

NIAGARA GROUP UNCONFORMITIES IN INDIANA.

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Prof. Richard Owen, in the Indiana Geological Survey, 1859-60, calls attention to an unconformity near Huntington, which he supposed to indicate the dividing line between the Devonian and Upper Silurian. He describes the arenaceous limestone of the Devonian as resting unconformably, rate of dip 25 to 40 degrees southeast, on the silicious limestone of the Silurian. Of the Linn's Mill exposure, on Treaty Creek, Wabash County, he says: "Here we again found evidence of the convulsions and unconformable stratification noticed at the Fair Ground quarries of Huntington and in this county. On the west side of the creek, opposite the mill and close to the dam, a hill is formed by an anticlinal axis, the beds dip northward and southward about 43 degrees. But the extreme summit of the hill has evidently been subsequently denuded and abraded by water until a hollow affords a channel for a rippling rivulet, while in the bed of the main stream, beneath the axis, the undisturbed strata are visible." In the light of more recent investigations it is probable Prof. Owen's arenaceous limestone of Huntington and the upper member of his Wabash County unconformities should be correlated with the porous lime-rock of Prof. Collett, and the picket rock of Messrs. Elrod and Benedict. It should also be noted that the underlying layers of stone, at Treaty Creek, are approximately horizontal, and exclude an uplift as the cause of the distorted bedding.

Prof. John Collett, in the Geological Survey of Indiana, 1872, describes an unconformity seen by him at Calvert's quarry, near Georgetown, Cass County. He found a gray limestone resting unconformably on the "silico magnesia with a small parting of clay." This clay parting, he claims, is general, and is often found in wells some 20 or 30 feet below the surface at Logansport. At a later period the observations of Prof. Collett were confirmed by Mr. A. C. Benedict. Commenting on a section made, near Georgetown, for the report on the Geology of Cass County, 1894, he describes the surface of the first layers under the "gray limestone" as showing evidence, when exposed, "of having been eroded into channels and hummocks before the overlying rock was deposited."

Prof. Collett, under the section of his 1872 report devoted to Wabash County, correlates the "gray limestone seen at Logansport and at a few localities in Miami County" with the "thin-bedded paving stone" of Wa-

bash. The silico magnesian beds of Logansport, he says, "part with the greater portion of the calcareous matter at Peru, becoming argillaceous, while in Wabash this bed is characteristically argillaceous, and in appearance very similar to the hydraulic stone at Louisville." In his general section of Wabash County he places (1) porous limerock at the top, and gives its thickness at from 0 to 40 feet; (2) paving stone, 8 feet; (3) thick-bedded argillaceous limestone, 10 to 20 feet; (4) hydraulic limestone, 10 to 50 feet, and referred the whole series to the Niagara group. The subdivisions adopted by Elrod and Benedict in their report on the Geology of Wabash County, 1891, do not differ greatly from those of Prof. Collett. They placed the quarry stone, the equivalent of his paving stone and thick-bedded argillaceous limestone, at the top of the series. Between the quarry stone and his hydraulic limestone they recognized a local stratum of laminated shale, closely related to the quarry stone, and all below the laminated shale was called cement shale or cement rock. The porous limerock was not given a separate place in the section, because it was the opinion of the writers that it did not form a distinct geologic horizon; but was composed of the changed materials derived from the quarry stone and the underlying formations, but came mainly from the quarry stone layers. The materials were recemented by infiltration, and, as a consequence, the beds have no true stratification planes. For it they adopted the name picket rock, a local term then in common use at Wabash.

These correlations are deemed necessary that the reader may understand the stratigraphic position of the Wabash County unconformities, and the probable relations of the others of the Wabash Valley.

A very remarkable and plain example of unconformity between the quarry stone layers and the blue cement rock may be seen on the east bank of Lagro Creek, one-half mile north of Lagro. Here 30 feet of horizontal quarry stone abuts against a nearly perpendicular wall of cement rock. Below the unconformity, in the creek channel, the cement rock is found to be continuous and connected with the south wall of the unconformity and to pass under the more recent quarry stone. Dip is scarcely appreciable in any of the layers. Other unconformities of great interest are those at the Martin Willis quarry, south of Lagro, on the township line pike, and at Leonard Hyman's quarry, on the Mississinewa River. At these quarries the quarry stone rests on the laminated shale in a valley. On one side of the Martin Willis quarry the shale rises 10 feet above the lowest exposed horizontal layers of quarry stone.

Some convulsion of nature, a local upheaval and subsidence of the earth's crust, was among the theories generally accepted for a time, to account for the false bedding of the Wabash Valley rocks. Prof. Collett, in 1872, was the first to offer an explanation more nearly in accord with recent observations. Of a Delphi locality he writes: "The Pentamerus bed is an irregular deposit, variable in its mode of occurrence and thickness, evidently deposited by currents flowing across irregularities in the surface of the regularly deposited rocks below. It is generally found thrown down upon or against these irregularities, and consequently exhibits remarkable peculiarities of false bedding." But his theory does not account for the uneven surface of the regularly deposited rocks. The most obvious explanation is to suppose that they are due to erosion, and that they indicate the upper surface of the lower member of an unconformity. Especially must this be true where the stratification of the stone, comprising the irregular surface, is found to be level and the layers of uniform thickness. Where the irregularity forming the axis or center of a cone is composed of shale it is not impossible that it may have been formed by currents. The effect of currents on the contour of a shale bed was clearly demonstrated in an example of irregular bedding seen in the quarry of James Lambert at South Wabash. Here an axis of shale had been deposited between the quarry stone layers, which maintain a uniform thickness while conforming to the irregular surface of the shale. Near Lagro, at the Watson Briggs ravine, is a beautiful exposure on a large scale of the picket rock passing over a central axis of a cement shale with the dip in opposite directions. On the flanks of the axis the dip changes from 20 to 12 degrees and the layers become horizontal as they pass over the top. These exposures are supposed to show the primary origin of the false bedding in nearly all cases, and especially so when the distorted layers are of nearly uniform thickness. But in many cases other phenomena are involved and the explanation is not so simple. Irregularities of the underlying surface do not account for the brecciated condition, changed physical characters and the nearly vertical planes of so-called stratification.

The brecciated character of the Indiana stone seems to have been first pointed out by Prof. Orton in the eighth annual report of the United States Geological Survey. Of the Ohio stone, with which he compares the Indiana outcrop, he says: "The layers of limestone appear to have been traversed by joints dividing them into cubical blocks of two or ten inches

in diameter, and the separate blocks have been recemented by material of the same sort that composes the substance of the rock. The cause is not obvious, but the phenomena is certainly not referable to uplift and disturbance. It seems more probable that if we were able to trace out the history we should find some modification of the force that produces joints, whatever it may be, as the cause of the phenomena we are considering."

The high angle stylolite planes of the interior conformation of the cones is another feature which should be considered in connection with the brecciated structure. The columnar part of the stylolite seam is peculiar in having its axis lie parallel with the separation plane, and seems to show that the columnar structure is the result of a downward movement of the overlying layer. At the Stauffer quarry, two miles west of South Wabash, and at Rockyway Creek the angle of the separation planes does not exceed 25 degrees, and it is probable that they may be modified bedding planes, something like those described by Mr. T. C. Hopkins in his report, of 1896, on the Bedford oolitic limestone of Indiana.

The exposures at Stauffer's and Rockyway also show that the picket rock gradually changes into even bedded quarry stone, and that the picket rock is a modified form of the other. At the same time the dip changes from an angle of 25 degrees to nearly horizontal.

The high angle stylolite planes are too nearly vertical to have been the result of sedimentation. They evidently grow out of a number of conditions. Briefly, the picket rock cones and ridges rest on a core or axis of cement rock or shale, the latter being the result of erosion. It is probable the layers of stone, overlying the core, were of continuous thickness when deposited, and that the brecciated character and stylolite planes are the result of pressure and unequal resistance to a downward shear.

A somewhat similar system of brecciated and irregularly bedded stone extends from the interior of Ohio, across Indiana and into Illinois. Through Indiana and in the vicinity of Chicago high angle stylolite planes are a marked feature of the exposures. In Ohio the distorted bedding is referred to the Waterline formation. In Indiana similar irregularities are supposed to be confined to the Niagara group beds. Dr. A. J. Phinney has been the only Indiana geologist to dissent from this opinion by assigning the Delphi and much of the Logansport exposures to the Lower Helderberg. Prof. Orton, in his report on the Ohio and Indiana gas field,

says: "The well-known Wabash flaggings are here counted of Lower Helderberg age." Dr. Phinney, in a report on the natural gas field of Indiana, eleventh United States Geological Survey, dissents from this opinion, and says: "The exposures in the vicinity of Wabash have been considered Niagara limestone, as the fossils are identical with those found at Marion, where the exposure is undoubtedly Niagara." In the Wabash County report of 1891 forty species of fossils are tabulated, which were collected from the quarry stone. The most of these were characteristic Niagara fossils. The Illinois geologists have always considered the equivalent beds of that State as of Niagara age.

By some writers great significance is attached to the brecciated structure in determining the age of the stone in which it occurs. However, Dr. Phinney describes the Waterline at Kokomo as "an even-bedded limestone." About Logansport, he says, the Lower Helderberg is a common rock, and "finely exposed," but, so far as known, never shows a brecciated surface. If the Waterline formation is excluded from the Lower Helderberg it is probable no true representative of that period is to be found in Indiana.

Prof. Dana, in the fourth edition of his *Manual of Geology*, assigns the Waterline formation to the Salina group. And in a bulletin of the Geological Society of America, May, 1900, Mr. Charles Schuchert presents facts to show that all of the Lower Helderberg above the Waterline and Tentaculite limestone should be included with the Devonian. Mr. Schuchert seems to consider the Tentaculite limestone as transitional to the Lower Helderberg. Of twenty-six species found in the Tentaculite beds of New York, only four are known to occur in some higher member of the Lower Helderberg. In Ohio, out of thirteen species described from the hydraulic limestone only four are known to occur in the higher beds. So, then, in view of what is now known, it seems safe to assume that the Wabash County unconformities and pronounced irregularities of bedding were the result of forces in operation near the close of the Niagara epoch, and at all events before the close of the Silurian age.

The subdivisions of the Niagara group in Southern Indiana have been much better defined and correlated than those of the Wabash Valley. The remarkable uniformity in the bedding of the Laurel limestone from Connersville to the Ohio River has been fully described, and the Waldron shale exposures traced from Milroy to Charlestown landing. Slight irregularities of bedding had been noticed in the layers immediately above the

Waldron shale, but nothing worthy the name of an unconformity until Mr. Foerste, in the twenty-second Indiana Geological Report, called attention to the Avery quarry as showing evidence of a period of erosion. Other unconformities on Flatrock and Conn's creeks have been described and illustrated by Messrs. J. A. Price and E. M. Kindle in later reports.



Avery Quarry, Southeast Corner.

The Avery quarry is located on the east bank of Conn's Creek, one mile south of Waldron. The Louisville limestone, as the workable bed of stone has been called, rests conformably on the Waldron, is 10 feet thick on the north wall and five feet thick in the southeast corner. The layers have a general dip to the north of three degrees. On the south face of the quarry, near the southeast corner, three discontinuous layers are exposed at the top of the Louisville limestone. They aggregate nine inches in thickness at the west end, and thin to nothing before reaching the southeast corner. Immediately under the attenuated strata is a $6\frac{1}{2}$ -inch layer which is continuous around the south and east faces of the quarry. From $6\frac{1}{2}$ inches at the southwest end it gradually diminishes to $2\frac{1}{2}$ inches at the northeast corner. Below the continuous layer is a layer which measures 11 inches at the north end; it soon divides into two layers, whose

combined thickness is 9 inches at the south end. On the east face two layers, near the top of the wall, were measured, one of which changed in thickness from $2\frac{1}{4}$ to 5 inches in 33 inches, and the other from $2\frac{1}{2}$ to $5\frac{1}{2}$ inches in 21 inches. At the northeast corner of the quarry there is 5 feet of Louisville limestone about the $6\frac{1}{2}$ -inch continuous layer, which diminishes in thickness to nothing at the south end. The layers composing this 5-foot stratum do not thin gradually, but by an abrupt ending of the several layers. Twenty feet north of the southeast corner is a slight thickening in the upper layer, which causes a slight dip north and south. These measurements show that the thickness of some layers increase and others decrease with the dip. Below the $6\frac{1}{2}$ -inch continuous layer the stone is evenly bedded.

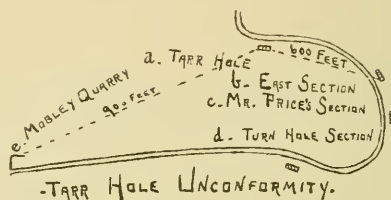
Above the nearly level line of unconformity is from 20 to 48 inches of coarse, sandy-looking limestone in broken layers, with a thin covering of earth above it. Viewed from across the quarry the exposure looks like a broken wall of rubble stone. The results of weathering are very evident, but has not wholly destroyed the lines of continuity, which show irregular bedding.

The color of the Louisville limestone changes from blue or blue-gray at the bottom to a gray near the unconformity. The overlying layers are very nearly brown. The upper Louisville layers change color gradually, and the freshly broken surface of the brown stone can scarcely be distinguished from it, but a marked difference is developed by weathering.

The quarrymen allege that the underlying shale is five feet thick, which is very nearly its average thickness at other places. So far as the thin-bedded shale can be said to have dip it seems to conform to that of the Louisville limestone. If this is true the surface of the Laurel limestone, on which it rests, must be irregular. The exposed Laurel limestone in the bottom of Conn's Creek nearby shows that it has no appreciable dip, nor has it been disturbed by an uplift. Hence it is reasonable to conclude that the irregular surface below the Waldron shale has been the result of erosion which took place after the Laurel beds were deposited and before the Waldron shale came into existence. The inclined position of the Louisville limestone layers is the outcome of irregularities formed during sedimentation.

The unconformities described on Flatrock Creek are minor affairs compared with the Avery quarry locality. The horizon of the Geneva and Louisville limestone unconformities change, and at one place is found be-

tween the layers of the "soft, sandy limestone." Generally they appear to be nothing more than lines of irregular bedding, with a slight difference in the structure of the upper and lower members.

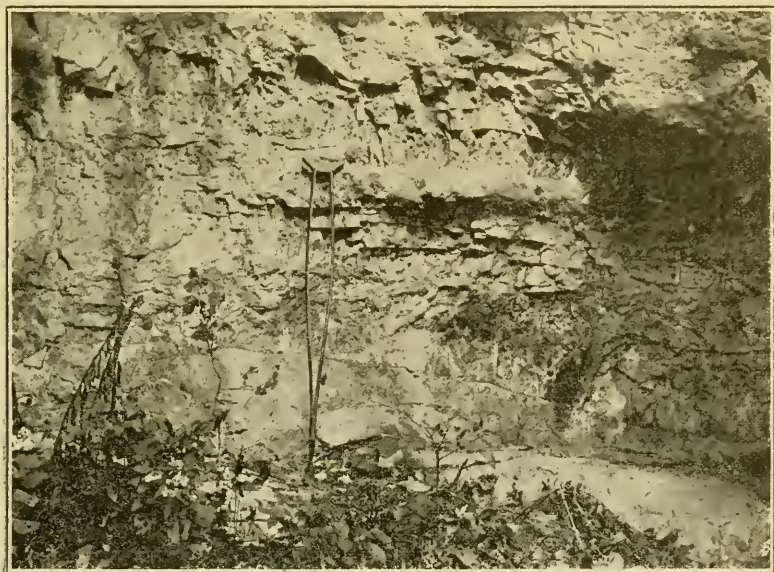


The top of the Waldron shale at *a* is 12 feet, at *b* 17 feet, at *c* 18 feet, at *d* 9 feet above low water; at *e* it is below the surface. The fall in the creek bed from *a* to *e* is 40 inches.

One mile south of Hartsville, in the Tarr hole vicinity, there seems to be conclusive evidence of a period of erosion after the Laurel limestone beds were formed and before the shale beds were deposited. Below the Tarr hole Clifty Creek makes a horseshoe bend within a radius of one-fourth mile. The Tarr hole exposure shows that the top of the Waldron shale is 12 feet above low water, and the shale nearly 7 feet thick. Six hundred feet east the top of the shale is 17 feet above low water and $4\frac{1}{2}$ feet above the same level at the Tarr hole. Near the middle of the bend Mr. Price estimates the shale to be 3 feet thick and its top at from 18 to 21 feet above the bed of the creek. In 1881, when the shale was better exposed than now, a section was made at the Turn hole which showed the top of the shale at 12 feet above low water, and the shale 5 feet and 8 inches thick. After due allowance is made for the decline in the bed of the creek, where it passes over a long riffle, it indicates the surface of the shale is 3 feet below a corresponding level north of it at the Tarr hole. Seven hundred feet west of the last locality is the Jesse Mobley quarry, where a well was put down a few years ago that penetrated the Waldron shale 20 feet below the surface. Twenty feet below the surface, at this place, puts the top of the shale below the bed of the creek. The writer is certain of the position of the shale in this well, as he has a number of the Waldron fossils taken from it at the time the well was dug. Here the top of the shale, after adding 3 feet for decline in creek bed, is seen to be 15 feet below the same level at the Tarr hole, and from 18 to 21 feet below two other points.

Following the bend of the creek on the east side some four or five feet of thin bedded Laurel limestone is exposed, next to the shale, that is not found at the Tarr or Turn holes. The Mobley quarry, since the report on Bartholomew County was written, has developed a number of irregularities of bedding not then visible. There is a slight irregularity on the line dividing the lower grayish stone from the brown layers, and if weathered a few more years might be classed with the Flatrock unconformities.

In lithologic structure and color the Louisville limestone at the Tarr hole and Mobley's quarry very closely resembles the upper and equivalent layers at Avery's quarry. It is probable the quarry stone at both places was deposited under similar conditions, and does not show dip at Mobley's because the quarry is not located over a marked irregularity on the surface of the underlying Laurel limestone. Where investigations have been made it has become evident that all large displays of Louisville limestone are located in an erosion valley or on an anticline connected with a synclinal axis, and that the exposure of the Louisville beds are correspondingly local.



Devonian Exposure, Cave mill Park.

The irregular bedding of the Devonian at Cass, Cass County, is quite marked, and the same is true of the Geneva beds in some parts of Southern Indiana. A fine exposure of mixed bedding is to be seen in the Geneva limestone at the Cave mill park, which presents an eighteen-foot wall of discontinuous, uneven and distorted stratification, overlying what appears to be Louisville limestone. This seems to be the formation from which Mr. Kindle collected a number of Devonian fossils, three-quarters of a mile farther up the creek, opposite Charles' mill, and the equivalent of the Devonian bluffs near Hartsville. According to Mr. Price, irregular bedding is common above the Waldron shale in Rush County. It is probable that further search will reveal many more irregularities that are now obscured by weathering. The irregular bedding of the Louisville and Geneva limestones is probably the result of marine currents, and it certainly is not necessary to invoke a local uplift or convulsion of nature to account for its origin or that of the unconformities.

No unconformities have been reported from the Upper Helderberg, but there is evidence that the Niagara limestone and New Albany black shale are not conformable at Delphi.

By Mr. Foerste and others the Louisville beds are referred to the Niagara epoch, and this may be their place if based on paleontologic evidence. Its horizon, however, can not be established by the existence of a few minor unconformities at the top of Louisville limestone. If unconformities are conceded to have occurred during the Niagara epoch or Silurian age, in the Wabash Valley, they certainly show that the changes in the coast line necessary to their formation, whether submarine or aerial, did not destroy a large per cent. of the fauna in existence before the erosion period began. Of course it is conceded that many of the species found in the Waldron shale are peculiar to that formation, but many of them also came up from the preceding epoch. Therefore, the Upper Niagara and Geneva limestone unconformities have very little significance in determining the age of the formation between which they occur.

An interesting question arises whether the Waldron shale can be correlated with the quarry stone of Wabash County. Not enough is known to give anything like certainty to what now may be said on the subject, but it may not be improper to call attention to a few observations which indicate that they occupy the same horizon. It is generally known that the Waldron shale is often highly calcareous, with intercalated plates of limestone, and changes to thin layers of limestone as it is traced north-

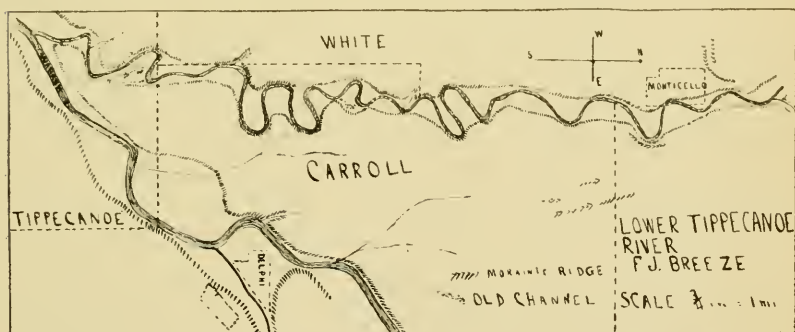
ward. Frequently on Clifty Creek a stratum of stone below the Waldron shale is seen which very much resembles the hydraulic beds of Wabash County, both in appearance and jointed structure. The laminated shale of Wabash is duplicated by some of the more argillaceous shales of Clifty Creek. The Wabash Valley and Laurel-Waldron unconformities seem to be of the same horizon and lend color to the inference that the quarry stone of Wabash County and the Waldron shale are of the same age.

THE VALLEY OF THE LOWER TIPPECANOE RIVER.

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[Abstract.]

The Tippecanoe River deserves far more attention from the geographer and geologist than has ever been given to it. A careful study of this stream will shed light upon some of the problems of glacial phenomena, and will doubtless yield something of interest concerning stream and valley development. Believing this, the writer has begun a somewhat systematic study of this river. Several days of the last three months have been devoted to the necessary field work in the preparation of a map of



the lower part of the Tippecanoe Valley. This map shows the meanders of the stream and of its valley, and is presented at this time with the hope that it may be some little contribution to the geography and geology of Indiana.

By Lower Tippecanoe is meant that part of the river from the point where it leaves the region of the Glacial Lake Kankakee to its mouth.