five feet less than at Cincinnati.' Now with reference to the equivalence of the Madison and Cincinnati beds I can only say the limestone and bluish gray marl with which they alternate may be followed, without losing sight of their crop, from Cincinnati to Madison, and the predominating fossils are the same. The finding of a few variations in some of the genera at the latter place is not of sufficient importance to enable one to establish a different epoch or geological horizon, and I shall therefore consider them as belonging to the same geological time.

Thirty-two feet of the upper part of the Hudson river beds at Madison is composed of a thick bedded, close grained, bluish gray rock. The following analyses show it to be an impure limestone, and closely related to the hydraulic limestone of the Niagara age at Wabash, in Wabash county.

No. 1 is the Madison specimen, and No. 2 from Wabash, which is given for comparison:

	No. 1, Madison.	No. 2, Wabash.
Silica	19.80	30.00
Alumina	15.05	16.72
Magnesia	1.55	6.05
Oxide of iron	4.45	2.48
Lime	29.19	14.34
Carbonic acid	24.61	17.91
Water (dried at 212° F.)	0.35	1.00
Water and loss	5.00	11.50
	100.00	100.00

In the Madison stone a part of the silica is replaced by lime, and there is a large per cent. of iron. This rock forms a conspicuous bench on all sides of the hills at Madison. The Madison road has been cut through it, as well as the Indianapolis & Madison railroad grade, called the "deep cut." The color is bluish gray, with numerous bands of a deeper shade of blue; hence the name of "Banded rock" applied to this number by the first State Geologist of Indiana—Dr. David Dale Owen.

It is barren of fossils of any description; hence Dr. Cornett, in his papers on the Geology of Jefferson county, calls it the non-fossiliferous bed. However, the bands form a conspicuous feature, and I think we had better retain Dr. Owen's name.

Both David Dale and Richard Owen refer the Banded rock to the Upper Silurian. Professor James Hall, of New York, also refers it to this age; and Mr. Borden, in the Indiana Geological Report for 1874, has very naturally followed in the footsteps of the eminent geologists who preceded him. It rests upon the *Tetradium fibratum* bed; contains *Favistella stellata*, locally in the upper and lower parts; and being otherwise without fossils, and more nearly resembling the overlying, unmistakable, Upper Silurian beds in lithological features, has led to the mistake of placing it in the Niagara group. Now Dr. Cornett has found, resting upon the banded rock, a thin stratum of shaly limestone, resembling the Lower Silurian beds below and carrying an abundance of Hudson river fossils: *Orthis biforata*, var. *acutilirata; Orthis retrorsa; Orthis subquadrata; Orthis insculpta; Strophomena planumbona; Strophomena sulcata; Streptelasma corniculum; Rynchonella capax; Rynchonella dentata; Zygospira headi; Ambonychia radiata.*

These are well known Hudson river fossils, and I am inclined to believe with Dr. Cornett, after a careful study of

the locality, that they mark the top of the Lower Silurian at Madison, instead of the *Tetradium fibratum* bed which underlies the Banded rock. I am aware that many paleontologists will say that it is no unusual thing to find the fossils of one formation reaching upward into succeeding formations that are distant in time; and this is undoubtedly true of many species, as I have often had occasion to make public, but there can be no good reason in this case, when so large a number of Hudson River species completely terminate under the magnesio-niagara, or Cliff rock, should not be assumed as marking the true boundary line of the formations.

Dana very truly says in his Manual of Geology: "Nature does not build up walls to divide off her boundaries." So it is natural to have at some localities a difference of opinion in the assignment of a few feet more or less to a definite epoch.

From the top of the Hudson River fossil bed, that lies over the Banded rock, and extending up to the top of the hill at the toll gate, there is about one hundred feet of strata, composed for the most part of thick and thin beds of buff and light colored magnesian limestone. Portions of this member are rough-weathering, and almost worthless for building, while other portions furnish good durable stone, of which large quantities have been quarried for market. The most abundant fossil is *Calymene blumenbachi.* The lower twenty-three feet of these beds, Dr. Cornett refers to the Clinton, but I can see no good grounds for separating it from the Niagara. I have now followed the Upper Silurian beds from the Ohio river on the south, to the limits of their crop on the Wabash river in the north, without finding any well defined character by which the Clinton epoch can be recognized in Indiana.

Of course one may go to work and make indefinite di-

visions of any formation, however small the space it occupies in vertical range. The bottom will be the oldest and each succeeding division will follow in regular sequence; but a classification, based upon such a system, could never be maintained over a large area of country, and the attempt in that direction would lead to the greatest confusion and interminable disputes. In New York and Pennsylvania, where the entire Upper Silurian formation is from fifteen hundred to three thousand two hundred and seventy feet thick, it is possible to establish well defined boundaries of subdivision; but here, where the formation has dwindled to from fifty to two hundred and fifty feet, the attempt is fraught with mischief, and should, in my judgment, be abandoned.

From Madison to the mouth of Fourteen-mile creek the Lower Silurian dips in a southerly direction, and passes beneath the Ohio river at the latter place, which is fourteen miles above Louisville, Kentucky, and has an elevation of four hundred and four feet above the ocean—a dip of three hundred and fifty-nine feet in about thirty miles, or a little over ten feet to the mile. Taking the elevation at Madison to be seven hundred and sixty-five feet above the ocean. Fourteen-mile creek, in Clark county, is the most westerly crop of the Lower Silurian rocks known in the State.

Mr. A. S. Miller, of Cincinnati, author of a recent work on American Palæozoic Fossils, has very obligingly, at my request, furnished a complete catalogue of all the fossils which have been found in the Lower Silurian rocks over a portion of Ohio, Indiana and Kentucky.

Mr. Miller's work on the American Palæozoic Fossils, has very justly won for him the reputation of the very highest authority on American fossils, and this list, coming as it does first from his pen, can not fail to be of incalculable value to collectors of Lower Silurian fossils.