

THE STRATIGRAPHY
AND PALEONTOLOGY

OF THE

Niagara of Northern Indiana.

BY EDWARD M. KINDLE.

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PART I.—STRATIGRAPHY.

INTRODUCTION.

The present paper is the outgrowth of field work done during parts of the field seasons of 1899 and 1902. Considerable collections and many notes on Niagara stratigraphy were obtained during the summer of 1899 while studying the Devonian rocks for the Indiana Geological Survey. Through the coöperation of the United States Geological Survey and the Indiana Survey, the writer was able to spend one month during the summer of 1902 in mapping the Niagara outcrops of northern Indiana, and in making collections of their fossils. Prof. George L. Collie accompanied the writer during the summer of 1902, and Mr. V. H. Barnett in 1899, and to these gentlemen we are indebted for much valuable assistance.

Nearly all of the Niagara outcrops in the northern half of the State have been examined. Particular attention has been given to the Niagara dips which have received such widely different explanations from different geologists.

TOPOGRAPHY.

The original topography of northern Indiana is almost entirely masked by the drift. Deep well records indicate considerable topographic relief in preglacial times. The thickness of the drift in the vicinity of some of the outcrops shows some of the preglacial valleys to have had a depth of four hundred feet or more. Previous to the coming of the ice sheet the topography of northern Indiana was of a rather rugged type, which probably did not

differ greatly from the topography of southern Indiana. In place of this, we have now a great sheet of glacial till, which has obliterated the ancient valleys, and forms a comparatively level plain. In some sections of the northern and northeastern portions of the State morainal topography varies the general uniformity of level which prevails over much of this plain. In the western part, the gently rolling prairies of Newton and White counties merge into the extensive marshes of the Kankakee.

Randolph County attains the greatest elevation of any part of the area, the highest railroad level being 1,234.4 A. T., which is also the highest recorded elevation in the State. The southern part forms the watershed of eastern Indiana and from it streams flow in every direction. The Wabash, Kankakee and White rivers receive most of the drainage of the Niagara area.

The longer streams have excavated shallow valleys in the glacial till, most of which do not reach down to bedrock. The Wabash Valley, however, cuts through the drift at many localities, and along the upper part of its valley affords many excellent exposures of the Niagara. The Niagara also reaches the surface in Newton and Jasper counties, and in some of the counties to the southeast of the Wabash. In nearly one-half of the counties of northern Indiana, however, the drift is so deep that no outcrops of bedrock occur within them. No outcrops of paleozoic rocks are known in the tier of counties along the Michigan State line.

STRUCTURE AND CORRELATION.

VIEWS OF PREVIOUS WRITERS.

The earlier workers on the geology of Indiana generally believed the geological structure of the State to be much simpler than recent investigations have shown it to be. Their firmly rooted belief in the uniformity of the geological structure of Indiana prevented many of them from ever entertaining any explanation of the Niagara dips which would include deformation. Prof. John Collett, for many years State Geologist, says in describing Niagara beds which show dips: "The uniform undisturbed condition of the strata of this and adjoining States, will not allow the presumption of upheaval and such dislocation

of strata as would account for these phenomena.”* Starting with the assumption of the “undisturbed condition” of the strata, it is not surprising that Collett was compelled to confess in describing a locality exhibiting tilted beds, that “This quarry is a mystery.”**

It will be the purpose of the following pages to show that we have in the Niagara beds of northern Indiana a notable exception to the nearly horizontal and undisturbed condition which generally characterizes most of the other formations of Indiana. A number of theories concerning the structure of the Niagara area and the dips have been advanced, and the more important ones will be briefly reviewed.

Owen.—Richard Owen first directed attention to the tilted Niagara rocks of northern Indiana. Forty years ago Owen wrote that he had found, near Delphi, “A local dip to the southeast amounting to 40° .”† He mentioned also the sharp dips at Wabash and Huntington.

Cox.—Ten years later E. T. Cox, then State Geologist, gave a brief description of these localities, but ascribed the inclined beds to false bedding.‡

Oblique or false bedding on a large scale is an unusual phenomenon in limestones. The seas in which they are deposited are seldom sufficiently shallow to permit the action of currents strong enough to produce oblique bedding. As a possible explanation of the dip, however, the hypothesis of oblique bedding proposed by Cox requires an examination. The history of the discussions concerning the Le Claire limestone of Iowa illustrates the difficulty sometimes met with in discovering positive evidence as to the character of the bedding. Even where true bedding seems obvious, it is not always easy to discover in the strata intrinsic evidence which will entirely eliminate the possibility of false bedding being the cause of the inclined strata.

At a number of localities highly inclined beds, richly fossiliferous, have been observed in contact with barren or nearly barren beds where the evidence of tilting seemed so clear as to require no special comment but for the fact that the oppo-

* Twelfth Ann. Rep. Ind. Geol. Surv., p. 59.

** Twelfth Ann. Rep. Ind. Geol. Surv., p. 59.

† Ind. Geol. Surv. 1859-60, p. 98, 1862.

‡ Rep. Ind. Geol. Surv., 1872, p. 307.

site opinion has been held regarding them. The final test of the false bedding hypothesis comes in applying it to particular cases. Does it afford a satisfactory explanation of such examples as the following? Near Delphi a bed fifteen feet or more in thickness occurs, composed almost entirely of the shells of *Conchidium laqueatum*, one to three inches in length, which is inclined at an angle of 20° . While it is, perhaps, not impossible that such a bed should occur in false-bedded strata, it appears to the writer highly improbable. In the case, however, of strata having a dip of 70° or more, as shown in Fig. 1, oblique bedding can not be considered even as a possible explanation. The materials composing the beds, if piled in layers inclined at such a high angle, could not possibly retain their position. Deformation alone offers a satisfactory explanation for such dips.

Gorby.—In 1886, S. S. Gorby* described a considerable number of outcrops showing tilted strata, and announced that they indicated a great anticlinal, “extending entirely across the State,” which he called the “Wabash Arch.” Many of the dips recorded by the author of this hypothetical arch afford evidence against it. About half of them are east or west dips, while the supposed arch has an east and west axis which calls for north and south dips, and fails to explain the others. Phinney in discussing the “Wabash Arch” points out that the gas well records furnish evidence against it.

Phinney.—The tilted strata are, according to Phinney, due to irregularity of deposition rather than to deformation, and he states that “they are to be attributed to the building up of coral reefs and rocky prominences over portions corresponding to the dome and offshoots of the Cincinnati Arch or to inequalities in the sea bottom.”** A serious objection to the coral reef theory is the frequent absence or scarcity of corals where the dips are heaviest. Corals are not at all abundant in the Niagara of this region. They have not been observed anywhere in sufficient abundance to form reefs. While inequalities in the sea bottom may be responsible for some of the smaller undulations in the strata, neither they nor “offshoots of the Cincinnati Arch” appear to offer a satisfactory ex-

*Fifteenth Ann. Rep. State Geol. of Ind., 1886, p. 241.

**Eleventh Ann. Rep. U. S. Geol. Surv., p. 653.

PLATE X.



Fig. 1. Tilted Niagara Limestone at McKee Quarry, Kentland, Ind.



Fig. 2. Quarry East of Delphi, Showing Tilted Niagara Strata.

planation of dips of 45° to 75° in the Niagara rocks, which the accompanying photographs show.

Thompson.—Maurice Thompson considered the dip to be the result of the disturbance of beds originally horizontal. He states: "The structure of the Niagara limestone does not in the least indicate false bedding."* Thompson accepts Gorby's hypothetical "Wabash Arch," but evidently had a pretty clear understanding of the local dome-like structures in the Niagara. A summary of his views is best stated in his own words: "The arch formed by this upheaval consists of a vast series of low bubbles or cones that make the surface of the Niagara limestone somewhat like that of a sea in a brisk breeze."†

Elrod and Benedict.—In the same volume with Thompson's paper appeared a paper by M. N. Elrod and A. C. Benedict on a portion of the northern Indiana Niagara area. These authors conclude that the Niagara "cones" which they describe are the result of a variety of cleavage which simulates stratification, and cuts across the original bedding plains.

A second paper by the same authors appeared in 1894, in which they deny that there has been any tilting of the Niagara beds of the Wabash Valley.‡ Cleavage, or a "modified form of joint structure" is the explanation offered of the dips. This hypothesis would deserve careful consideration but for the testimony of the fossils. The occurrence of richly fossiliferous bands, running parallel with the so-called cleavage planes, affords conclusive evidence that they are true bedding plains.

Ashley and Siebenthal.—Dr. Ashley in his report on Newton County,§ based upon C. E. Siebenthal's notes, mentions the heavy dips at the Kentland quarry and states that "it would almost seem as though volcanic or other agencies had produced an upheaval of a kind seldom found in Nature."**

Kindle.—During the summer of 1899 the writer visited a number of outcrops in northern Indiana, and became convinced that the dips of the Niagara outcrops in northern Indiana were not

*Seventeenth Ann. Rep. Ind. Geol. Surv., 1891, p. 183.

†Seventeenth Ann. Rep. Ind. Geol. Surv., 1891, p. 185.

‡Nineteenth Ann. Rep. State Geol. of Ind., p. 22.

§Twenty-third Ann. Rep. Ind. Geol. Surv., p. 190.

**Twenty-third Ann. Rep. Ind. Geol. Surv., p. 190.

apparent but real dips. Two of the outcrops showing tilted strata which were studied were described in a recent paper.*

Extent and Composition of Beds.—The area in which rocks of Niagara age occur extends from the Illinois line in Newton County eastward nearly to the Ohio line, embracing the upper Wabash Valley. Throughout this area the strata are frequently found to be highly inclined. Highly tilted beds occur in Hamilton County, seventy miles south of the Wabash. It is probable that the Niagara rocks in the intervening territory have heavy dips at many localities, but the great thickness of the drift over this area makes it impossible to ascertain whether or not this is true.

The Niagara rocks of this region consist principally of magnesian limestone, often varying considerably in texture and composition in a short distance at the same horizon.

The principal types include dull buff dolomites, light gray sacheroidal dolomitic limestones and two or three varieties of nearly pure limestone. Beds of buffish or gray calcareous shale are sometimes associated with the limestone. Local lenses of sandstone have been observed in the Niagara limestone at some localities. One of these, near Kenneth, has a thickness of five and one-half feet, and is composed of pure white quartz sand containing only a trace of calcium carbonate and iron. The Niagara outcrops show only a small portion of the total thickness of the beds of this group, none of the sections extending down to the Lower Silurian. The information which we have concerning its thickness is derived from well records. From these it appears that the Niagara has a thickness of from 250 to 500 feet.

Correlation.—A study of the faunas of the region has shown the presence in it of faunas representing two distinct and successive epochs of the Niagara group. In a previous paper** by the author, the earlier of these faunas as represented at a typical locality was listed, and the fauna was correlated with that of the Lockport limestone of New York. The later fauna which has been recognized contains many species of the Guelph limestone fauna of Canada, which has not hitherto been known to occur in Indiana.

*Am. Journ. Sci., Vol. XIV., 1902, pp. 221-224.

**Am. Jour. Sci., Vol. XIV., 1902, pp. 221-224.

The beds holding the earlier fauna are perhaps better exposed at Connor's mill on the bank of White River in Hamilton County than anywhere else in northern Indiana. They will be called, from the township in the northeast corner of which they outcrop, the *Noblesville dolomite*. The rock is a hard, thin-bedded, buff-colored dolomite lying in strata three to ten inches thick, of which there are 25 feet or more exposed at the type-locality. Just what the total thickness is which should be included in this division of the Niagara can not be stated, since the upper and lower limits have not been seen in any single section; it is probable, however, that this formation includes not less than 100 feet of strata. Faunally the beds are characterized by such well-known Niagara (Lockport limestone) fossils as *Spirifer nobilis*, *S. radiatus*, *S. crispa* var. *simplex*, *Conchidium multicostatum*, *Sphaerexochus romingeri* etc. No trace of the Guelph fauna appears in it. The faunal affinities of the Noblesville dolomite point to its approximate equivalence with the Lockport limestone. The Noblesville dolomite is well exposed in a quarry southwest of Fishersburg and near Helm's Mill in the southeast part of Hamilton County. The faunal characters are essentially the same at both places as at Connor's Mill, but the dolomite is much softer at the latter point and lighter colored. The Niagara beds at Pendleton are of this horizon, the rock being a soft, drab dolomite, becoming shaly in places. At Delphi the Noblesville dolomite is represented by the outcrops of drab-colored dolomite in the "Old Deer Creek Channel" east of town between Deer Creek and the wagon road. These beds contain *Sphaerexochus romingeri*, *Cyrtia myrtia*, and other Niagara species without any trace of the varied cephalopod and gasteropod fauna common in the higher beds exposed in the quarries to the northeast.

In the quarries at Huntington is found a fauna of later age, and very different from that of the Noblesville dolomite. The bulk of this fauna consists of a congeries of cephalopod and gasteropod species, mostly of large size, together with a few heavy-shelled brachiopods. Only four of the fifty species of brachiopods which occur in the Niagara rocks of northern Indiana have been recognized in the collections from Huntington. Two of these are *Conchidium*s, one of which is a new species; a third is the wide-

ranging *Atrypa reticularis* and the fourth is *Dinobolus conradi*, a species common in the Guelph of Ohio. Only two trilobites have been recognized—a new species of *Encrinurus* and a large *Illæenus* comparable with *I. insignis*, which is associated with the Guelph species in Wisconsin. The cephalopod and gasteropod element of the fauna appears to be of distinctly Guelphic affinities.

This affinity is seen in the presence of *Trochoceras desplainense*, *Pragmaceras parvum*, three species of *Murchisonia*—one of which is the well known Guelph species *M. bivittata*, and other species which are represented by closely allied forms in the Guelph.

The rock in which this fauna occurs at Huntington is a light gray, or cream colored, granular dolomitic limestone of saccharoidal texture. It differs very decidedly in physical appearance as well as faunal characters, from the dull buff-colored *Noblesville dolomite*. It will be convenient to designate the beds exposed in the Huntington quarries as the *Huntington limestone*. This name was used for the same beds by Cox in the Report of this Department for 1878, p. 66. The total thickness of the Huntington limestone is not known, but it is probably not less than 150 or 200 feet. About 80 feet are exposed at Huntington.

A magnesian limestone similar in physical and faunal characters is seen in the lime quarries northeast of Delphi. The fauna of the *Huntington limestone* at Delphi, as at Huntington, is essentially a cephalopod and gasteropod fauna. Of the eight species of brachiopods recorded from it, four are forms having strong Guelph affinities; these are *Monomorella* sp., *Trimerella* sp. and two varieties of *Pentamerus oblongus*. The latter species, although occurring in the earlier Niagara fauna in New York, is a common form in the Guelph of Ohio and does not appear in the fauna of the *Noblesville limestone* in Indiana.

In the case of the localities which have been mentioned in connection with the *Noblesville dolomite* and the *Huntington limestone*, the correlations which have been made are based upon paleontological and lithological data, which appear to be entirely adequate. There are, however, many localities where a scarcity of fossils, or variability of lithologic features have made it impossible in the rapid survey which circumstances necessitated, to secure satisfactory data for correlating the beds with either of the divi-

sions of the Niagara which are here recognized. For this reason the broader term, Niagara limestone, has been generally employed.

Structure.—The general structure of the Niagara beds of northern Indiana is that of a broad arch with gently sloping sides trending northwest and southeast. It represents a northwestern extension of the Cincinnati geanticline. Its axis, approximately located, enters the State near Richmond, and passes northwesterly in the vicinity of Muncie, Marion and Peru, and continues north of the Wabash through Cass, White, Jasper and Newton counties into Illinois. On the two sides of this line of maximum elevation of the Niagara the Devonian and Carboniferous rocks dip in opposite directions; in Michigan and Ohio, toward the north and northeast; in Indiana, toward the southwest or south. The following table shows the elevation of the surface of the Niagara A. T. along a line approximately at right angles to this axis extending from Crawfordsville to Auburn, Indiana, a distance of 140 miles.

*Crawfordsville	81 A. T.
Frankfort	463
Kokomo	778
Wabash	652
Columbia City	599
Auburn	50

The arch described above is not the "Wabash Arch" of Gorby, which apparently was supposed by its author to follow the Wabash Valley in eastern Indiana. The tilted beds which were cited as the evidence of the "Wabash Arch" will be shown in another part of this paper to be independent of the above described arch in origin.

Dips.—A large percentage of the outcrops throughout the Niagara area is characterized by dips of from 5° to 80° . In a few instances the dips represent cleavage planes. In one case (at the Means quarry, Newton County) both cleavage and bedding planes are well defined and nearly at right angles to each other, both being inclined at a high angle to the horizontal. A few localities have also been noted where the dip is the result of irregular or false bedding. But the great majority of the dips can be referred to neither of these causes. They are clearly the result of the deformation of strata which were originally horizontal.

*The figures given above are based upon gas well records published in the 16th Ann. Rep. Ind. Geol. Surv., pp. 217-268.

A brief study of the tilted beds will suffice to show that they are not referable to ordinary anticlines. A description of the beds near Kentland will illustrate this. At the Means quarry (N. E. of N. W. of sec. 25) the rock is a hard gray limestone, very fine grained, in strata 3 inches to 25 inches in thickness, dipping N. 60° to 65° , with strike of N. 82° E. At the McKee quarry, less than half a mile to the east, the strata dip 70° to 75° toward the east, with a strike of N. 12° W., or nearly at right angles to the strike at the Means quarry.

Numerous exposures of the Niagara limestone occur near Delphi, which show dips of from 10° to 45° . The dips here, like those at Kentland, do not conform to an anticlinal structure, but appear to be quaquaversal.

Domes.—At Wabash a fine exposure of the Niagara occurs near the railroad station which affords a key to the puzzling dips at Kentland and other points where only small exposures can be seen. A railroad cut has exposed a cross-section through the center of a small dome in the Niagara limestone and shale. In passing through the cut the beds are seen dipping in all directions from the center. On the northeast, east and south of the dome, the Wabash River has denuded the dome of superficial deposits and the beds are seen dipping sharply in these several directions as shown in the accompanying photographs. At the south end of the cut the strata dip 25° to 30° S. 40° W. Toward the north end of the cut they are seen dipping to the northwest and north. On the east side the dips are east and southeast. The width of the dome from north to south exposed in the cut is about 840 feet. A portion of the south side of the dome has been removed by erosion. It is estimated that the total north and south diameter has been about 1,150 feet. The excavation for the railroad gives a continuous exposure of the Niagara shale and limestone for half a mile from the center of the dome. The dips of the beds going north from the center of the dome are observed to drop down gradually from a maximum of 30° to perfectly horizontal beds. No dip or other disturbance is noticeable in the half-mile exposure north of the dome.

A group of small domes occur in the Wabash Valley near Lagro. One of these, known as the Hanging Rock, is situated about one mile southeast of Lagro. It consists of a mass of limestone and

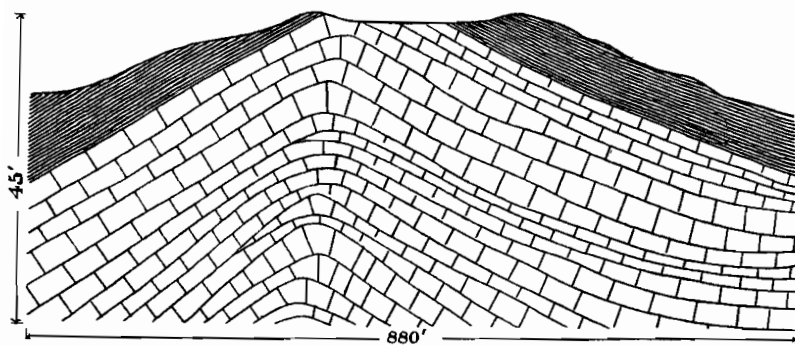


Fig. 3. Cross Section of Wabash Dome.

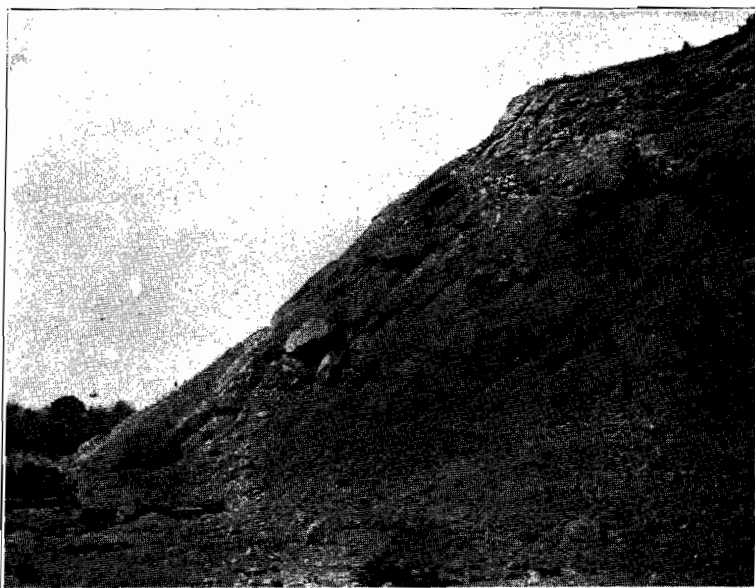


Fig. 4. East Side of Wabash Dome; Strata Dipping East and Southeast.

shale which rises abruptly from the bank of the Wabash River to a height of about 80 feet. The beds exhibit quaquaversal dips and represent a part of the dome the north and east sides of which have been cut away by the river. The upper beds dip to the south and west at an angle of 25° . The lower strata are less inclined.

At Huntington a large area of Niagara limestone is exposed at the quarry one mile east of town. The beds here exhibit quaquaversal dips and indicate a dome having its center within and near the east side of the area exposed by the quarry. The highest dips noted here are 35° or 40° . The exposures are not sufficiently extended to determine the exact diameter of the dome, but from the horizontal strata exposed in nearby outcrops, it is probable that it does not exceed 2,000 feet. At the old quarry, a quarter of a mile northeast, the strata are horizontal.

The quaquaversal dips show a general tendency to drop rapidly from a high inclination to nothing. This is noticeable at the quarry half a mile west of Huntington. The beds in the new quarries on the north side of the railroad show a dip of 25° to the south, while the strata in the old quarry, not more than 100 yards away, show dips of from $1\frac{1}{2}^\circ$ to 0. It was doubtless the proximity of outcrops showing highly tilted strata to those of horizontal beds which led Owen* into the error of reporting tilted Devonian rocks at Huntington resting unconformably on horizontal Niagara beds. There is no evidence of either Devonian beds or unconformity in the vicinity of Huntington.

It has been shown that the dips observed in at least three localities are quaquaversal and the expression of dome structure. Nowhere in the area does the strike and dip of the beds conform to an anticlinal or synclinal structure. The dips seem everywhere to be quaquaversal, and it is believed that all of the tilted Niagara beds of northern Indiana represent small domes similar to those at Huntington and Wabash.

Origin and Age.—There is at present no positive evidence as to the nature of the forces which produced the domes. It seems probable, however, that they may be analogous in origin to the "mud lumps" at the mouth of the Mississippi. From a recently

*Ind. Geol. Surv., 1859-60, p. 66.

published description of the "mud lumps," they appear to have a similar structure to the Niagara domes. Harris has studied these interesting masses of recently elevated sea-bottom and states, "that they rise up in domes or anticlinals and preserve their regular bedding is proven by their present structure."

Whatever the causes may have been which produced the domes, there is clear evidence that they were developed about the close of the Niagara period. Many of them were elevated above the Paleozoic sea, while others probably did not reach its surface. Some of the domes remained above sea level during a considerable portion of the Devonian age, and there is some evidence that others continued as islands to the end of Devonian time. The evidence of the exposures indicates that the gradual deepening of the Devonian sea which initiated the "Black shale" sedimentation submerged some of the Niagara domes which had remained above sea level throughout the Corniferous and Hamilton epochs. These conclusions are based upon the relations which have been observed to exist between the Devonian and Niagara beds at Delphi, Georgetown, Kentland and other localities. At Georgetown the horizontal Corniferous limestone beds rest on Niagara beds showing a small dip, but there is no evidence of land surface conditions having existed previous to the Corniferous sedimentation.

Near Delphi, at one locality, horizontal beds of Hamilton age lie unconformably above the Niagara limestone, which shows a dip of 45° ; a bed of ferruginous clay and iron ore separates the two. The New Albany shale is seen resting on the Niagara at another locality near the one last mentioned, the ferruginous clay separating these two as in the first instance.

The highly tilted beds near Kentland occur on high ground in the open prairie, remote from any stream. Rocks of later age have been encountered at much lower levels in all directions from this point, within two or three miles, and it appears probable that the Kentland dome remained above sea level until the end of the Devonian or later.

The occurrence of outliers of Mansfield sandstone (Pottsville conglomerate) in the center of the Niagara area of northwestern Indiana near Remington and Jasper indicate that a subsidence occurred after the formation of the Niagara domes in northwestern Indiana which submerged all or nearly all of the Niagara area

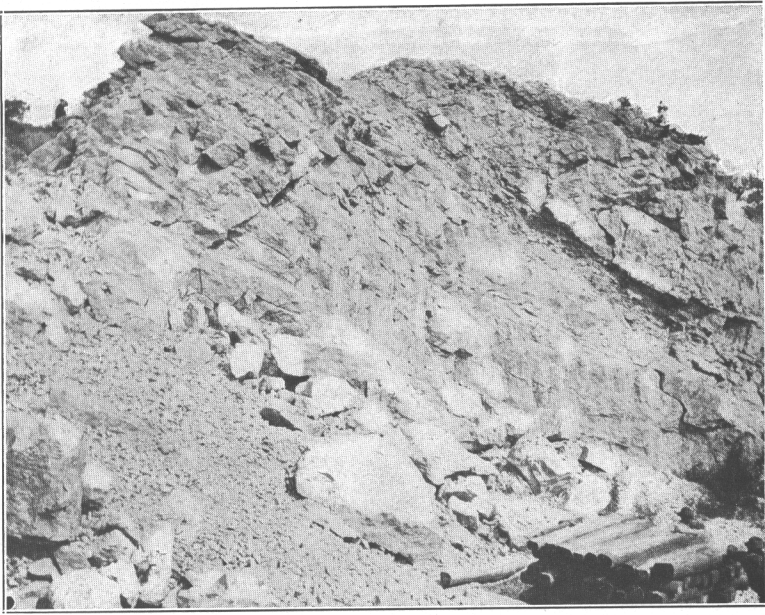


Fig. 5. Northeast Part of Wabash Dome; Strata Dipping Northeast.

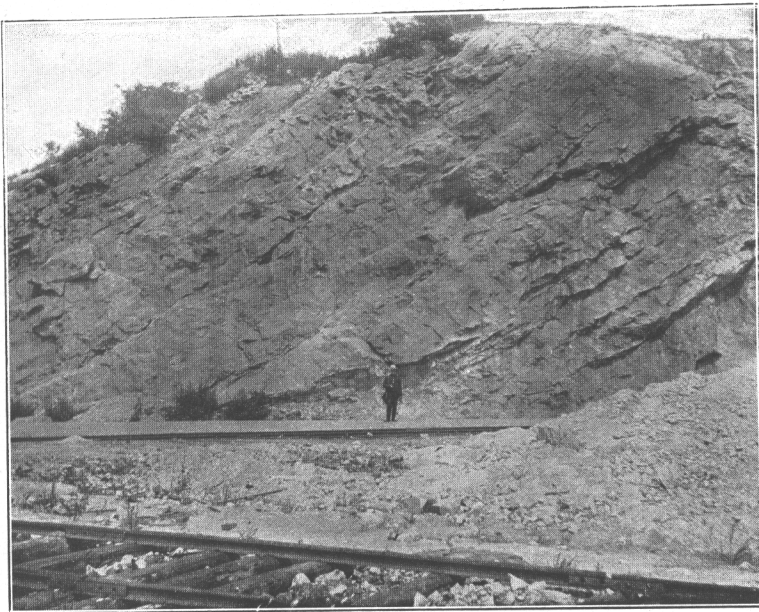


Fig. 6. Southwest Part of Wabash Dome; Strata Dipping Southwest.

of that region beneath the Carboniferous sea. The development of the present Niagara arch in northwestern Indiana was, therefore, of much later date and independent of the formation of the Niagara domes. While the domes date back to the end of the Niagara, the Niagara arch is of Carboniferous or post-Carboniferous age.

The Niagara-Devonian unconformity which has been described, though much more pronounced, may be correlated with that which has been recognized in Shelby County,* Indiana, and with the slight unconformity between the Devonian and Upper Silurian which has been recorded by Newberry,† on the east side of the Cincinnati geanticline. The evidence at hand points to a general elevation of the sea bottom at the close of the Niagara in the area around the northern end of the Cincinnati geanticline. The resulting shallow sea was doubtless an important factor in the sudden disappearance of the Niagara fauna and the substitution of the corraline fauna of the Corniferous.

AREA NORTHWEST OF THE WABASH.

Newton County.—The Niagara limestone outcrops at two localities in Newton County. One of these is one mile northwest of Goodland, and the other is about three miles southeast of Kentland. Elsewhere in this county the bedrock is deeply covered by the drift with the exception of localities in section 25, T. 27 N., R. 8 W., where Collett reports outcrops of the Lower Carboniferous.‡

The Niagara limestone has been quarried in a small way northwest of Goodland in the S. E. of the N. W. quarter of section 22. At the time of my visit the quarry was filled with water and only the uppermost layers of the rock were visible. These show a rather soft, buff magnesian limestone. It is too soft to make a very good "road metal" but has been used to some extent in road building and also for foundation work. The strata appear to lie horizontal and are covered by three or four feet of surface clay and soil. The same rock is struck in ditching a few hundred yards to the northwest of the quarry. On the Blough and Conway farms,

*Twenty-fifth Ann. Rep. Ind. Geol. Surv.

†Geol. Surv. of Ohio, vol. I, p. 106.

‡Twelfth Rep. Ind. Geol. Surv., 1882, pp. 59-60.

which are near the quarry, bed rock is encountered in shallow excavations. Apparently the Niagara limestone approaches very near the surface over an area of several hundred acres in sections 22 and 15 T. 27 N., R. 8 W. Fossils are very scarce, but sufficient fragmentary material was secured to indicate the Niagara age of the bed.

Three miles southeast of Kentland, in section 25, the Niagara limestone outcrops on the highest ground in the vicinity. The limestone here approaches very near to the surface over an area of more than one hundred acres in sections 24 and 25. In the surrounding country bedrock is seldom found in wells nearer the surface than fifty feet, and frequently it lies at more than twice that depth. The quarries have been opened at points where the rock outcrops or reaches to within a few feet of the surface. The McKee quarry is the most easterly of these and gives the best exposure of the rock. It is located in the N. E. quarter of section 25, T. 27 N., R. 9 W. In the vicinity of the quarry the limestone outcrops or comes within a few inches of the surface for two hundred yards in a direction corresponding with the strike. The strata dip 70° to 75° toward the west, with a strike of N. 12° W. magnetic. A thickness of about 50 feet is exposed in the quarry. On the east side the rock is a hard gray limestone with a semi-lithographic texture and breaking with a conchoidal fracture; cone-in-cone structure is developed in some of these strata. The texture of the stone changes gradually toward the center of the quarry, and on the west side the beds are composed of soft buff magnesian limestone. A large amount of stone has been quarried here and crushed for road building. The harder beds furnish an excellent stone for this purpose.

A low mound which rises perhaps twenty feet above the strip of prairie separating it from the McKee quarry lies about one-fourth of a mile to the northwest of the latter. Hard gray limestone outcrops along the top of this knoll. The strike here is nearly north and south, but the exposure was not sufficient to measure the amount of dip, which appears to be nearly 90° . The Fidelity Insurance Company is opening a quarry at this locality for the purpose of supplying material for road building. The rock is a very tough, hard limestone of excellent quality for this purpose.

About 300 yards west of the Fidelity Insurance Company's quarry, a quarry has been operated on the farm of Mr. S. A. Means for a number of years. The rock here is similar in appearance to that at the McKee quarry; the dip is 60° to 65° to the north, strike N. 82° E. The strata are in layers 3 to 25 inches in thickness. In one part of the quarry a system of cleavage planes, somewhat resembling bedding, have been developed nearly at right angles to the true bedding. These were doubtless developed by the pressure which produced the heavy dip seen here. Fossils are scarce, but more common than at the other quarries.

Deep wells at Kentland and other points within a few miles to the west, northwest and southwest reach the New Albany shale at depths varying from 80 to 180 feet below the surface.* The top of the New Albany shale at some of these wells is more than 100 feet lower than the Niagara at the McKee and Means quarries. The outcrops of the New Albany shale on Carpenter's Creek, a few miles to the northeast, are also lower. Rocks of Carboniferous age lie at a lower level two miles south of the McKee quarry. This would indicate that the Niagara and Devonian are unconformable in Newton County, as they have been shown to be in the Wabash Valley. The relations observed indicate one or more Niagara domes whose summits and sides remained above the sea during Devonian sedimentation and probably through a part of Carboniferous time.

Jasper County.—The principal outcrops of the Niagara limestones occur along the Iroquois River in the vicinity of Rensselaer. Bed rock, which is probably of Niagara age, is also reported in the bed of the Pickamink River. High water covered these outcrops, as well as most of those in the vicinity of Rensselaer at the time of my visit. The beds which could be examined were composed of hard, gray magnesian limestone of good quality for road building.

Collett† reported Devonian limestone overlying the Niagara at the dam in Rensselaer, but this bed was not exposed at the time of my visit.

Niagara beds reach the surface in the highway near the center

*Collett, 12th Ann. Rep. Ind. Geol. Surv., pp. 53-56. Collett, 23d Ann. Rep. Ind. Geol. Surv., p. 187.

†Twelfth Rep. Ind. Geol. Surv., p. 71.

of section 29, six and a half miles east of Rensselaer, and also at Pleasant Ridge station. The Niagara holds a small amount of petroleum in some localities. In section 35, T. 29 N., R. 6 W., a well 35 feet in depth, on Andy Yoeman's farm, furnishes a small amount of dark lubricating oil.

In the south part of the county the New Albany shale outcrops at intervals for more than three miles along Carpenter's Creek. The "black shale" outcrops begin at Remington, where it forms the bed and sides of the stream, exposing a thickness of 15 feet of bluish black to drab shale. In descending the stream the New Albany shale outcrops are interrupted in the north part of section 24 by exposures of the Mansfield sandstone ("Millstone grit") which forms the bed and sides of the creek at the wagon bridge, three-quarters of a mile northwest of Remington. At this point the creek flows through a post-glacial gorge in this formation. The rock is a coarse buff sandstone, locally conglomeritic, the pebbles varying in size from buckshot to hickory nuts. Geodes five to six inches in diameter occur in it. About forty rods below the bridge the New Albany shale again appears in the bed and sides of the stream. At the forks of Carpenter's Creek the Mansfield sandstone outcrops on the east side of the stream and the New Albany shale on the west side. Further down the stream the two formations may be traced to within a few yards of each other at the same level, but the contact of the two was not observed. The relationship to each other of the outcrops described above seems to indicate that the two formations are unconformable. Apparently the Mansfield sandstone has been deposited in an old valley of erosion in the Devonian shale.

White County.—The only outcrops of the Niagara limestone in this county known to the writer occur along Monon Creek. It is well exposed in the bed of the stream just west of the railway at Monon. Both the New Albany shale and the Devonian limestone outcrop at much lower levels a few miles to the southeast. These have been described by the writer in a previous paper.²² The outcrops at Monon apparently represent one of the Niagara domes. Collett recognized the quaquaversal character of the dips here and stated that "the strata seem to dip from this point in

²²Twenty-fifth Ann. Rep. Ind. Geol. Surv., p. 562.

almost every direction.”* The limestone at Monon has been used to some extent for making lime.

Four miles northeast of Monon, the Big Monon Ditch cuts through the Niagara limestone for 3,300 feet. The beds here show a dip of from 30° to 45° toward the southwest.

Just west of Wolcott the Mansfield sandstone approaches the surface. It is extensively quarried for glass making in the S. W. quarter of section 25. The section exposed in the quarry shows:

Surface clay	6 ft. 8 in.
Light bluish gray, coarse sandstone with coarse quartz pebbles scattered through it.....	25 ft.

The sandstone is very friable, and in a part of the quarry is but little more than an unconsolidated sand.

WABASH VALLEY.

Carroll County.—No other county offers so good an opportunity to study the relationship between the Niagara and the Devonian rocks as Carroll. Both the Devonian and the Niagara are well exposed in the vicinity of Delphi. The Niagara limestone is a magnesian limestone, buff or gray, usually very hard, but sometimes showing soft beds.

At the mouth of Little Rock Creek, in the northeast part of the county, the lower division of the Devonian limestone (“Corniferous”) is seen resting on the Niagara limestone. Both appear to be horizontal at this point. One mile below this the Niagara limestone outcrops opposite Lockport in the banks of the Wabash. Here the beds show a northwesterly dip of 35°. They show a light gray ragged looking limestone, splitting into irregular fragments by frost action.

At Delphi the Niagara limestone is well exposed in the old Deer Creek channel on the northeast side of town. Just south of the Monon railway in the quarry a thickness of 150 feet is exposed. This is the greatest thickness which has been observed in any single section in the county. The dip here varies from 30° to 40°. This series of beds belongs to the Huntington limestone formation. The Noblesville dolomite is represented by outcrops

*Rep. Geol. Surv. Ind., 1872, p. 303.

between the highway south of the quarry and Deer Creek. Above the upturned edges of the Huntington limestone rests a thin bed of impure Devonian limestone of Hamilton age. A bed of iron ore and red clay eight or ten inches thick lies between the two unconformable beds. In the railroad cut just north of the city high school building the unconformity of the Niagara and the Devonian may also be seen, a thin bed of ferruginous clay separating the two as at the quarry section. In the latter case, however, the Devonian is represented by the New Albany shale, the Niagara at this point having evidently remained above the Devonian sea until the beginning of the New Albany shale epoch or later.

At the lime quarry of Harley Brothers the Niagara limestone shows dips of 10° to 15° , mostly toward the south, although the direction of dip tends to swing round toward the west in the north part of the quarry.

In the quarry one-half a mile northeast of the Harley Brothers' quarry the beds dip 20° to 30° toward the northeast.

The Niagara limestone at Delphi makes an excellent lime and is extensively quarried and burned for this purpose at the above mentioned quarries. Lime was formerly burned from outcrops near the river west of Delphi, but the kilns there have been abandoned.

In Carrollton township the Niagara beds reach the surface in the bed and sides of Little Deer Creek, about 200 yards above its junction with the north fork of Deer Creek. The limestone here is a light gray crystalline rock, apparently containing but little magnesia.

Cass County.—Nearly all of the outcrops of bedrock in this county are confined to the bluffs of the Wabash River; the exceptions being those along Pipe Creek and in the vicinity of Adamsborough and Logansport. The Niagara limestone outcrops at very frequent intervals along the Wabash from the Carroll County line almost to Miami County. Small patches of Devonian limestone of Corniferous age occur, but less frequently.

The irregular manner of occurrence of the Devonian outcrops is due to the unconformity existing between the Niagara and Devonian beds. Many outcrops of the latter appear to have been deposited in depressions of the Niagara limestone. An example

of this is seen in the Devonian limestone which forms the bed of the Wabash one-half mile below Georgetown. The Niagara limestone rises from 10 to 20 feet above the bed of the river immediately above and below this point. Just below Georgetown both the Niagara and the Devonian are exposed on each side of the river. From five to eight feet of gray, crystalline Devonian limestone rests unconformably on the Niagara. The line of contact between the two is an irregular one, frequently rising or sagging. On the east side of the river the Niagara dips from eight to sixteen degrees to the east, while the Devonian limestone lies horizontal above it.

At Logansport, the Niagara limestone forms the bed of the Wabash. The Devonian limestone appears above it at a number of points in and near the city. It caps the knoll on which the hospital for the insane is located, and outcrops over sixty acres or more in section 2, southeast of the city. At the last named locality it is quarried and burned for lime by Mr. Harry Lux. It makes a superior quality of lime, which is free from magnesia and whiter than the lime from the Niagara dolomite.

The extensive outcrop at the upper Eel River dam in Logansport shows the following section:

1. Gray limestone (Devonian).....3 ft. 4 in.
2. Bluish clay shale.....2 to 3 in.
3. Hard gray limestone breaking with conchoidal fracture (Niagara)2 to 4 ft.

The Niagara beds in Cass County exhibit three well marked varieties of limestone: (1) a hard gray, fine-grained limestone, breaking with conchoidal fracture; (2) a crystalline or semi-crystalline, moderately soft rock, and (3) a buff or gray, evenly bedded magnesian limestone, usually with saccharoidal texture. These three appear to represent local varieties of the same beds. The exposure in the banks of the Eel and the Wabash rivers at Logansport are mostly of the first class. An interesting lens of very pure white, fine-grained sandstone about six feet thick, occurs in the hard gray limestone below Kenneth about half a mile. The lateral extent of the bed is not known, as only a single exposure has been seen at the head of a small ravine entering the Wabash from the north. The stone will make an excellent glass sand.

The second variety of limestone is seen in the outcrops one-half mile above Georgetown, on the north bank of the Wabash, and at a few other localities. These limestones were formed under conditions favorable to molluscan life and contain an abundance of fossils.

The beds which are so extensively quarried at Kenneth belong partly to the third class.

The section exposed in the quarry north of Kenneth Station is as follows:

- | | |
|--|------------|
| 1. Clay and soil..... | 6 to 8 ft. |
| 2. Blue limestone | 20 ft. |
| 3. Buff magnesian limestone in strata 10 to 4 in.
thick | 30 ft. |
| 4. Thin bedded bluish-gray limestone..... | 10 ft. |
| 5. Heavy bedded dark gray limestone..... | 20 ft. |

The beds lie nearly horizontal, showing only slight wavy undulations.

A small amount of number three is used for dimension stone; the remainder is used by the Chicago Steel Company as a flux. Several hundred carloads per week are shipped for this purpose. The blue limestone (No. 4) contains a few fossils, but the other beds are almost entirely barren.

In the quarry on the south side of the railroad near Kenneth, which was formerly operated by Harry Lux, the beds exposed are similar to those of the above section.

At Keesport, three and a half miles east of Logansport, the Niagara limestone is quarried and burned for lime.

Miami County.—Both the Devonian and Niagara limestones outcrop on Pipe Creek, near Bunker Hill. Elsewhere in the county the Niagara beds are the only beds outcropping. They show numerous exposures along the Wabash near Peru, and in the bluffs of the Mississinewa River the outcrops are almost continuous from the county line to its mouth. At the old limekiln, one mile above Peru, the Niagara limestone shows a dip to the west of 28°. Some very irregular dips are exposed in a small quarry on the south bank of the Wabash, one-half mile above the railroad bridge, which are due to false bedding.

The limestone is quarried from the bed of the river at Peru, and various small quarries have furnished rock for foundation

work. Much of the stone is of a poor quality. It has been burned for lime one mile above Peru.

Wabash County.—The Niagara limestone outcrops in great force along both the Wabash and the Mississinewa rivers. At most of the exposures along the latter stream the beds lie nearly horizontal, but inclined beds occur at a few localities. At the mill dam one mile above Somerset a small stream enters the river, exposing in its bed and sides the highly inclined beds of the Niagara dipping toward the north at an angle of about 30°.

The Wabash crosses the county from east to west, flowing in a valley which, in many places, has been cut into the Niagara rocks. The bluffs, 40 to 80 feet high, which border the valley, afford many good exposures of the Niagara beds. The domes which interrupt the otherwise horizontal beds of the Niagara limestone at many points along the Wabash constitute the most interesting feature of the geology of this county. These have been described in another section of this paper. The occurrence of a group of these domes in the flat plain of the Wabash near Lagro is doubtless due to the fact that their development elevated beds of limestone offering considerably more resistance to erosion than the softer Niagara shales in which the lower levels of the Wabash Valley are excavated.

The exposure at the Wabash dome in Wabash affords the longest continuous section noted in the county. It is as follows:

1. Drab gray calcareous shale..... 45 ft.
2. Bluish gray to buff limestone..... 4 to 10 ft.
3. Bluish shale 7 ft.
4. Buff dolomitic limestone..... 75 ft.

In some sections a bluish calcareous shale or hydraulic limestone is exposed. This is seen at the base of the Hanging Rock section. It is said to make a good cement and has been used for that purpose. The limestone at Wabash is extensively quarried for flagstone and foundation stone.

Upper Wabash Valley.—Above the Wabash and Huntington County line outcrops cease along the river for about seven miles. Near the forks of the river they reappear, and for more than four miles the Niagara limestone appears at numerous exposures in or near the banks of the Little Wabash. For some distance above

Huntington the channel of the stream is cut in the Niagara limestone. The beds show heavy dips at Huntington which have been described in another part of this paper. The limestone at Huntington makes an excellent quality of lime and is extensively quarried and burned for that purpose. The chemical composition of the stone used for lime is shown in the following analysis:*

Water at 212°.....	0.50
Silicic acid	1.50
Lime	31.92
Magnesia	7.58
Alumina and ferric oxide.....	8.25
Carbonic anhydride	49.52
Sulphuric acid	0.34
Loss	0.39
	100.00

Prof. E. T. Cox refers to the "Corniferous epoch" a bed of sandstone at Huntington. He states that "in Huntington County it forms the upper fifteen inches, close grained and loosely coherent." The bed referred to is probably a thin bed which appears in the quarry just west of Huntington. This bed lies between strata of Niagara limestone and is tilted with them at an angle of 25°. While no fossils were noted in it, its position between beds of Niagara limestone show it to be a local sandstone lens in the Niagara.

Occasional outcrops of the Niagara limestone occur along the south or main branch of the Wabash as far east as the State line. At Markle, Buena Vista and other points, the limestone has been quarried for local use. The exposures near Markle show highly tilted beds.

The Niagara limestone does not outcrop in the vicinity of Decatur, but it is extensively quarried after removing the 15 to 20 feet of drift clay and sand. The quarry at the north side of town shows the following section:

1. Surface clay and gravel..... 19 ft.
2. White, soft, thin-bedded saccharoidal limestone..... 8 ft.
3. Heavy-bedded, white saccharoidal limestone..... 15 ft.

*Geol. Surv. of Ind., 1878, p. 60.

The section exposed in the J. S. Bowers quarry, one-third of a mile northwest of Decatur, is as follows:

1. Gravel and clay 20 ft.
2. Dark gray, very hard saccharoidal limestone with frequent patches of chert in the strata in layers of 5 to 18 in. thick..... 20 ft.

The contrast in color and texture between the limestones at these two quarries is most marked, but they probably expose beds of the same geological horizon and the differences doubtless represent local variations of the stone. The white stone is easy to work, and has a handsome appearance when dressed.

AREA SOUTH OF THE WABASH.

Hamilton County.—This county is located slightly north of the geographical center of Indiana. The drift in this part of the State is so deep that the Paleozoic rocks are rarely exposed at the surface. Only a few outcrops occur in the county. The most extensive exposure is the one at Connor’s mill on White River, five miles above Noblesville. Two small quarries southwest of Fishersville afford an equally good opportunity to study the Paleozoic rocks of the county. Several days were spent by the writer in collecting from the beds exposed at these two localities.

Connor’s Mill.—The outcrop at Connor’s mill consists of a hard, light buff dolomite, which is exposed for two or three hundred yards below the dam. The beds show a dip of from 20° to 40° to the southwest. Above the dam one-third of a mile the limestone outcrops again, dipping 30° to the northwest.

The following is a list of fossils collected from beds exposed below the dam:*

- Favosites favosus* f.
- Streptelasma cf. calicula* f.
- Amplexus shumardi* f.
- Eucalyptocrinus cf. crassus* f.
- Conchidium multicosatum* a.
- Conchidium sp.* f.

*The list here given is a revision of a preliminary list published in the Am. Jour. Sci., Vol. XIV, 1902, pp. 221-224.

<i>Atrypa reticularis</i>	c.
<i>Strophonella williamsi</i> n. sp	c.
<i>Leptaena rhomboidalis</i>	c.
<i>Meristina maria</i>	f.
<i>Spirifer nobilis</i>	f.
<i>Spirifer</i> cf. <i>crispa</i>	f.
<i>Dalmanella elegantula</i>	f.
<i>Plectambonites</i> cf. <i>sericeus</i>	f.
<i>Conocardium</i> sp	f.
<i>Platyostoma</i> cf. <i>niagarensis</i>	c.
<i>Spherexochus romingeri</i>	a.
<i>Calamene vogdesi</i>	c.
<i>Ulaenus insignis</i>	c.
<i>Phacops</i> cf. <i>pulchellus</i>	c.
<i>Encrinurus americanus</i> n. sp	c.

Fishersburg Quarries.—Southwest of Fishersburg one-half mile a very pure, white sandstone has been quarried for glass making. It is a fine-grained, massive, loosely cemented rock, crumbling easily. A buff dolomite, having the same lithological characteristics as the outcrop at Connor's mill, rests upon the sandstone. The line of contact between the two formations is clearly shown in the quarry, and is seen to be a very irregular one, resembling unconformity. The sandstone is believed, however, to be a local lens. Such lenses are known at other localities in the State where both the upper and lower contact with the Niagara is clear. The limestone on either side of the projecting mass of sandstone extends below the surface of the pool which fills the quarry. The limestone beds show a dip of about 35° to the north.

The following section is exposed at the east pit:

1. Surface clay 2 ft. to 18 in.
2. Buff magnesian limestone 1 ft. to 0
3. Hard, fine-grained white sandstone..... 5 ft.

A careful search failed to discover any fossils in the sandstone.

The fauna of the limestone, as well as its physical characters, indicate that it belongs to the same formation as the beds at Connor's mill.

A comparatively short time was spent in collecting from the Fishersburg quarries, and for this reason the following list of fossils from that locality include fewer species than the preceding list:

<i>Streptelasma cf. calicula</i>	f.
<i>Favosites niagarensis</i>	c.
<i>Spirifer cf. radiatus</i>	f.
<i>Conchidium multicostratum</i>	a.
<i>Reticularia sp</i>	f.
<i>Orthothetes subplanus</i>	f.
<i>Stropheodonta sp</i>	c.
<i>Meristina maria</i>	c.
<i>Nucleospira pisiformis</i>	f.
<i>Leptaena rhomboidalis</i>	f.
<i>Spirifer nobilis</i>	f.
<i>Iliaenus insignis</i>	f.
<i>Sphærexochus romingeri</i>	f.
<i>Phacops cf. pulchellus</i>	f.
<i>Encrinurus americanus n. sp</i>	f.

In the southwest part of the county the Niagara dolomite comes near the surface in sections 5, 6 and 32 on the north side of the Fall Creek. A small outcrop of hard gray limestone occurs at the roadside about one-half mile northeast of Helm's mill. Just north of this a small amount of stone has been quarried on Samuel Patterson's land. The quarry has not been worked recently, and only ten inches of buff dolomite are exposed.

A small amount of stone for local use has been quarried in the southwest quarter of section 32, T. 17 N., R. 6 E. The excavation exposes about two feet of thin-bedded, light orange colored magnesian limestone with from two to four feet of striping.

Outcrops were reported along Duck Creek by Brown,* but a careful search failed to locate them.

Correlation.—Richard Owen described the outcrop at Connor's mill in his report published in 1863,† but offered no opinion as to the age of the bed. The earliest reference to the age of these beds occurs in a report on the geology of Hamilton County** by Dr. R. T. Brown, who considered them to be of Devonian age. No paleontological evidence was offered in support of this opinion, the author of the report stating that "the outcrops of rock in Hamilton County are quite barren of fossils." In 1901 the limestones at Connor's mill and near Fishersburg were referred by the writer‡ to the Niagara, but the paleontological evi-

*Rep. Ind. Geol. Surv., 1884.

†Rep. Ind. Geol. Surv. for 1859-62, p. 102.

**Fourteenth Ann. Rep. Ind. Geol. Surv., 1884, p. 27.

‡Twenty-fifth Ann. Rep. Dep. Geol. and Nat. Res. Ind., p. 599.

dence for this determination was not given. The faunal lists here given clearly show the Niagara age of these beds. The Lockport (Niagara) limestone is their probable equivalent in the Niagara group. As stated on a preceding page the local name Noblesville dolomite has been given to these beds.

The Hamilton County outcrops are the most southern exposures in the State which show highly tilted Niagara strata. The orogenic disturbances, which caused a general tilting of the Niagara rocks in northern Indiana previous to the beginning of Devonian sedimentation, did not affect the southern portion of the State, where they lie nearly horizontal, and are conformable with the Devonian rocks. North of the Ohio River eighty miles the Niagara rocks are slightly unconformable with the Devonian,* but nearly horizontal. The Devonian rocks have not been observed in contact with the Niagara in Hamilton County, but it is very probable that they are unconformable, as they have been shown to be farther north in the Wabash Valley.

Madison County.—The Niagara beds outcrop at three points on the south bank of Fall Creek in the town of Pendleton. These are at the lower edge of town, at the foot of the fall, and on a knoll 200 yards below the fall. The formation is represented at the foot of the fall by a bluish drab calcareous shale or fine-grained sandstone, above which rests the massive Pendleton sandstone (Devonian). The section at the fall is as follows:

1. Hard gray limestone.....	3 ft. 6 in.
2. Heavy bedded white sandstone.....	6 ft. 8 in.
3. Bluish drab, fine-grained calcareous sandstone or shale	10 in.

The beds exposed 200 yards below this section are composed of buff to ash colored soft magnesian limestone and lie at nearly the same elevation or a little higher than the Devonian beds of the above section. It was doubtless the relative elevation of the Devonian and Niagara beds which led Cox† into the error of placing the latter above the Devonian sandstone and limestone in his section of the Pendleton rocks. The buff dolomite contains *Sphaerexochus romingeri*, *Spirifer niagarensis* and other Niagara

*Kindle, 25th Ann. Dept. Geol. and Nat. Res. Ind., p. 559.

†Eighth Ann. Rep., Ind. Geol. Surv., 1879, p. 60.

fossils in considerable abundance, and belongs to the Noblesville dolomite formation. The beds appear to lie horizontal. The occurrence of Devonian beds at a lower level than the Niagara, in outcrops so near those of the latter, is doubtless due to unconformity.

Niagara limestone of the hard, gray facies outcrops on Foster's Branch four miles below Pendleton. On the north bank of Fall Creek north of Alfonte it is extensively burned for lime.

About two miles west of the Anderson courthouse a quarry has been opened in the Niagara beds on the south bank of White River. The rock is a drab colored limestone, very shaly, and most of the beds are of little value for dimension stone. This quarry has furnished a considerable amount of macadamizing material.

Other points where Niagara limestone has been quarried in Madison County are near Frankton on Pipe Creek and two miles northeast of Frankton, in section 33, T. 21 N., R. 7 E.

Other Outcrops.—A single outcrop of the Niagara is known in Henry County. At the Quarry mills, three miles southwest of Greensborough, limestone was formerly quarried and burned for lime. All that can be seen of the bed at present is about two feet of shaly, bluish-gray limestone near the old limekiln. The foundation of the mill is constructed of this stone.

In Grant County numerous outcrops of the Niagara limestones occur along the Mississinewa River below Marion.

Niagara beds are said to outcrop in the bed of White River above Muncie, but they have not been seen by the writer. Mr. Charles Gough, County Surveyor of Delaware County, states that bed rock lies within a few feet of the surface in the following sections:

Section 14.....	Township 20.....	Range 10 East.
Section 14.....	Township 20.....	Range 9 East.
Section 16.....	Township 21.....	Range 11 East.
Section 23.....	Township 22.....	Range 10 East.
Section 27.....	Township 21.....	Range 11 East.
Section 28.....	Township 21.....	Range 11 East.
Section 21.....	Township 21.....	Range 11 East.

A number of outcrops of the Niagara occur in Randolph County. The stone is used for lime and quarried for flagging

and other purposes. The following analysis of the Randolph County limestone is republished from the Report of the State Geologist for 1878, p. 59.

	Macksville.	Ridgeville.
Water at 212°F.....	1.18	0.90
Silicic acid	1.20	0.70
Ferric oxide	1.30	2.70
Alumina	4.40	3.75
Lime	45.45	45.08
Magnesia	4.01	4.36
Carbonic anhydride	40.12	89.21
Sulphuric acid	0.27	0.44
Combined water and loss.....	2.07	2.86.
	100.00	100.00

PART II. PALEONTOLOGY.*

BRACHIOPODA.†

Dinobolus conradi Hall.

Pl. I, fig. 8.

The natural cast of the brachial valve, which is figured from the Gilbert collection, is the only specimen observed. A feature not shown in most of the figures published of this species is a low, indistinct ridge traversing the broad, shallow, longitudinal groove which crosses the muscular plate.

Rare. Huntington.

Monomorella sp.

Pl. I, fig. 1.

Internal casts of the brachial valve of an undescribed species show the following characters:

*NOTE.—Mr. C. L. Breger has assisted in the preparation of the greater portion of Part II and is the joint author of this part of the paper.

For the loan of literature and assistance in the determination of certain species, acknowledgments are due to Dr. C. D. Walcott, Professor H. S. Williams and Prof. C. E. Beecher.

Mr. J. R. Gilbert, of Huntington, has generously loaned us his valuable collection of Huntington fossils, a number of which are here figured. To Mr. G. K. Greene we are indebted for the opportunity to compare the northern Indiana species with those in his Niagara collection from Louisville and southern Indiana.

The illustrations are by Dr. J. C. McConnell and Mr. G. S. Barkentin, with the exception of the figures on plate 25, which were made by Mr. Breger.

The *Coelenterata* and *Echinodermata* and parts of some other groups have been omitted from this paper because of the scarcity of satisfactory material in the collections.

†The student is referred to Bull. No. 87, U. S. G. S., for the synonymy of the species.

Brachial valve semi-circular in outline, uniformly concave; length of largest specimen 75 mm., width 110 mm. The smallest is about half this size. Platform pear-shaped, tapering toward the front. The platform is divided transversely about the middle into two parts by a shallow furrow, bending backward in the middle; the posterior division is subdivided by a similar but less conspicuous furrow at right angles to the first. Two diverging low ridges extend forward from the ends of the transverse furrow. A second pair extend forward from the anterior end of the platform and reach nearly to the margin of the valve. No specific name will be proposed until a more complete description is possible.

Six specimens have been found at Delphi.

Trimerella sp.

Pl. I, fig. 2.

This genus is represented in the collection by a single fragment which is here figured, of the internal cast of the valve of an undetermined species.

Delphi.

Crania sp.

Pl. I, figs. 9, 10.

Shell broadly ovate, truncated posteriorly; apex rather depressed, near the posterior margin. Anterior adductor scars about one-third the distance from the truncated margin to the front. Surface, apparently with fine concentric striæ.

Only one specimen has been seen which is a cast of a brachial valve from Pendleton, Ind.

Strapheodonta cf. *corrugata* Conrad.

Pl. I, fig. 3.

Shell nearly flat; surface marked by fine, prominent, radiating striæ; these are nearly equal, bifurcating at intervals and crossed by fine concentric striæ. Four or five oblique folds appear on the hinge margin near the extremities of the hinge line. The alternating finer striæ which are said by Hall to characterize the New York forms have not been observed.

A single, well marked specimen from Georgetown.

Pholidostrophia niagarensis n. sp.

Pl. II, figs. 13-15.

Shell small, semi-elliptical, highly arched; the height of the convexity equals half the width of the shell. Greatest width between the hinge extremities which are slightly pointed. The very convex pedicel valve rises abruptly from the hinge line. The gibbous umbonal region projects slightly beyond the hinge line, then descends regularly to the front and sides. Beak small and incurved. Brachial valve not seen. Surface with nacreous luster, smooth except near the front, where faint traces of distant radiating striæ may be observed under a strong lens. Inner surface of shell strongly and coarsely punctate.

Two specimens from Little Deer Creek, Carroll County.

Strophonella cf. striata Hall.

Pl. I, fig. 4.

Four or five poorly preserved specimens are provisionally referred to this species. Shell resupinate. Strong radiating plications cover the surface.

Connor's Mill, Hamilton County.

Strophonella williamsi n. sp.

Pl. I, figs. 6, 7 and 11.

Shell semi-elliptical, length about three-fourths the width; extremities of hinge line mucronate, extending beyond the rest of the shell. Shell profoundly reflexed about the middle of the valves. Pedicel valve near the beak slightly concave; anterior to the concave region the valve is deeply convex; the depth of the convexity is equal to nearly half the length of the shell. Brachial valve nearly flat or slightly convex near the hinge line, elsewhere very convex. Interior with a strong bilobed cardinal process, directed forward. Inner margin of narrow area crenulated on each side of the beak for about half the distance to the extremities. Surface covered with fine, closely arranged, fasciculate striæ in bundles of from five to ten, which are separated by distinct grooves, most of the latter reaching to the beak. Each groove has the width of about two striæ.

This species is readily distinguished from *Strophonella semi-fasciata* of the Waldron shale by the absence of the strong elevated striae which characterize the Waldron species.

The species is represented by about ten specimens from Georgetown, Pendleton, Connor's Mill (Hamilton County), and Delphi.

Stropheodonta sp.

A number of casts represent a nearly flat *Stropheodonta* of undetermined species.

Common at Connor's Mill, Hamilton County.

Leptaena rhomboidalis Wilckens.

Pl. II, fig. 17.

Shell semi-elliptical to semi-circular in outline; valves nearly flat or slightly convex on dorsal, and concave on ventral side in posterior portion of shell; abruptly deflected towards the front sometimes at a right angle to the plane of the posterior portion of the shell. Surface marked by numerous strong, radiating striae. Six to fifteen strong, concentric wrinkles mark the flat portion of the shell.

The species is common, occurring at Georgetown, Pendleton, and at Connor's Mill, Hamilton County.

Plectambonites cf. *sericeus* Sowerby.

Pl. II, fig. 22.

Shell transversely semi-oval, greatest width of the shell along the hinge line, which is slightly extended in mucronate points. The interior of the pedicel valve shows a strongly marked, bilobed, muscular impression.

The specimens are casts of the interior and show only internal features. The surface is marked according to Hall "by fine striae which are even and uniform or alternating with stronger ones; striae increasing in number toward the margin; granulose or papillose, crossed by a few lines of growth."

Two specimens from Connor's Mill, Hamilton County.

Orthothetes subplanus Conrad.

Pl. I, fig. 5.

Shell semi-circular to semi-elliptical, depressed, convex; length of hinge somewhat greater than the width of the shell. A distinct area extends the length of the hinge in both valves. Surface marked by forty to fifty prominent, rounded, radiating striæ which increase both by interstitial addition and by bifurcation; these are crossed by fine concentric striæ.

A few specimens from Little Deer Creek, Carroll County, are doubtfully referred to this species. In size they resemble Whitfield's *O. hydraulicus*, the largest measuring $6\frac{1}{2}$ mm. in length and $8\frac{1}{2}$ mm. in width. They differ from Whitfield's species in having the radiating striæ of nearly equal strength. The shell is rounded at the cardinal extremities and has a very high area. Beak of pedicel valve sometimes twisted.

The species is rare; found at Pendleton and Georgetown.

Chonetes cf. cornutus Hall.

Pl. II, fig. 12.

Shell small, transversely subelliptical; strongly arched in the middle of the shell; length about one-half the width. Hinge extremities pointed and projecting somewhat beyond the sides of the shell. Four to six small spines on each side of the beak. Surface covered by twenty-five or thirty rounded striæ.

Abundant at Bunker Hill and Logansport; one specimen from Pendleton.

Orthis flabellites Foerste.

Pl. II, figs. 3, 4, 5, 6 and 11.

This species occurs in the dolomitic limestones as natural casts having the appearance shown in the figure. The cardinal area of the pedicel valve forms a low triangle. Surface marked by 22 to 30 broad, prominent radii which are crossed by fine concentric striæ.

Comparatively rare. Known from Wabash and Lagro, Pendleton, and Little Deer Creek, Carroll County.

Orthis (f) subnodosa Hall.

Pl. II, fig. 7.

The species is represented by two pedicel valves.

Hinge line somewhat shorter than the width of the shell; area with triangular foramen extending to the beak; beak slightly incurved. A shallow undefined mesial depression extends from the beak to the front bearing two or three plications. Surface marked by fifteen to eighteen bifurcating plications, which are crossed by fine lamellose lines of growth. The shell shows traces of fimbriate surface markings in the best preserved portions.

Rare. Little Deer Creek, Carroll County.

Dalmanella elegantula Dalman.

Pl. II, fig. 9.

Pedicel valve strongly convex, brachial valve nearly flat, longitudinally concave in the middle. Beak of the ventral valve incurved over the high narrow area. Surface covered with fine, radiating striæ.

Rare. Found at Georgetown, at Little Deer Creek, Carroll County, and Helm's mill, Hamilton County.

Rhipidomella hybrida Sowerby.

Pl. II, fig. 8.

Shell rather small, suborbicular, valves nearly equal. Pedicel valve gently convex; brachial valve moderately convex, but with a flat or depressed area along the middle. Surface marked by fine, closely-set, bifurcating striæ arching upwards on the sides of the posterior portion of the shell.

The species is represented by natural casts in the dolomitic limestone showing the impressions of the cardinal teeth and strongly marked muscular areas. Length and breadth apparently equal.

The species is common at Wabash; it occurs rarely at Pendleton, Little Deer Creek (Carroll County), Big Monon Creek (White County), and at Connor's Mill (Hamilton County).

Rhipidomella circulus Hall. ?

Pl. II, fig. 16.

A couple of specimens referred doubtfully to this species are subcircular in outline, slightly broader than long, and moderately convex. Surface covered with fine radiating striae.

Rare. Georgetown.

Anastrophia internascens Hall.

Pl. II, fig. 10.

Five natural casts of brachial valves represent this species in the collection. These exhibit the following characters:

Valves gibbous, width slightly exceeding the length; surface marked by from 13 to 17 radiating, angular plications, which occasionally increase by intercalation or by bifurcation; fold not well defined, marked with five or six plications. A short, thin septum is present on each side of the beak.

Rare. Found at Wabash and at Pendleton.

Conchidium laqueatum Conrad.

Pl. III, figs. 1, 2; Pl. IV, fig. 3; Pl. VI, figs. 1, 2.

In mature, well preserved specimens with both valves in conjunction, the shell is trigonal or trapezoidal, ventricose and with the depth as great as, or greater than, the width. The pedicel valve is larger and more gibbous than the brachial, the latter being merely operculate. The former valve is elongate, the ratio of length and width being 3:2, with the greatest width in front. The beak is hooked down so that its tip is in the plane of the hinge line. The depth of the valve is equal to half the length, the greatest depth being one-third the distance from the beak to the anterior margin. The lateral portion of the shell is abruptly deflected to meet the hinge line, thus producing a high, rather concave face on each side of the valve. The surface is marked by from 22 to 32, but usually 28 rounded or subangular plications which disappear as the lateral faces are approached. These faces and the umbonal quarter of the ventral valve are smooth except for a few concentric wrinkles of growth, which are very obscure. The delthyrium is equilaterally triangular and extends to the tip of the beak.

The brachial valve is smaller, less elongate and less robust than the pedicel valve. Whole specimens are pentagonal, with the greatest width at the anterior margin. The beak is obtuse and curved down, so that its tip is below the plane of the hinge line, while the umbonal region is concealed in the delthyrial opening of the pedicel valve. This concealment, when both valves are conjoined, makes the brachial valve seem to be smaller and flatter than it really is. The surface markings are about the same as those of the pedicel valve except that the lateral smooth faces are perceptibly lower than those in that valve. Internal casts are marked by two parallel septa, about three millimeters apart in the middle of the valve. These septa extend three-quarters of the length of the valve and diverge only very slightly. The dental sockets are long, parallel to the margin, and diverge at an angle of nearly 90 degrees.

Abundant. Delphi, Big Monon Ditch (White County), Huntington and Georgetown.

Conchidium cf. littoni Hall.

Pl. III, figs. 3-6; Pl. IV, figs. 1, 2, 4; Pl. V, figs. 4, 5.

Pal. New York, III, 1859, p. 262.

"Shell ovoid, somewhat elongate. Dorsal valve moderately and regularly convex from base to umbo; beak almost rectangularly incurved beneath the beak of the opposite valve. Ventral valve very gibbous; beak subattenuate, incurved. Surface marked by about eighteen or twenty simple subangular plications. There is a broad, concave, smooth space on each side below the beak of the ventral valve, and a much narrower space on each side of the dorsal valve."

The specimens here referred to this species are considerably larger and more gibbous than the specimens heretofore figured, but seem to agree in most essentials with the original description given above.

Common at Georgetown.

Conchidium cf. multicostratum Hall.

Pl. VI, fig 3.

Several pedicel valves are referred to this species. Beak moderately incurved, valve sloping uniformly to the sides and front.

Surface covered by about thirty-five rounded, closely set plications. Septum extending two-thirds of the distance from the beak to the front.

Connor's Mill, Hamilton County, Ind.

Conchidium trilobatum n. sp.

Pl. V, figs. 1-3.

Shell large, subovate in outline. Both valves strongly trilobed; greatest width at about the anterior termination of the lateral lobes. Brachial valve deeper than the pedicel valve, beak incurved; cardinal slopes not plicated, descending abruptly, almost vertically, to the margin of the shell. A strong sinus on each side of the median line of the shell and extending nearly to the beaks divides the shell into three lobes, the median lobe being broader and much higher than the lateral lobes. Brachial valve with the beak closely incurved, depth about one-half that of the pedicel valve. Lateral sinuses shallow near the beak, deepening rapidly toward the front and dividing this valve, like the other, into three lobes. Surface of the shell marked with 40 to 70 strong, angular, bifurcating plications. Concentric lines of growth cross these at irregular intervals.

Known only from Huntington.

Conchidium unguiformis Ulrich. (?)

Pl. VI, figs. 4, 5.

A single brachial valve is doubtfully referred to this species. The posterior third of the valve is bent nearly at right angles to the rest of the shell. Beak incurved; surface marked by about eighteen strong angular plications, eleven of which reach to, or nearly to the beak; the remainder arise at one of the strong lines of growth. The plications are crossed by sublamellar, concentric striæ.

Rare. Little Deer Creek, Carroll County.

Pentamerus oblongus var. *cylindricus* Hall and Whitfield.

Pl. VI, figs. 6-10; Pl. VII, fig. 6.

Shell large, elongate-ovate; subcircular in transverse section. Valves more or less distinctly trilobed in the anterior half, rounded or truncate in front; in the latter case a shallow sinus is present

near the front in each valve. Ventral valve deeper and more convex than the brachial; beak arched over the umbone of the opposite valve.

Surface smooth except for occasional concentric ridges of growth.

Common in a single zone at Delphi.

Pentamerus oblongus var. *compressa*, n. var.

Pl. VII, figs. 1-5.

This variety is distinguished from *P. oblongus* var. *cylindricus* with which it is associated by the great inequality in the depth and width of the shell. The greatest height of the shell is from two to two and one-half times the greatest width. The depth of the pedicel valve is about one and one-half times that of the brachial valve. Anterior end of shell rounded or truncate. One specimen shows obscure traces of obsolescent, rounded plications at the anterior end. All other specimens observed have the surface smooth except for occasional ridges of growth.

Abundant in a single zone at Delphi.

Gypidula (Sieberella) galeatus Dalman.

Pl. II, figs. 20, 21 and 23 to 29.

Shell ovoid or subglobose; valves unequal, the pedicel valve being much larger and more convex than the brachial. Pedicel valve uniformly rounded from the umbone to the front, the outline being nearly that of a segment of a circle; beak very gibbous and strongly incurved. Some specimens have an indistinct, broad fold at the front bearing four or five plications. In most individuals, however, there is little or no trace of a fold. Surface frequently marked with low, indistinct plications, which are obsolescent in the umbonal region. Fine concentric striæ are seen in perfectly preserved specimens. Many specimens show no trace of radiating plications. Very few brachial valves have been observed. These show a broad shallow sinus with three or four plications which are obsolescent posterior to the middle of the valve.

The specimens from Georgetown, which occur in a nearly pure limestone, greatly exceed in size those from other localities, which are all from dolomites. An average brachial valve from the

Georgetown locality measures in width 26 mm., length 27 mm. An average specimen from the dolomite measures in width 15 mm., length 16 mm. A brachial valve from the dolomite has the following dimensions—width 17 mm., length 12 mm.

The species occurs commonly as natural casts showing the single strong septum of the pedicel valve extending about one-third the distance to the front, and in the brachial valve two much finer septa in the umbonal region.

Hall and Clarke in the Pal. N. Y., Vol. VIII, have proposed to distinguish the Niagara Group forms of this species by the name *Gypidula (Sieberella) roemeri*. The specimens from the Glades in Perry County, Tenn., which have been made the types, are similar in all respects to the Georgetown material. However, no difference can be detected between these forms and the typical expression of Dalman's species, as the latter occurs in Europe and in well preserved specimens in the Lower Helderberg of New York. *G. roemeri*, which was never described, must therefore be considered only as a synonym of *G. galeata*. *G. nucleus* should also, perhaps, be referred to this species, as the Indiana material shows many gradations between the round plications of *G. galeata* and the more angular ones of *G. nucleus*, while some specimens are smooth. Prof. Whitfield informs us that the specific description of the latter species was drawn from the best specimen which happened to have angular plications, though many, if not most, of his specimens were either smooth or had rounded plications. The name "nucleus," therefore, can represent at most only a variety.

It is worthy of note that at Georgetown, where the only specimen of the type of *G. nucleus* was found, *G. galeata* is quite abundant and varied.

The species is common, occurring at Georgetown, Pendleton, Wabash, Fishersburg, and Little Deer Creek, Carroll County.

Gypidula (Sieberella) nucleus Hall and Whitfield.

Pl. II, figs. 18, 19.

This "species," which is represented by a single pedicel valve from Georgetown, shows the following characters:

Valve ventricose and strongly arched; umbone inflated and beak incurved. Surface marked by seven angular plications

which become obsolescent in the umbonal region. The two strongest of these are slightly elevated to form a median fold.

Camarotoechia sp. undt.

Pl. VIII, fig. 3.

A single brachial valve of an undetermined species appears in the collection from Little Deer Creek.

The valve is very gibbous, length three-quarters the width. Surface marked by twelve strong plications, four of which are elevated into a median fold.

Rare. Little Deer Creek, Carroll County.

Camarotoechia cf. acinus Hall.

Pl. VIII, figs. 1, 2.

Casts of two or three brachial valves are doubtfully referred to this species. Surface with seven rather strong plications, two or three of which are elevated into a median fold which is not very prominent.

Rare. Pendleton.

Wilsonia saffordi Hall.

Pl. VIII, figs. 4-9.

Shell very gibbous or subglobose; surface marked by from 20 to 36 plications which vary in strength according to their number; plications frequently marked by shallow median groove near the front. Fold and sinus not sharply defined, apparent only at the front and marked by 5 to 11 plications. Beak of pedicel valve acute, curved over the brachial valve.

This shell is comparatively rare. Found at Georgetown and at Bunker Hill.

Eatonia goodlandensis n. sp.

Pl. VIII, figs. 10-12.

Shell subcircular, hinge line straight, equal to two-thirds the greatest width of the shell. Brachial valve ventricose, the gibbous umbone extending over the hinge line, while the beak is incurved closely against that of the pedicel valve. An indistinct fold is developed near the front. Pedicel valve moderately convex in the umbonal region, from which the slope to the margin is quite

regular. A deep, rounded sinus toward the front deflects a tongue-like projection of the valve into the front of the opposite valve nearly at right angles to the plane of the margin. A weak plication marks the bottom of the sinus; beak closely incurved against the beak of the brachial valve. Surface smooth except for the plication in the sinus and occasional lines of growth.

The species is known from a single specimen from a quarry one mile northwest of Goodland.

Atrypa calvini Nettleroth.

Pl. VIII, figs. 13-15.

Shell small, brachial valve more convex than the other. In young specimens brachial valve is nearly flat. Ventral valve sloping gently from the convex umbonal region toward the lateral margins, near which it is abruptly deflected downwards, forming a concave zone inside the margin; beak prominent, pointed and slightly incurved. Sinus most prominent at the front, where its junction with the fold forms a high U-shaped loop. Two or three plications usually occupy the sinus. Dorsal valve with well developed fold toward the front usually bearing two plications; fold scarcely elevated above the adjacent parts of the shell. The plications of the fold are sometimes depressed below the general surface in the posterior portion of the shell, giving the appearance of a sinus. Surface of the shell marked by 15 to 20 strong, rounded plications, which increase by bifurcation and interstitial addition. No other surface markings visible.

This species is placed by Schuchert as a synonym of *A. rugosa* (Hall), but the specimens though showing the finer growth lines afford no trace of the strong, elevated lamellæ characterizing that species.

This is one of the most abundant and generally distributed species in the Niagara of Northern Indiana, occurring at Georgetown, Delphi, Logansport, Pendleton, and other localities.

Atrypa reticularis Linnæus.

Pl. VIII, figs. 16-18.

Shell subcircular in outline. Valves moderately convex to gibbous; usually the two valves are about equally convex, but the brachial valve is sometimes much more convex than the ped-

ical valve. Pedicel valve frequently with a faintly defined sinus at the front; brachial valve sloping regularly to the front and sides. Surface marked with thirty-five to fifty fine, radiating plications which bifurcate freely in the posterior half of the shell. The largest specimen seen measures in length 20 mm., in width 19 mm. An average specimen has a length of 16 mm., width, 16 mm., and thickness, 11 mm. The most striking difference between the Niagara phase of this species and the form occurring in the Devonian limestones of Indiana is in the size, the latter being three or four times the size of the former; in the Devonian form, also, the brachial valve is usually much the more convex in contrast with the nearly equal convexity of the valves in the forms here described. The species is common at some localities. It occurs at Wabash (4A), and at Little Deer Creek, Carroll County.

Spirifer foggi Nettleroth.

Pl. VIII, figs. 24, 25.

Outline of the shell as shown in the figure; ventral valve more convex than the pedicel; umbonal region gibbous, beak incurved. Fold and sinus prominent, with four to six, low, rounded plications on each side; entire surface covered with fine, thread-like striæ which dichotomize toward the front.

The largest specimen in the collection has the following dimensions: Width, 19 mm; length, 20mm; thickness, 13½ mm.

This species as suggested by Nettleroth is very closely allied to *Spirifer radiatus*, and it is doubtful whether it should be regarded as anything more than a variety of that species approaching the *Sp. niagarensis* type.

Known only from Georgetown, where four specimens were secured.

Spirifer nobilis Barrande.

Pl. IX, figs. 1-5.

Shell transversely elliptical, valves moderately convex, cardinal extremities rounded; prominent fold and sinus, the former broad and simple, the latter without plications in the material examined. There are from four to eight strong, dichotomizing plications on each side of the fold and sinus. Entire surface covered by distinct, fine, radiating striæ.

The bifurcating and much stronger plications distinguish this form from *Sp. niagarensis*.

This is not a common species; from one to three specimens represent it in the collection from each of the following localities. Pendleton, Connor's Mill (Hamilton County), and Georgetown.

Spirifer radiatus Sowerby.

Pl. VIII, figs. 19-23.

Shell rather large, rotund or robust; cardinal extremities rounded. Beak of the ventral valve incurved over the area, sinus broad and shallow; surface of the shell everywhere covered by fine, radiating striæ.

Two specimens of this shell from Georgetown show no trace of radiating plications, agreeing in this respect with the species as it occurs in the Waldron shale; all of the other specimens are marked by very low, rounded, radiating folds, of which there are four or five on each side of the fold and sinus. The latter type in some individuals approaches *Sp. niagarensis* closely in appearance.

The species is rather rare, occurring at Georgetown, Wabash, Connor's Mill (Hamilton County), and at Pendleton.

Spirifer (Reticularia) crispus var. *simplex* Hall.

Pl. VIII, figs. 26, 27, 28.

Shell small, gibbous; ventral valve much more convex than the dorsal. There are two or three rounded plications on each side of the fold and sinus, the outer ones not reaching to the beaks; plications are crossed by fine lamellose, concentric striæ which have, fringing their margins, numerous very fine setæ; the latter characters are very well preserved in the natural moulds. Specimens from Waldron show them well developed. Ventral valve with thin, low, median septum extending about one-third the distance to the front. A thin dental plate, half the length of the septum lies on each side of it.

Comparatively rare, occurring at Georgetown, Pendleton, Little Deer Creek (Carroll County), and at Connor's Mill (Hamilton County).

Reticularia proxima n. sp.

Pl. IX, figs. 6-8.

Shell transversely subovate; area short and low, partly concealed by the closely approximate beaks. Pedicel valve more convex than the brachial, marked by a distinct subangular sinus extending from beak to front. Brachial valve moderately convex in the posterior half. Slope very gentle to the front, but more abrupt to the hinge line. A mesial fold limited by a narrow but distinct depression extends from the umbone to the front; the fold is not elevated above the adjacent portion of the shell. Entire surface of shell marked by strong concentric lamellæ.

This species may be distinguished from *R. bicostata petilla* (Hall) by the lower area, and the absence of lateral plications or folds.

Rare. Represented by one specimen from Fishersburg, Hamilton County.

Reticularia sp.

Pl. IX, fig. 9.

Two imperfect pedicel valves from Pendleton show the following characters: Strongly convex, sloping regularly to the front and sides; a very shallow sinus extends from the beak to the front; and a low, median septum extends about one third that distance; shorter dental plates on either side of the septum. Surface marked by fimbriate, concentric striæ; no plications or folds. The surface markings resemble those of *Spirifer crispus* as figured by Clarke and Ruedeman, Pl. IV, Memoir V, N. Y. State Mus.

Pendleton.

Cyrtia myrtia Billings.

Pl. IX, figs. 10-12.

Shell pyramidal from front view; brachial valve semi-elliptical in outline. Pedicel valve with greatly elevated, slightly concave, triangular area, the beak inclined slightly backward over it. Surface sloping at an acute angle from the beak to the margin of the shell. A prominent rounded sinus extends from the beak to the front of the valve. Brachial valve gently and regularly convex. A low, rounded indistinct fold extends across the middle of the

valve. Surface of both valves covered with fine radiating striæ, of which there are eight or ten in the space of 1 mm.

Rare. Only two specimens seen, Georgetown and Delphi.

Whitfieldella nitida Hall.

Pl. IX, figs. 13, 14.

Shell small; valves strongly and nearly equally convex; beak of pedicel valve acute and incurved. Surface smooth except for lines of growth. Front straight, slightly emarginate or rounded; faint sinus is present in emarginate specimens at the front of both valves.

Rare. Represented by five specimens from Georgetown and from Helm's Mill, Hamilton County.

Nucleospira pisiformis Hall.

Pl. VIII, fig. 29.

The species is represented by poorly preserved casts showing the shallow sinus in each valve and the impressions of the low median septum of the pedicel valve extending nearly the entire length of the valve. Hall's description of the species as it occurs at Waldron is as follows:

"Shell lenticular, globose; valves nearly equal, each valve with a depression down the center. Ventral valve somewhat more convex, with the beak more elevated than in the dorsal valve. Area narrow, small, scarcely extending beyond the width of the beaks at their base. Surface marked by fine concentric striæ usually obscured by the covering of minute hair-like spines, which, when removed, leave a punctate surface."

Rare. Pendleton, and at Connor's Mill, Hamilton County.

Anoplothecca congregata n. sp.

Pl. IX, figs. 18-20.

Shell small, subcircular and plano-convex. Pedicel valve very convex, beak incurved and extending slightly beyond the brachial valve. Two strong plications with a third intermediate somewhat weaker one form a prominent median fold, extending from beak to front. Three or four plications appear on each side of the fold. Interior of pedicel valve with transverse tooth on each side anterior to the area. A strong median septum extends one half to three quarters the distance to the front. Sides of brachial valve flat, with deep median sinus widening from the beak to the front.

From one to three indistinct plications occupy the sinus; surface on either side marked by three or four plications.

This species is abundant at one point in Logansport. The only species observed associated with it is a *Chonetes*. The species apparently does not belong to the Niagara fauna and is probably a representative of the "Waterlime" fauna.

Meristina maria Hall.

Pl. IX, figs. 29-32.

Shell large, outline as shown in figure. Valves about equally convex. Pedicel valve with incurved beak, gibbous in the umbonal region, becoming deeply sinuate toward the front and deflected upward in a linuiform extension. Interior of the valve with a deep, triangular-shaped muscular impression. Brachial valve convex in the umbonal region, sloping abruptly to the cardinal and lateral margins of the shell. A subangular or rounded ridge extends from the umbo to the front. Interior with a low septum extending one-third the distance from the beak to the front. Surface apparently smooth.

Common, occurring at Fishersburg, Georgetown, Pendleton and Connor's Mill, Hamilton County.

Meristina rectirostris Hall.

Pl. IX, figs. 21-24.

Shell broadly ovate, margin nearly straight from the beaks one-third the distance to the front; thence regularly rounded to the front. Valves about equally convex. Pedicel valve sloping regularly to the sides from a median line of maximum elevation. Beak acute, nearly straight, and projecting beyond the opposite valve; area triangular. Brachial valve regularly convex; beak small and closely incurved. No surface markings preserved.

Rare. Known only from Little Deer Creek, Carroll County.

Maristina cf. princeps Hall.

Pl. IX, fig. 25.

A single brachial valve has been seen which probably belongs to this species. It differs from *M. maria* in having the surface marked with distinct radiating striae toward the front and lateral margin.

Rare. Georgetown.

PELECYPODA.*

Tellinomya cf. nasuta Hall.

Pl. X, fig. 1.

A single specimen found east of Kentland has the following characters:

Shell transverse, length twice the height. Beak a little anterior to the center. Upper margin extending forward in a direction parallel to the transverse axis, thence continuing in a broad curve extending downward to a point in front of the middle of the ventral margin; thence deflecting upward in a broad, shallow, undefined sinus. Posterior end half the height of the anterior end, sharply rounded, nasute; superior margin straight or barely arcuate to the umbo, deflected a little upward. The beaks are broadly obtuse, incurved, slightly directed forward, and extending very little beyond the hinge. The most convex portion of the shell is just back of the anterior muscular scar. In front of the posterior scar is a somewhat flattened shelf or platform. The pallial line is fimbriate, entire, and does not partake of even the very shallow sinus of the ventral margin. The muscular scars are large, deeply impressed in the shell, with a distinctly elevated rim except at the distal ends, and with their major axes in the respective lines running from the middle of the beak to the center of the anterior margin, and from the beak to the posterior margin. The anterior muscular scar is seven-eighths as high as long, close to the superior margin, and two-fifths in length the distance from the beak to the middle of the anterior margin. Posterior scar in similar relative position, but narrower, with the length more than twice the height and equal to two-fifths the distance from the beak to the middle of the posterior margin. The anterior and posterior limits of the muscular scars undefined. Each of the scars is a little nearer the anterior or posterior margin respectively than to the beak. There are no umbonal scars, nor accessory retractile scars, nor can the dentition be seen. This shell evidently belongs to the typical group of *Tellinomya* as represented by the *T. nasuta* from the Trenton limestone. A shell very similar in outline, the *Nucula hanoverensis* of Kindle is found in the Devonian lime-

*For references to the original descriptions of the species of this and succeeding groups, see Miller's North American Geology and Paleontology.

stones, but the latter represents a species which generically is very distinct. About the only difference which can be detected between our species and *T. nasuta* as found in the Trenton of Wisconsin is that in the former the posterior end is just perceptibly narrower than in the Wisconsin forms.

The single specimen described above is a left valve and its cast from Kentland (1C1). The inside surface of the shell is smooth as is also the cast. The height of the shell at the posterior end of the anterior scar is 23 mm. The transverse axis passing just below the scars is 49 mm., and the valve is about 4 mm. thick.

Whitella (?) *sibiriana* n. sp.

Pl. X, fig. 15.

Shell small, quadrate, rhomboid, length and height about equal. Hinge line straight, three-fourths the length of the shell, and forming at an angle of about 130 degrees with the upper part of the posterior margin. The last named is arcuate to the gonial angle which is broadly rounded. Basal margin straight or nearly so; abruptly curved at a right angle into the short vertical anterior margin. Beaks consisting only of the upper end of the gonial ridge, incurved, protruding, depressed to the plane of the margin. Gonial ridge very prominent, hardly arcuate, becoming less well defined posteriorly. Point of greatest convexity of the shell on the ridge, just above the middle. Cast smooth.

Only a single right valve which is the type of the species is known. Length, $6\frac{1}{2}$ mm., height, $5\frac{1}{2}$ mm., thickness, $2\frac{1}{2}$ mm. It is referred to *Whitella* with some hesitancy. There is a striated external ligament, and a very pronounced linear posterior elevation which seems to be a well developed tooth rather than the platform of an internal ligament as Ulrich considers a somewhat similar feature in Ordovician typical forms of the genus. The form is somewhat like Hall's *Cypricardites* (?) *quadrilatera*, but our species is higher, with the superior and ventral sides parallel, and has a rather different hinge structure. There is some resemblance to *W truncata* (Ulrich) but that is a much more gibbous shell.

One specimen, Wabash.

Cypricardinia sp.

Pl. X, fig. 14.

A single external mould of a left valve from Pendleton has the following characters:

Shell small, rhomboidal; anterior end small, ventral margin formed by two subequal, slightly arcuate lines extending from the antero-ventral and postero-ventral margins and meeting in a broad angle; posterior margin, abruptly truncated, forming an angle of 135 degrees with the hinge. There is a slight retral curve to the posterior margin which produces an alation and gives the shell an aviculoid appearance. Hinge line unknown but apparently straight. The markings consist of concentric folds which have a slight but very distinct sinus at the anterior fifth and another sinus corresponding to the alation of the posterior margin. The folds are small and at the anterior portion of the shell are close together; but from just back of the sinus to the gonial ridge these folds are very strong, becoming obsolescent on the posterior slope. There are faint traces of fine concentric striæ.

This shell has the outline of the *Clidophorus* (?) *mc. chesneyanus* of Winchell and Marcy, which is now considered a *Colpomya* but which Miller believed to have been identical with the *Modiolopsis rectus* of Hall. The first named species differs from that described above in the absence of the strong folds and also of the posterior alation.

Our specimen from Pendleton has a length of 15 mm., and height of 8 mm.

Pterinea sp. undet.

Pl. X, fig. 8.

In the subcentral position of the beaks there is a resemblance to the *Pterinea curiosa* of Billings. The beak of the left valve of the Indiana species is not protruded beyond the hinge line, nor is it elevated. The casts are smooth with no markings whatever.

Of the two specimens found, the larger which is figured is from Delphi (2/A1), and the smaller one from Wabash (4/A2).

Amphicoelia neglecta McChesney.

Pl. X, fig. 10.

A large left valve belonging to this species shows the following characters:

Shell large, gibbous; approximate length, 72 mm., height 56 mm., thickness 18 mm. Beaks anterior, ventricose, incurved, pointed forward. Most convex point on the shell at upper and anterior third. Cast marked by fine striæ, of which there are twenty in 16 mm., at a distance of 50 mm. below the beak. These striæ are very low on the cast, though distinctly visible; more prominent in front. Towards the umbones and posteriorly, they become obsolescent, while below the hinge the cast is smooth. The hinge line is nearly equal to the length of the shell.

One specimen, Wabash.

Paleopinna sp. undet.

Pl. X, fig. 13.

A fragment from Wabash (4/A2), is figured on Pl. X, Fig. 13. The hinge line is long and straight. The beak is anterior. The umbonal region is gibbous with an undefined post cardinal cincture or sinus. Shell thin, covered with radiate striæ and concentric growth lines. The latter are sharply elevated and are stronger than the radial striæ, which increase by implantation.

Conocardium multistriatum n. sp.

Pl. X, fig. 4.

Shell smaller than *C. oweni*, the only specimen found having an approximate height of 8 mm., length 9 mm. and thickness 6 mm. The anterior truncation is obsolescent, being represented merely by a slight deflection of the surface and the cessation of the surface markings. The latter consist of about twenty-seven fine striæ which are flat-topped in the casts but angular on the surface. The interspaces in the casts are fine impressed lines. The posterior striation is greatly enlarged and serves to demarcate the posterior portion of the shell which forms an angle of about 50 degrees. This posterior portion is covered by about eleven striæ or plications, which are very faint near the strong rib, but increase quite rapidly in size and strength as the posterior tube is approached.

The concentric markings consist of very fine, close-set rugose striae, which are most prominent on the umbones and on the posterior portion of the shell. There are also two or three secular growth lines.

This species may be recognized by the fine surface markings.

The single specimen described above was found at Georgetown.

Conocardium oweni n. sp.

Pl. X, figs. 2, 3.

Shell small, gibbous, the type specimen being 11 mm. long, 8 mm. high, and $6\frac{1}{2}$ mm. thick. Anterior end abruptly truncated. Anterior margin beginning a little below the front end of the hinge line, and at an angle of about 100 degrees thereto, extending in a very slightly concave line to the base of the truncation which is the most anterior point in the shell. From this point, the ventral margin rounds strongly to near the middle, where it is gradually deflected in a broad curve up to the posterior opening. Hinge line straight. Beaks prominent, extending little beyond the hinge, and directed slightly backward. Greatest convexity of the shell one-third the distance from the beak to the base, and just behind the truncation. The front of the shell down to the top of the anterior edge is drawn out into an apparently broad but very short tube or opening.

The surface is marked by radiating, narrow plications crossed by lines of growth which become lamellose on the post-cardinal slope. There are two or three rounded plications on the truncate end near the upper edge, but these become obsolescent toward the umbones and toward the front, so that the base of the forward one is at the middle of the anterior edge. The interspaces are indistinct and are crossed by very faint lines of growth which become stronger near the anterior tube. From the edge of the truncation to the posterior tube, the surface is covered by about 18 low, rounded plications. These are most sharply defined on the more convex portions of the shell, where they are nearly flat-topped and with smooth interspaces about equal in width to, or perhaps a trifle wider than, the plications. Posteriorly the plications are a little sharper, but the interspaces and the plications too, are rather less developed than in front. Simultaneously with the obsolescence of

the interspaces, the growth lines begin to develop quite strongly. These are hardly perceptible on the convex portion of the shell, but beginning at the post-cardinal slope they become lamellose so that at the base of the posterior tube, they are nearly as strong as the radiate markings. These lamellæ when well preserved cross the ridges of the plications and produce a minutely crenulated effect, but usually they are preserved only in the interspaces, where they show a rather cancellate structure. The surface of the posterior tube is smooth except for faint growth lines. No secular growth lines have been observed.

This species is very closely allied to and perhaps identical with the *Pleurohynchus antiqua* of D. D. Owen (Rep. Geol. Reconnaissance of Wis., Minnesota and Iowa, 1852, Pl. 2B, Fig. 19). Owen's species is very poorly figured, not at all described, and even the locality at which it was found is omitted. Poor as his figure is, there is, however, a rather close resemblance to our species. There is also a close resemblance to *C. niagarensis* of Winchell and Marey; but the lamellose lines of growth characterizing our species are not recognized in *C. niagarensis*, nor does the figure of the Chicago species (nor the description) show the anterior end partially plicate as is the case in our species.

The type specimen and another fragment were found at Little Deer Creek, while a third fragment of a specimen similar to the above was observed from Connor's Mill, Hamilton County. The last named must have been at least 15 mm. long when entire.

Plethomytilus cuneatus n. sp.

Pl. X, fig. 9.

Shell mytiloid, height about one and a half times the width. Greatest width two-fifths the distance from the base up. Anterior margin approximately straight, rounding off basally and posteriorly. Beaks gibbous, acuminate, protruding beyond the hinge, not twisted nor laterally bent. The point of greatest convexity is in the anterior portion and one-third the height from the umbones. Anterior slope perpendicular to the plane of the margin. Posterior slope very steep at the umbones, but becoming less so at the base. Muscular scar (?) ventro-posterior. Ligamental area with one or two striations posteriorly.

This species is much wider than *Mytilarca acutirostra* Hall's sp. The beak is more acuminate than in his *Ambonychia aphea*, and is not twisted as it is in that species. From the *Mytilarca sigilla* (which is probably an *Ambonychia*) our species differs in the absence of the posterior alation.

A single left valve was found at Georgetown (3/A1). It has the following dimensions: Height, 32 mm.; width, 22 mm.; thickness, 8 mm.

Streptomytilus n. g.

Shells mytiloid, erect, beaks twisted toward the front, acuminate, protruding beyond the hinge line. Surface markings concentric growth lines. Hinge furnished with a posterior ligamental groove. There is an internal linear platform or septum as in *Mytilus edulis* to which the ligament is attached. This platform is present as a groove in the cast. There are no teeth nor are there any ligamental striations. Type, *S. wabashensis n. sp.*

Ambonychia aphea (Hall) and the *Mytilarca eduliformis* (Conrad) and of Clarke and Ruedeman should also be included in this genus.

Streptomytilus wabashensis n. sp.

Pl. X, figs. 11, 12.

Shell small mytiliform, erect, height less than one and a half times the width. Anterior margin straight from the hinge half way to the base, thence curving in an arc of 240 degrees to half way up the posterior side, and continuing in an arcuate line to the umbonal hinge, which is rather obtusely rounded. Beaks terminal, gibbous, twisted to the front, protruding beyond the hinge lines, and depressed to its plane. Greatest convexity of the shell one-third the distance from tip of beak to the base. Anterior and posterior slopes about equal. Shell thin. Surface markings faint, concentric growth lines.

Only a left valve of this species is known. It was found at Wabash, and has a height of 13 mm., width $9\frac{1}{2}$ mm., thickness 3 mm. It is, however, so distinct as to fully warrant its generic separation from the known forms of lamellibranchs. It differs from *Plethomytilus*, its nearest Paleozoic ally in the absence of a

straight hinge line, of lateral teeth, and of the striations on the ligamental groove. From the recent forms of *Mytilus*, it may be distinguished by its more protruding and twisted umbones.

Anodontopsis wabashensis n. sp.

Pl. X, figs. 5-7.

Shell small to medium sized, rhomboidal to trapezoidal in outline; length twice the thickness and one-fourth greater than the height. Margin rapidly rounded in front, broadly rounded ventrally to the posterior two-thirds; thence curving upward to the postero-ventral angle, where there is a more or less abrupt and oblique truncation at an angle of about 120 degrees to the hinge. The last named is straight and half the length of the shell. Beaks in the anterior sixth, quite prominent, pointed forward, and extending very little beyond the hinge line. Point of greatest convexity posterior and superior to the center. Post cardinal slope steep and slightly concave. Surface markings faint concentric growth lines. The hinge characters are preserved in only one large specimen which shows fairly long, linear tooth. Anterior portion of the hinge unknown.

The type specimen is 20 mm. long, 16 mm. high, and has a thickness of 5 mm. (one valve).

The species may be recognized by the short hinge line and character of the surface markings.

Six valves of this species all of nearly the same size were found at Wabash (4/A2 and 4/A4) in a few hours' collecting.

GASTEROPODA.

Platyceras (*Diaphorostoma*) *cornutum* Hisinger.

Pl. XIII, figs. 9-16.

In the dolomitic limestones of northern Indiana several localities have shown the presence of this species. The specimens from Little Deer Creek, Pendleton, Georgetown, and Wabash bear but little resemblance to the spire-bearing forms from Waldron, but show a great affinity to Roemer's Tennessee specimens, and especially to that phase of the species described from Chicago by Winchell and Marcy as *Platyceras campanulatum*.

The spire is depressed, with the apex more or less below the plane of the upper side of the body whorl. The initial one or two

volutions are minute, but there is a sudden expansion and increase in the size of the body whorl. The body whorl is partially free. The aperture, where preserved, is flaring and the peristome is reflexed like the end of a trumpet. The surface markings are usually almost imperceptible lines of growth. A large Georgetown specimen shows about fifteen fine, revolving lines on the volution next to the body whorl, while the latter exhibits only very lamellose ridges of growth increasing in number as the peristome is approached.

At Connor's Mill, Hamilton County, from the dolomitic limestones of which place more specimens of the species have been obtained than from anywhere else in northern Indiana, there is in the general aspect great difference from the forms described above. All the seven specimens obtained from here show a remarkable uniformity of characteristics. The spire is elevated, consisting of three regularly-rounded and contiguous whorls, increasing gradually in size from the apex to the mouth. The length of the spire is two-thirds the greatest width of the body whorl. The surface is marked by nine or ten low, rounded, revolving bands which disappear on the upper side near the suture and are crossed by almost imperceptible lines of growth. The apertural characters are unknown, but the peristome was evidently not reflexed. It is possible that the remarkable uniformity of the Connor's Mill material, and its persistent differences from the forms of *Platyceras cornutum* occurring in the surrounding portions of northern Indiana, may be sufficient cause for the separation of the former specimens from that species.

The forms referred to this species have a world-wide distribution, occurring in Bohemia, the Hartz, France, England, Wales, Scotland, Ireland, Canada, and the United States. In England the species has also a great vertical distribution; but on this continent, where it has been recorded from New York, Canada West, Michigan, Wisconsin, Illinois, Indiana, Ohio, Pennsylvania, Kentucky, and Tennessee, it is confined to the beds of the Niagara Group (including the Guelph dolomites). The species occurs in great abundance in the Rochester shale of New York, and at Waldron, Indiana.

Known from Carroll County, Pendleton, Connor's Mill, and Georgetown.

Bucania sp. undet.

Pl. XI, fig. 3.

A fragment of a *Buchania* similar to those figured in Vol. II, Pal. N. Y., Pl. 76, Figs. 5, 6, was found at Georgetown.

Pleurotomaria (?) *idia* Hall.

Pl. XII, fig. 6.

Spire depressed convex. Width of the shell two or more times the greatest height. Volutions three or four, very gradually increasing in size; not marked in the casts by any peripheral band or keels. Umbilicus broad and open.

A large cast referred to this species has a height of 45 mm., and width of 21 mm., and there are apparently only three or three and a half whorls. In all other respects it is like the typical forms described from Racine, Wisconsin.

Rare. Huntington.

Pleurotomaria laphami Whitfield.

Pl. XI, fig. 4.

Spire conical, moderately elevated, apical angle about ninety degrees or less. Volutions three to three and one-half, subtriangular, flattened exteriorly in the direction of the apical angle, subangular in the periphery and rounded below; suture distinct in cast, indistinct on surface of shell; umbilicus large. Surface of shell smooth or marked only by striæ of growth.

The above description is drawn mainly from Whitfield. The species is occasionally seen in the form of casts at Delphi.

Pleurotomaria hoyi Hall.

20th Rep. N. Y. State Cab. Nat. Hist., 1867, p. 364, pl. 15, fig. 10.

"Shell broadly depressed—conical. The spire moderately elevated, consisting of about four volutions, which are gradually enlarged from the apex, the last one being slightly ventricose toward the aperture. Volutions flattened on the upper side, and the entire height of each one showing above the other; periphery somewhat flattened, with a depressed band truncating the upper angle. Lower side of volutions flattened, except the outer half of the last one, which is rounded toward the aperture and abruptly descending into the wide umbilicus.

"Surface finely striated on the lower side of the volution, with a deep retral curve on the band, where the striae are somewhat fasciculate. The periphery of the cast is sometimes marked by three or four strong, but obscure striae below and parallel to the revolving band."

The above description by Hall is based upon much better material than the collection at hand affords.

This species is represented by casts from Delphi.

Pleurotomaria pauper Hall.

Pl. XII, figs. 5, 6.

"Shell small, depressed conical, the apical angle being about seventy or seventy-five degrees; volutions three or four rounded and somewhat rapidly increasing in size from the apex; the aperture has been a little longer than wide. The specimens occur in the condition of casts, which preserve the evidence of a spiral band a little above the middle of the volution, and between this and the suture line there is a slightly elevated line or carina.

"The surface of shell is unknown."

The above is the original description of the species (20th Rep. N. Y. State Mus., p. 343).

Casts and moulds of this species occur in the quarries at Huntington.

Pleurotomaria sp. undet.

A single quite remarkable fragment belonging to a probably undescribed group of the *Pleurotomarias* has the following characters (only the body whorl is preserved):

Width of body 35 mm., height 18 mm. Whorls subcircular in section, columella solid, narrow; umbilicus quite wide but shallow. Slit-band prominent, vertical, elevated at the periphery, slightly concave. About midway between the band and the suture there is a strong raised line, which is one-third as wide as the slit-band. Between this line and the suture the surface is marked by strong, rounded, transverse undulations. From the line to the slit-band, the surface is smooth except for faint traces near the line of the undulations. The surface markings are faint lines of growth which follow the undulations. Above the slit-band, where the undulations die out, the striae swing back at an angle of between forty

and sixty degrees. There are apparently no other revolving markings. In the markings above the slit-band, this species is remarkably similar to the *Pleur. dolium* of Lindstrom, but is decidedly distinct in all other respects. There is also a resemblance in the presence of a sort of revolving line between the band and the suture to some of the forms referred by Clarke and Ruedeman to *Lophospira*.

One specimen. Old Deer Creek channel (2A3), Delphi.

Pleurotomaria (?) axion Hall.

Pl. XII, fig. 4.

Shell subconical, volutions about four, contiguous, the upper ones increasing gradually in size; the body whorl is greatly enlarged. Suture nearly transverse, deeply impressed with more than half the preceding volution* exposed above it. Whorls rounded to ventricose, nowhere flattened nor sharply angular.

Mouth very large, about half the length of the shell. Inner lip long, directly anteriorly, slightly recurved. Slit-band at the middle of the body whorl, but in the upper whorls a little more than its width above the suture. In the Bridgeport, Ill., specimens, there are, according to Hall, "strong revolving striæ which are crossed by concentric striæ of less strength giving a cancellated structure." The aperture is not preserved in the Illinois specimens so that its description is drawn from the Huntington specimen. This is an external mould which, with the exception of the faintly-preserved carina, shows no surface markings. Its height is 48 mm., width, 28 mm.

There is a rather close resemblance to the variable European *Pl. lloydii*, but the inner lip of the American species is much longer and recurved.** In our form also, it cannot be determined whether this recurved cylindrical lip is hollow (a canal), or solid.

Rare. Huntington.

Pleurotomaria eloroidea n. sp.

Pl. XIII, figs. 1, 2.

Shell subconical, medium sized. Whorls contiguous, about four in number. Sutures not deeply impressed, and nearly

*Exclusive of the prolongation of the inner lip.

**The direction of this "recurvature" is the opposite to that ordinarily met with; that is, the inner lip is concave in a view into the aperture.

transverse. Whorls depressed above, broadly rounding off down to the peripheral band; outline slightly concave just above the concave (?) slit-band. The lower border of the slit-band is developed into a rim or flange, the inner edge of which forms the suture. Surface or character of the volution below the slit-band unknown. The markings consist of strong lines of growth and revolving lines. The former begin quite transversely from the suture, but after extending in this direction two-fifths the distance to the keel, they swing back in a broad curve, become almost parallel to the slit-band for a short distance and just above it, and then develop slight lunulæ on the band. By the unequal crowding of these lines of growth, the surface is thrown into very low, indistinct folds. The revolving lines are very fine, and nearly a millimeter apart.

Known from a single specimen which has a width of 50 mm., height from apex to flange, 18 mm., half of this partial height being in the body whorl.

There is a very close resemblance in the outline and rim of this species and that present in the genus *Euomphalopterus*, but an examination of the characters described above will reveal the fact that not even a generic identity can exist between the two. The broad backward swing of the striæ above the slit-band and their direction parallel to the latter just above the band, show the presence of a very deep notch and of a slit (?) not found in *Euomphalopterus*. The flange also is a free extension of each border of the slit-band (see Pl. XIV sp. cf. *eloroidea*) so that the similarity between *Pleurotomaria eloidea* and *Euomphalopterus* is wholly superficial. There is no sigmoid curve to the striæ and the flange does not rest on the lower whorls as it does in *Euomphalopterus*, but these are minor characters.

A generic comparison may perhaps be made with *Mourlonia*, but the extension of the flange along the suture in our species at once distinguishes it from that genus in which the flange is exposed near the middle of all the whorls.

There is some resemblance in outline between our species and the *Pleurotomaria elora* of Billings.

Rare. Delphi.

Pleurotomaria cf. eloroidea.

Pl. XIV, fig. 3.

Shell very large, resembling the preceding in outline and in surface markings.

The slit-band in the form now described is very plainly convex. It is bordered on both sides by diverging curved flanges. The lunulæ are shallow and evenly convex. The striæ of growth in the upper portion of the whorl swing back, and this backward swing is continued across the slit-band and lunulæ.

The characters described show a close similarity to *Mourlonia*, from which our shell differs in having plain crescents, and the flanges disposed along the suture. It occupies an extremely important position which can not be overlooked between *Euomphalopeterus* and *Mourlonia*, and forming a phylogenetic series with those two in the order named. A recurving of the upper face of the flange would be almost all that would be required to develop from *Euomphalopeterus* the form represented by our species. The development of the whorls so that the flanges would be on the periphery instead of on the suture would generate a form which would very easily pass off into the *Mourlonia limata* type by the chronogenetic addition of the lobe to the crescent.

Rare. Huntington.

Euomphalopeterus alatus var. americanus n. var.

Pl. XIII, fig. 6.

Shells small depressed conical, consisting of three to four very gradually increasing and contiguous whorls. The volutions are subcircular in cross-section; horizontally flattened or depressed convex near the suture, sharply rounded at the sides, and rounding off into the umbilicus. The latter is very wide and included in a broad columella which is as wide at the base as the cross-section of the body whorl. At the middle of the periphery is a very sharp and projecting carina or rim, somewhat similar in character to that in the *Murchisonia worthenana* of Miller, and especially to the forms of *Pleur. alata* from Gotland. The surface is covered with close-set, transverse lines which arch very strongly forward over the rim or flange. Some of the striæ dichotomize on both faces of this flange. There is an obscure line or ridge concentric with, and near to, the inner edge of the flange.

The suture between the whorls is along the bottom face of the rim, which, when flattened over the upper portions of the younger whorls, presents a false appearance of a shoulder. Apertural characters unknown. The rim extends all along the suture, and may be traced almost to the initial whorls. The striæ as exposed on the upper face of the rim along the sutures, are straight and pointed forward.

Two specimens have respectively the following dimensions: Width, 10 mm. and 6 mm.; height (approximate), 5 mm. and 3 mm.

This shell belongs to the group of the *Pleurotomarias* designated by Roemer in 1876, *Euomphalopterus*, with *E. (Pleur.) alatus* as the type. It includes *Pleurotomaria alata*, *pretexta*, *togata*, *frenata*, *undulans*, *marklini*, and among American forms the *E. alatus* of Ulrich, which was recently (1897) described by that author as coming from near Waldron, Ind. The group is characterized by the expansion of the "slit-band" into a rim or flange which extends along the suture line. There is no slit, and in most of the typical forms the striæ are directed forward to the rim. There are no revolving bands and only rarely faint revolving markings. This is perhaps the most strongly marked and easily separated group of the *Pleurotomarias*.

The variety described above is very close to Lindström's variety *opposita*, but the American form is a much smaller shell with lower spire and fewer whorls, and with the striæ when dividing, bifurcating instead of being divided into a brush as in the Gotland variety. From Ulrich's variety and also from true forms of *Euomphalopterus*, the variety described above differs in having the band situated at the middle of the periphery and having the whorls regularly rounded.

Though apparently widespread and abundant in Europe, *Euomphalopterus* is quite rare on this continent, where Ulrich's variety has been the only representative known up to date. A closely allied form is the *Murchisonia worthenana* of Miller, which is probably equivalent to *Pleurotomaria (Mourlonia) limata* of Lindström, though Miller's name has priority. In *Mourlonia* the striæ always curve backward to the band, there is a true slit-band, while the rim, instead of extending along the suture as in *Euomphalopterus*, is exposed some distance above the suture near the periphery

of the upper whorls. There are also some minor differences which will be noticed later.

Rare. Little Deer Creek, Carroll County.

Euomphalopterus alatus var.

A single specimen of a third variety of this species resembles a large form of the variety *americanus*; but is discoidal, almost plane-coiled. The flange along the suture is the only important character observed. It has not the smaller line or ridge near the inner edge possessed by the variety *americanus*, and the striae on the flange are almost straight, pointed forward, and crenulated by very fine, faint, revolving lines, which are barely visible under a strong magnifying glass.

Rare. Georgetown.

Euomphalopterus alatus var. *limatoidea* n. var.

Pl. XIV, fig. 4.

Shell very large, depressed turbinate. Whorls four or five or more, contiguous, flattened above by the sutural band, turned in a broad curve downward, slightly concave just above the flange, and continuing below the latter in a nearly horizontal plane, curving upward toward the middle. The flange is therefore on the lower margin of the periphery, and may almost be said to bound the umbilicus. The umbilicus is very broad. The surface is marked by striae arching forward to the flange, and also by revolving lines.

A single, large specimen, belonging to the Indiana State Museum, has an approximate height of 36 mm., and a width of 70 mm. The body whorl is 23 mm. high.

This form, as the name is intended to signify, is intermediate between *E. alatus* and *Pleur.* (*Mourlonia*) *limata*. It is larger than either, and has a greater umbilicus and lower spire. Its markings are very distinctive. It should more probably be made a separate species.

Rare. Delphi.

Murchisonia (*Turritoma*) *lophami* Hall.

Pl. XIII, fig. 7.

Shell rather large, turreted, height several times the width. Volutions contiguous, seven or eight in number, and increasing gradually in size. Sutures close and oblique. Sides straight or

flat, sloping from the suture to the slitband, which is concave, but becomes almost flat on the body whorl, where its height is one-sixth the height of the whorl. The lower portion of the volution is ventricose. The band is in the center of the body whorl, but in the upper whorls it is half its height above the suture.

Owing to the unnatural and improper divisions which have been formed from *Murchisonia*, it is preferred in this paper to regard all the species thereof as species of the original genus.

Several casts and moulds of this species have been obtained at Huntington. One mould of the three lower whorls showed a height of 44 mm., width 23 mm., height of body whorl 22 mm. The outline, etc., seem to be the same as in typical forms of *M. laphami*, but the slit-band of the Huntington specimens is rather wider than that of the Wisconsin material.

Murchisonia (Coelacaulis) bivittata Hall.

Pl. XIII, fig. 4.

Shell very elongated, consisting of about twelve rounded volution without trace of carina, but with a strong biplicate columella.

The plicate columella and the absence of the dorsal band are characters which should remove this species from the *Murchisonia* group.

A large internal cast referred to this species was found at Huntington by Mr. Gilbert. There are six of the lower plications exposed, showing a height of 50 mm., a width at the base of 29 mm., and at the summit of 14 mm. There are obscure traces of revolving lines on the surface and of a plicate columella in the highest whorl.

Rare. Huntington.

Murchisonia sp. undet.

Fragments of a very large species of *Murchisonia* are quite common at Huntington. The specimens are larger and differ from any of the species of that genus hitherto described from the Silurian. An idea of the size may be obtained when it is stated that a cast of the body whorl and one upper whorl has a height of at least 54 mm. The whorl above the body whorl has an exposed height of 18 mm. There are several specimens quite as large as the one mentioned. The uppermost portion from the suture down

to the shoulder, is flat, or perhaps a trifle concave. From the shoulder the sides extend straight downward, making with the upper, flattish portion an angle (in profile) of about 135 degrees. The base of the whorl is broadly rounded. A section of the body whorl is subhexagonal, higher than wide, with the suture at the upper angle. In the upper whorls only the flat, sloping portion from the suture to the shoulder and the vertical sides are exposed. There is a general resemblance in the contour of the whorls to those of *Trochonema fatuum* Hall, but our form is evidently a turreted *Murchisonia*, much larger in size, and the vertical sides in Hall's species are smaller than in ours.

Two or three other species of large *Murchisonias* occur at Huntington, but they are unidentifiable. It is an interesting fact that no species of this genus have hitherto been recorded from the Silurian of Indiana.

Common. Huntington.

Oriostoma huntingtonensis n. sp.

Pl. XIV, figs. 14, 15.

Shell turbinate, fairly large, consisting of three or more rounded volutions which are circular in cross-section and increase gradually in size. The whorls are contiguous, and each shows almost its entirety above the others. Shell substance thick and composed of at least three layers. The outer one is marked by strong revolving ribs with the interspaces concave and about equal to the ribs in width. The umbilicus is large and open, and is bounded by a very strong keel, which is stronger than any of the other keels on the surface. With the exception of traces of another keel in further in the umbilicus, the only markings observed in the latter are faint revolving striæ. The finer surface markings are but poorly preserved, and the test is found only on the lower half of the body whorl of the type specimen. This shows ten ribs in 17 mm. from the umbilicus to the middle of the periphery. Aperture unknown.

The specimens have the following dimensions:

	<i>Height.</i>	<i>Height of Body Whorl.</i>	<i>Width.</i>
Type	35 mm.	24 mm.	43 mm.
Second	36 mm.	25 mm.	46 mm.
Third	36 mm.	23 mm.	45 mm.

This species is closely related to the forms of *O. macrolineatum* as found in the Guelph limestone at Elora and Durham, C. W., and also to *Poleumita scamnata* of Clarke and Ruedeman, but the Indiana forms are distinct. The specimens found at Huntington show much stronger and more closely-set ribs, while the remarkable keel bounding the umbilicus is a feature never seen in any of the others, in which respect our forms are very close to the Gotland species described by Lindström.

Rare. Huntington.

Oriostoma (?) *opereula*.

Pl. XIV, figs. 10-13; Pl. XI, fig. 6.

Opercula referred to this genus have been found at Huntington by Mr. Gilbert, who, after a search of several years, has brought to light four of these specimens. They are all low cones. The apical region (the nucleus) is nearly smooth, but beginning a short distance from the center are eight to thirteen nearly lamellose coils, the number varying with the individual. The marginal characters are indistinct, but there seems to have been a low cylindrical extension rather than a flat band.

A natural mould at hand shows the characters of both the exterior and interior surfaces of the operculum, the specimen preserving about five-sixths of the latter and one-fifth of the former. The outer half of the interior surface is nearly flat and surrounded by a wide rim. From nearly flat the surface changes to moderately concave toward the center, a small circular, rather shallow pit appearing at the center. The interior surface is smooth except for a slight depression and groove on one side, which may not be structural features.

Following is a short tabular account of their characters:

Specimen.	Width.	Coils.
1.....	22 mm.....	7¾
2.....	23 mm.....	9
3.....	29 mm.....	13
4.....	23 mm.....	11½

The specimens may doubtless be referred to *H. huntingtonense*. The size of the mouth in the known specimens of that species corresponds very well with the size of numbers 1 and 2. Both the opercula and the type of *P. huntingtonense* were found in the same quarry.

Oriostoma huntingtonensis var. *alternatum* n. var.

Pl. XIV, fig. 9.

This differs from the above in the surface markings and in being a little more depressed. The markings from the umbilicus to the suture consist of eight or nine rather more distant ribs than are met with in the typical forms of the species, while between each pair of these ribs is a fainter one. The stronger keels are equal in strength, but the fainter, alternating ones, are obsolescent near the suture, and gradually increase in strength, descending toward the umbilicus until the lowest one is quite equal to the strongest keels. The umbilicus is wide and open, and is marked by faint revolving striæ and by a sharper keel near the middle.

Two specimens, preserving only the body whorl and part of the upper. Both show a width of the former of 34 mm., and a height of 17 mm. Both were found at Huntington.

Oriostoma plana n. sp.

Pl. XIV, figs. 7, 8.

Shell discoid, with the apex of the spire varying from the plane of the upper side of the whorls to depressed, so that the umbilicus of the apical side is almost equal to that at the opposite side. Volutions 3 to $3\frac{1}{2}$, contiguous, regularly rounded and as wide as high or wider, increasing very gradually in size. Surface marked by 10 or 12 sharp revolving bands, which become closer, more crowded and stronger toward the periphery. The interspaces are flat or slightly concave, and about $1\frac{1}{2}$ times as wide as the bands. These bands are crossed by very fine, clearcut, imbricating lamellæ, which arch slightly backward between the revolving bands, and swing forward across the ridges of the latter. The lines of growth, however, as seen in well-preserved casts, are much finer, more numerous, closer and less regular than the imbricating lamellæ, and arch forward between the ribs and swing gently backward across the ridges. These lines of growth are crossed by extremely fine revolving lines, barely visible under a strong lens.

In the number and disposition of its revolving ribs and in the depression of the spire, this very prettily marked shell is intermediate between *O. angulatum* and *O. lineatum*. In the finer markings there is some resemblance to *Poleumita scamnata*, but that

species as described and figured by Clarke and Ruedeman is clearly different from our shell.

The type specimen from Georgetown has a width of 18 mm. The body whorl just back of the mouth is 8 mm. wide. The height of the shell (the height of the body whorl) is $7\frac{1}{2}$ mm. A second specimen from Georgetown has these respective dimensions: 15 mm., 7 mm., $6\frac{3}{4}$ mm.

Oriostoma sp. undet.

Pl. XIV, figs. 1, 2.

Shell large, turbinate. Volutions five in number, the apical one minute, the lower ones increasing in size rather rapidly, but regularly; whorls subcircular in cross-section. Sutures transverse, impressed, exposing nearly all of the whorl above. The upper portion of the volution is flat or very much depressed, convex; from this, broadly rounding off in subangular arches toward the umbilicus. Umbilical and apertural characters unknown.

Surface marked by low, unequal, longitudinal ribs, which are rather distant and narrow. These are crossed by peculiarly wavy, transverse striæ. From the suture to the first rather prominent rib, a distance of $2\frac{1}{2}$ mm., the striæ arch backward; but thereafter, between each pair of ribs they arch forward. These markings are on the inside of the outermost layer or else on the outside of the next inner layer of the shell, and correspond in position and in direction to those on the "casts" of *O. plana*.

In the outline of the body whorl, and especially in the flattened upper portion, there is a resemblance to *Pleurotomaria eloroidea*, and this resemblance is increased by the low ribs. But the peculiar direction of the transverse striæ is sufficient evidence to include the shell described above in the genus *Oriostoma*, or perhaps in *Poleumita*.

One specimen. Huntington.

Schizolopha sp.

Pl. XII, fig. 3.

A single shell belonging to the State Museum has the following characters:

Medium-sized, turbinate; slightly higher than wide. Aperture two-fifths and body whorl two-thirds the height of the spire.

Mouth (as shown by the lines of growth) very deeply notched. Slit-band convex, not quite vertical, producing a subangular periphery. Profile above the slitband depressed, almost horizontal, forming a broad, low, double curve to the suture. Surface marked by distant, strongly elevated lines of "growth." Between these strong lines are 6 to 20, usually 12 to 15, very fine, even, raised lines, parallel to the lines of growth. The whole is crossed by fine concentric, revolving, raised lines, intermediate in strength between the two kinds mentioned above. The revolving lines are two or three times as far apart as the finer lines of growth. The species differs from *Clathrospira* in the convex slit-band. The aperture is not exposed, so that the presence of a slit is doubtful. In all other characters there is a generic resemblance to *Schizolopha moorei* Ulrich.

Should our species prove to be new, as it probably is, we would suggest the specific name, *S. (?) prosseri*, named after Prof. C. S. Prosser, of the Ohio State University.

One specimen. Delphi.

Cyclonema cancellata Hall.

Pl. XIV, figs. 5, 6.

A small but very well preserved specimen has the following characters:

Shell small, turbinate; volutions four or more, the upper ones small, rapidly but regularly increasing in size to the body whorl, which is very large, and constitutes six-sevenths the height of the spire. The whorls are, as shown by the mouth, oblique-vertically oval in section. The outer lip is not perceptibly expanded. The inner lip is slightly reflexed and is produced anteriorly so that the small umbilicus is exposed nearly at the middle of the length of the shell. The sutures are deeply impressed and quite transverse. Shell substance extremely thin, covered by revolving lines, one of which, near the periphery, is only slightly more prominent than the others. These lines are obsolescent in the umbilicus, and then become subequal, frequently double and about twenty in number up to the near suture, where they suddenly terminate. The interspaces are wider than the striae. Just below the suture there is a smooth space with three or four hardly perceptible, revolving lines.

The shell is marked also by extremely faint but distinct, raised transverse striæ, which extend obliquely backward from the suture across the longitudinal striæ. The latter are very much stronger than the transverse striæ.

The height of the shell is approximately 9 mm.; thickness, 6 mm.; width, 8 mm. The species may be recognized by the turbinate-turriculate outline, and by the fine revolving and finer transverse striæ. There is a strong resemblance to the *Turbo (Cyclonema) tennesseensis* of Roemer, but that species has forty revolving lines, while ours has about twenty, a few of which, however, are double. In the Georgetown specimen the transverse striæ are very much closer than in the *Cyclonema cancellatum* from the Clinton green shale of New York State.

Rare. Georgetown.

Cyclonema elevata Hall.

Pl. XIII, figs. 3, 5.

Shell turriculate, height $1\frac{1}{2}$ times the width. Spire consisting of five volutions, which increase very gradually in dimensions. Volutions in the casts regularly rounded, but the surface (which has never before been known) shows that the upper part of the body whorl is depressed convex, almost flattened, while the lower part is ventricose. The surface is marked by from four to six low longitudinal ribs, which become obsolescent on the upper and lower portions of the body whorl and on the upper portions of the older whorls. There are obscure lines of growth. The lower two-thirds of the whorl next to the body whorl shows three or four ribs. There is no median keel, nor is there any appearance of there having been a slit. A very narrow but distinct umbilicus is present.

This species may be distinguished from *Eunema* (?) *trilineata* by the greater narrowness of the latter. If *E. trilineata* really is a *Eunema* it should have no umbilicus whatever, and this is, therefore, another distinctive character.

The two specimens known, which are both larger than the Wisconsin forms, have a length of 35 mm. and a width of 24 mm.

An external mould of *Cyclonema elevata* has been obtained at Huntington, Ind. Another specimen, consisting of an external mould and its internal cast, was found in the quarries (5/A) one mile east of Huntington.

CEPHALOPODA.

Orthoceras medullare Hall.

Pl. XIX, figs. 1, 2.

Shell a longicone, large, sides straight, tapering at an angle of from 9-12 degrees. Section circular or subcircular, broadly elliptical when compressed. Chambers deep, siphon central, tubular, not at all expanding between the septa. The chambers do not perceptibly deepen with age. In one specimen having a width of about 36 mm. the chambers are 17 mm. deep. In another large specimen the chambers are 24 mm. deep where the shell is 63 mm. wide. Surface without annulations or longitudinal ridges; the specimens of Hall and of Meek and Worthen show, however, beautifully cancellating striae.

The species may be recognized by the distant septa and the absence of either annuli or ridges in the cast.

Ten large specimens have been obtained at Delphi, and one large specimen from a locality one mile west of Anderson.

Orthoceras (Kionoceras) orus Hall.

Pl. XXI, fig. 1; Pl. XXV, fig. 2.

Shell a longicone, large, tapering quite rapidly; section broadly oval, sometimes becoming circular or narrowly oval through rock pressure. Septa fairly distant, deeply concave; siphon small, placed three-sevenths the distance from one side to the other. Casts marked by longitudinal ridges; no annulations. Depth of the chambers varying from one-fourth to one-third the width.

Several specimens of body chambers from Huntington are referred to this species. These, together with a specifically identical chamber from Delphi, are circular or subcircular except when evidently much crushed, and bear the longitudinal ridges at the base. Higher up, these ridges become obsolescent. Just behind the mouth there is a broad constriction, below which the chamber is cylindrical. These body chambers are usually about 35 mm. wide and about 65 mm. high.

A narrowly ovate specimen from Wabash, now in the Indiana State Museum, is 175 mm. long, 35 mm. wide at one end and 54

mm. wide at the other. It shows 17 chambers in that distance. A couple of specimens from west of Anderson may be referred to this species.

Rather common. Huntington, Delphi, Wabash and Anderson.

Orthoceras (Kionoceras) delphiensis n. sp.

Pl. XX, figs. 1, 2.

Shell large, straight, tapering slightly, sides almost parallel. Section circular, with tubular siphon between the center and the margin or submarginal surface marked by low, narrow longitudinal ridges, of which there are eleven in 75 mm., at a point where the shell is 47 mm. thick. The ridges are perceptibly closer on the side on which the siphon is situated, where they seem also to be more pronounced. The interspaces are concave, several times as wide as the ridges, and seem to have been covered with coarse longitudinal striæ. There are also transverse striæ. The body chamber is a little constricted just back of the mouth.

The type specimen now in the Indiana State Museum is a fragment with a length of 162 mm., a width of 50 mm. at the mouth, and of 45 mm. about 120 mm. further back. The shell and siphon are greatly thickened.

This species may be recognized by the narrow and distant ridges, the absence of annulations, the slightly constricted mouth and thick submarginal siphon. The large size and straight sides are also distinctive features. It is hardly separable from the *Orth. angulatum* of Worthen, which shows the same thickening of the siphon. In Wahlenberg's species, however, the siphon is more nearly central, and there are some minor differences.

Besides the type, three other fragments have been found at Delphi.

Orthoceras (Kionoceras) kentlandensis n. sp.

Pl. XXI, fig. 2.

Shell a longicone, small, sides straight, slowly tapering. Section slightly oval (due to pressure ?); septa distant, almost flat; siphon large, eccentric. The depth of the chambers is more than half the width of the shell, except near the body chamber, where a few septa become crowded. Surface marked by longitudinal ribs which are quite faint in the cast.

This species is known from a single cast now in the Indiana State Museum (No. 685), which has a length of 78 mm., width at upper end 11 mm., at lower end 7 mm. At the lower extremity there are seven chambers in 32 mm., but just below the body chamber there are only five compartments in 9 mm. Twelve mm. above the base of the body chamber is a raised line, origin unknown.

This form can be recognized by its very distant septa. From *Orth. jolietensis* of Meek and Worthen, this species may be distinguished by the absence in the former of the longitudinal ridges, and the shallowness of the septa in the latter. Our species is also a much smaller shell.

Rare. Kentland.

Orthoceras (Geisonoceras) niagarensis Hall.

20th Rep. N. Y. State Cab. Nat. Hist., p. 356, pl. 20, fig. 3.

The following is Hall's description:

"Shell elongate, gradually tapering; section broadly elliptical; septa deeply concave; depth of chamber 5 lines where the diameter is $1\frac{1}{2}$ inches; siphuncle eccentric. Surface annulated by low, rounded annulations which are from one to two inches distant, according to the size of the shell; intermediate spaces regularly concave. In the larger parts of the shell there are about three annulations to each chamber. The finer surface markings unknown. The section in all the specimens examined is elliptical."

An important feature which Hall figured but failed to describe is the fact that the undulations are very oblique, especially on the wider portions of the shell, but become less oblique in the successive older parts of the same.

A single fragment is referred to this species, 54 mm. long, 14 mm. wide at the lower end, and 18 mm. wide at the upper end. The cross-section is elliptical and the septa are deep so that it corresponds almost exactly with the above. The annulations, though, are weaker and fewer in number, and the chambers comparatively deeper in our specimen, but these are characters which one would expect to find in the young of such a species.

Rare. Quarry one mile west of Anderson.

Orthoceras (Dawsonoceras) cf. annulatum Sowerby.

Pl. XIX, figs. 3, 4.

The Gilbert collection contains a fragment of an *Orthoceras* which is very closely allied to this species. The specimen is nearly 90 mm. long, 58 mm. wide at the broader end, and shows seven sutures in that distance. The annulation is not midway, between the sutures, but is nearer the older suture. The shorter slope of the annulation is depressed convex, and the longer slope with the normal concavity.

Rare. Huntington.

Orthoceras (Dawsonoceras) annulatum var. americanum Foord.

Shell a longicone, small to medium sized; slowly tapering; section circular. Characterized by strong annulations, with concave interspaces; the suture in the middle of each interspace. Septa deep, siphon central. The depth of two or three chambers is equal the breadth of the shell. Surface marked by transverse and longitudinal striæ.

It can be recognized readily by the character of the annulations, which are always strong in casts.

The collection contains about ten fragments, the largest 33 mm. wide. None of the surface striæ are preserved.

Rather common. Delphi.

Orthoceras (Kionoceras) angulatum Wahlenberg.

Pl. XXI, fig. 3.

Shell tapering gradually. Septa distant about one-fourth the diameter of the shell; siphuncle central or subcentral. Surface marked by angular longitudinal ridges.

Rare. Anderson.

Trochoceras (Sphyradoceras) cf. desplainense McChesney. (?)

20th Rep. N. Y. State Cab. Nat. Hist., 1867, p. 359, pl. 16, figs. 8-10.

Shell a torticone of 2 to $2\frac{1}{2}$ volutions, dextral spire very low; cross-section ovate, with flattened sides; siphuncle small, near ventral margin. Surface and casts marked by distinct, sharp ridges, directed backward across the sides and with flat or concave

interspaces. Fine markings consist of minutely cancellating, sub-equal, transverse and longitudinal striæ. (The description above is drawn mostly from that of Clarke and Ruedeman.)

A couple of fragments of casts apparently belonging to this species were found at Huntington.

Lituities marshii Hall.

Pl. XXI, fig. 4.

The principal features are shown by the figure.

This species is distinguished by its slender and more numerous volutions from *L. bickmoreanus*.

Represented by a single specimen from Wabash.

Lituities (Ophidioceras) bickmoreanus Whitfield.

Pl. XXV, fig. 1.

Shell large, thick; plane-coiled outer volution free and extending in nearly a straight line; subcircular in cross-section, depressed convex or nearly flattened on the back. Surface marked by broad bi-convex undulations, which have ventro-lateral sinuses, swing back across the side and develop a strong dorsal saddle. The undulations are obsolescent on the back and absent near the mouth. The base of the saddle is opposite the sinus of the third or a little nearer to that of the second undulation back. The interspaces are concave.

The finer surface markings according to Whitfield, consist of "almost microscopic lines which run lengthwise of the coils, and also in finer transverse lines of which three occupy the space of one of the longitudinal lines. The septa are moderately concave and are arranged at distances from each other less than that between the transverse undulations of the sides, so that ten of them occupy a distance equal to eight of the undulations."

This species may be readily recognized by its large size, and its low undulations, both of which characters distinguish it from *L. (O.) marshi*, and *L. (Trocholites) multicostatum*, etc., and also from *Trochoceras (Sphyradoceras) desprlinense*, the latter of which is not plane-coiled.

The species was described by Whitfield in the Bulletin of the American Museum of Natural History, Vol. I, No. VI, pp. 191-

192, Pl. xxi, Figs. 1-3. His specimens are from the dolomitic limestones of the Niagara group at Wabash City, Indiana. Our specimens agree very closely with Whitfield's species. The Huntington specimen is a fragment from just back of the mouth. It is about 60 mm. long, with a lateral width of 35 mm. and ventro-dorsal thickness of 30 mm. The angle at the dorsal saddle is a trifle sharper than that in Mr. Whitfield's figures.

Another large fragment was found at a mile west of Anderson (Madison County). The latter is from an individual which must have been over a foot in diameter. The septal sutures are preserved and show a low dorsal saddle, the result of a dorso-lateral sinus on each side. The saddle is under the third undulation from that at which the suture is observed on the ventral side. The dorso-ventral thickness in this specimen is greater than the lateral.

Rare. Delphi, Huntington, Wabash and Anderson.

Lituites (Ophidioceras ?) hereules carrollensis n. var.

Pl. XVI, fig. 1, and Pl. XVII, fig. 1.

Shell very large, nautilian, with the body chamber free and extended in an arched line. Cross section ovoid, flattened on the sides, with ventral and dorsal faces rounded, the latter more broadly so; greatest breadth just above the center; ratio of breadth to thickness is 10:11. Siphon eccentric but not marginal. The casts are marked by very broad, low undulations, each with a dorsal saddle. Near the ventral side* there are some longitudinal ribs, but both styles of markings are very obscure in the internal casts.

This variety may be easily recognized by the very large size, the flattened sides, and the peculiar curvature.

The type is a fragment of the body chamber with a few septa which are indistinct. The fragment has a length of 190 mm., breadth 60 mm., thickness 67 mm. The body chamber is 150 mm. long, but when entire must have been at least twice that length. The septa are rather distant, directed backward across the sides, and are furnished with shallow lateral sinuses and a dorsal saddle. Another fragment has a breadth of 67 mm., and thickness

*In the ventral side there is also observable in the type specimen a very shallow groove which should serve to place this form in the genus *Remeleceras*, provided that this groove is normal to this species.

of 75 mm. The depth of the dorsal saddle of the undulations is about 40 mm.

Represented by two specimens from Delphi.

Trimeroceras gilberti n. sp.

Pl. XV, fig. 1.

Shell breviconical, large, the lower portions of the ventral and dorsal sides converging at an angle of nearly 50 degrees. Section ovoid, rather pointed ventrally. Septa distant, 8 in 45 mm. There is a distinct saddle at the ventral side and an azygous sinus at the dorsal, with only one very shallow sinus on each lateral face. Body chamber large, broader than high. Siphuncle one-third the distance from the ventral face to the center. Dorsal periphery of the body chamber vertical, ventral periphery divergent from the base, both depressed convex. The upper side of the body chamber is rather flat, and parallel to the plane of the basal edge. The slit is narrow. Character of the apertural lobes unknown. Surface of septa with rather weak longitudinal ribs. Following are some statistics regarding these forms:

Length of specimen with body chamber and 11 septa.....	135 mm.
Length of the eleven septa.....	80 mm.
Length of body chamber.....(1) 72 mm. (2) 75 mm. (3) 83 mm.	
D.-V. thickness at base (body ch.)....	88 mm. 87 mm. 89 mm.
D.-V. thickness half way up (body ch.)	101 mm. 100 mm. 112 mm.
Lateral thickness at base (body ch.)..	68 mm. 63 mm. 65 mm.

(1), (2), and (3) refer to 3 other specimens.

The species is readily distinguished by its rapidly tapering, conical shape. The body chamber is recognized by the parallel bases and subordinate height. There is a resemblance to *Phragmoceras nestor*, var. *canadense* Whiteaves, from which our species differs in having the upper and lower bases of the body chamber parallel. Named after Mr. Gilbert, to whose kindness in loaning material the opportunity of studying much of the Huntington *Gasteropoda* and *Cephalopoda* is due. The type and specimens described above are from Huntington, Ind.

Rare. Huntington and Delphi.

Hexameroceras delphicum Newell.

Proc. Bost. Soc. Nat. Hist., Vol. XXIII, p. 479, figs. 1-4.

Shell an arcuate brevicone, medium sized; transverse section broadly ovoid, almost pointed at the ventral side; greatest breadth

eleven-twelfths of the thickness and situated two-thirds of the distance to the dorsum; siphon ventral, submarginal.

Chambers shallow, three of them with a total depth of 8 mm. on the ventral side and 16 mm. deep on the dorsum. Septa almost flat. Sutures straight with no perceptible sinus or saddle. The chamber adjacent to the body chamber has half the depth of those following it, and has the anterior margin crenulated. The body chamber is dome-shaped, wider than high, with all the sides rounded and with a contracted aperture. The dorsal opening of the living chamber is furnished with three lateral lobes on each side of a narrow median slit which connects them with the single ovate ventral opening. The length of slit and opening equals about five-sixths of the dorso-ventral diameter.

Faint indications of fluted longitudinal markings are present on the septa. The body chamber is 25 mm. high, 39 mm. wide and 43 mm. deep. The specimens described differ from Newell's description of the species in having the margins of the septa nearly straight instead of curved. In other respects the present specimen agrees closely with *H. delphicolum*.

Rare. Huntington.

Cyrtoceras gorbyi Miller.

One specimen from Huntington is referred to this species.

Gomphocera wabashensis Newell.

Pl. XX, figs. 3, 4.

Shell a brevicone, small, straight. Septa of moderate depth; siphon moniliform, situated one-third to one-half distance from ventral margin to center. Body chamber conical with the sides nearly straight, converging toward the apex at an angle of about 20 degrees. Aperture simply T-shaped, without any accessory lobes. Cross-section circular to broadly oval.

It may be distinguished from *G. scrinium* by the more conical and proportionally longer living chamber.

This species is quite abundant at Huntington, where about ten specimens have been found. They are preserved as casts of the body chamber. The largest has a height of 53 mm., thickness at the base 40 mm., breadth 34 mm. Another large specimen has a thickness of 39 mm., and width of 36½ mm. The smaller forms are circular in cross-section.

There is a single specimen in the Indiana State Museum which, labeled *G. subgracile*, is from Delphi.

A single specimen was found at Georgetown.

Phragmoceras parvum Hall and Whitfield.

Shell a small, arcuate, brevicone. Septal portion half the length. The species may be easily recognized by its small size, the tubular extensions of the aperture, and the sharp angle formed by the edge of the aperture and the plane of the base of the body chamber. In all of the figured and described specimens the ventral periphery of the body chamber is convex; but of the two specimens from Huntington, it is flat in one and very concave in the other, which is the specimen figured. This is the only difference to be detected between specimens from Huntington, and those from the Guelph of Canada and New York. The second specimen is a little larger than the one figured.

Common. Huntington.

Phragmoceras angustum Newell.

Pl. XVIII, fig. 1.

Shell large, arcuate; narrowly elliptical in cross section; increasing regularly in dorso-ventral diameter from the smallest camera to the aperture.

Living chamber elongate, length greater than greatest dorso-ventral diameter. Length of aperture about equal to greatest length of living chamber. Apertural margins not well preserved, but they appear to consist of a small oval opening at the antero-ventral angle and a larger similar opening at the antero-dorsal angle, not connected by a narrow slit. The sutures of the camera form broad, shallow lateral lobes and have ventral saddles.

The two specimens described are from Grant County. The type locality of the species is Wabash.

Phragmoceras cf. ellipticum H. and W.

Pl. XIX, fig. 5.

The following is the original description taken from p. 152, Pal. Ohio. II.

"Shell of large size, slightly curved, transverse section narrowly elliptical, a very little wider on the outer than on the inner side of the center. Outer chamber wider than high; very depressed

convex on the sides, and sharply rounded on the ventral and dorsal edges; the ventral side extended at the aperture, forming a tube-like projection; the remainder of the aperture not known. First chamber below the chamber of habitation very shallow; septa deeply concave; siphuncle large, situated close to the inner side of the shell.

“Formation and locality. In the limestones of the Niagara group, in Highland County, Ohio, associated with *Trimerella ohioensis*.”

A large fragment corresponding very well with this species occurs in the Gilbert collection. The base of the body chamber is 6 mm. thick and 39 mm wide. Measured along the center there are five chambers in a depth of 25 mm. On the ventral periphery these five chambers occupy a depth of 19 mm. and on the dorsum of 36 mm. The penultimate chamber in our specimen is not differentiated from the others. The upper and basal peripheries of the body chamber are subparallel as in the Ohio material. The species may be distinguished by the large size, the subparallel bases of the body chamber and by the slight curvature.

Rare. Huntington.

The following additional species of Cephalopoda, represented in the collections at hand by very poor material or not at all, have been described from the Niagara rocks of the Wabash Valley by Frederick H. Newell in the Proc. Bost. Soc. Nat. Hist., Vol. XXIII, pp. 466-486.

Orthoceras crebescens Hall.

Wabash City.

Orthoceras unionensis Worthen.

Wabash City.

Orthoceras rigidum.

Peru.

Orthoceras obstructum Newell.

Wabash City.

Kionoceras strix Hall & Whitf.

Wabash City.

Gomphoceras linearis Newell.

Wabash.

Gomphoceras projectum Newell.

Delphi.

Hexameroceras cacabiformis Newell.

Delphi.

Pentameroceras mirum Barrande.

Delphi.

Ascoceras newberryi Billings.

Delphi.

Ascoceras indianensis.

Delphi.

TRILOBITA.

Illænus armatus Hall.

Pl. XXII, fig. 6.

Two small pygida are referred to this species. The proportions of length and breadth are respectively three to four, and five to eight. They differ from *I. ioxus* in having the greatest elevation near the posterior end, and in sloping very abruptly to the posterior margin.

Georgetown and Wabash.

Illænus insignis Hall.

Pl. XXII, figs. 1-5.

Glabella strongly convex, regularly arched from front to back. Anterior and posterior margins of the cranidium strongly rounded, the latter bending backward outside the dorsal furrows and terminating in minute triangular pieces (the fixed cheeks) articulating with the free cheeks. Anterior margin with a thickened border. Dorsal furrows distinct, extending upward and forward from small pits in the occipital groove; opposite the palpebral lobes they widen and deepen perceptibly for the space of one or two mm.; thence as shallow furrows curving downward and forward, they terminate in deep pits about one-third to one-half the distance from the front of the cranidium to the palpebral lobes. Free cheeks with rounded genal angles, sloping abruptly downward from the eyes.

Pygidium semicircular to slightly paraboloid in outline. Anterior margin broadly rounded in the median two-thirds of its

length, making a slight backward bend one-half the distance from the lateral margin to the middle, thence extending nearly straight to the antero-lateral margin. Surface but slightly convex on the top, but sloping rapidly to the margin at the sides.

This species is rather common. It occurs at Connor's Mill (Hamilton County), Delphi, Georgetown, Fishersburg and Wabash.

Ulaenus ioxus Hall.

Pl. XXII, fig. 7; Pl. XXIII, fig. 3.

Pygidium rather short, length equal to three-fourths the width or less. Posterior border regularly rounded forming nearly a semi-circle. Articulating margin broadly rounded, sometimes bending backward slightly just at the middle. Surface moderately convex sloping to the posterior margin quite gently.

Cephalon much broader than long. Only one poorly preserved cranidium has been seen. Five pygidia have been found in the collections from Pendleton, Fishersburg, Helm's Mill, and Connor's Mill, Hamilton County.

Ceratocephala goniata Warder.

Pl. XXIV, fig. 13.

Cephalon subquadrangular in outline, width nearly twice the length. Glabella very tumid, consisting of a large median and three pairs of small lateral lobes. Median lobe narrowing slightly toward the front, its greatest width equal to half the length. Lateral lobes separated from the median lobes by deep furrows. Dorsal furrows very weak and indistinct, the lateral lobes merging into the fixed cheeks. One of the free cheeks is partially preserved, showing a nearly flat, broadly crescentric extension forming the antero-lateral margin of the cephalon. The strong ridges at the inner margins of the free cheeks support a pair of spine bases about midway between the genal angles and the anterior extremity of the cephalon. The occipital ring is separated from the glabella by a distinct but rather shallow groove. Two spine bases with a strong tubercle between occupy the ring. The border of the free cheek appears to have been ornamented with a fringe of tubercles or of fine spines. The genal angles terminate in strong diverging spines. The thorax and pygidium have not been seen.

The description is based on a single cephalon from Pendleton, which appears to be identical with the forms described from Bridgeport, Ill., by Hall as *Acidaspis danai* and by Winchell and Marcy as *A. ida*. The lateral gabella lobes are less distinct than in the figures of *A. danai et ida*, but this is due in part to a slight distortion of the specimen.

Odontopleura ortoni Foerste.

Pl. XXIV, figs. 16-19.

Cephalon subcircular in outline, strongly convex with granulose surface; length about one-third the width. Median glabellar lobe of nearly uniform width throughout, length about two and one-third times the width, lateral lobes in three pairs separated from the median lobe by deep furrows. The anterior pair of lobes are very small and situated near the anterior extremity of the median lobe; the posterior pair are oblong masses just anterior to the occipital groove and about twice the size of the median pair. A pair of elongated, subtriangular elevations pointing forward, and flanking the lateral lobes, extend forward to the groove between the anterior pair of lateral lobes. A distinct low ridge extends backwards on each side from the antero-lateral margin of the median lobe to the eyes. Facial sutures not discernible. Lateral margins of the free cheeks set with numerous small spines, about one and one-half millimeters in length, pointing downward. The genal angles terminate in strong spines, which are broken off in the specimen figured. Occipital ring smooth, separated from the glabella by a distinct furrow.

Thorax with nine segments. Axis moderately convex, pleura flattened except at the extremities which are directed downward and terminate each in a sharp spine.

Pygidium very short; flat or slightly concave; axis convex and unsegmented. Margin of the pygidium with a fringe of twelve spines, each about as long as the pygidium, except the third pair from the posterior end which are longer than the others. This pair is continued across the pygidium, in oblique, convex ridges, converging to the anterior margin alongside the axis. The species is represented by two specimens—a nearly complete individual from Georgetown, and a pygidium from Pendleton.

Encrinurus indianensis n. sp.

Pl. XXIV, figs. 14, 15.

Cephalon semicircular in outline; surface covered with large tubercles. Glabella with three very strong lateral tubercles on each side anterior to the occipital groove. Fixed cheeks separated from the glabella by very deep dorsal furrows. Genal angles apparently terminating in spines. Thorax unknown.

Pygidium elongate-triangular, strongly convex; the lateral lobes curve sharply down from the dorsal furrows to the margin. In the type specimen, the annulations of the axial lobe number 15; in each of the lateral lobes there are ten pleuræ, which are directed backward. Each annulation of the axis bears from three to five tubercles, the one at the middle of the annulation being the strongest. Three to six tubercles mark each of the lateral segments.

The cephalon and pygidium have not been found united, but the only *Encrinurus* cephalon found is from Connor's Mill, Hamilton County, which has furnished a number of *Encrinurus* pygidia all belonging to the species here described. This association makes the specific identity of the parts here figured very probable. This species seems to have no very close ally among described forms. The pygidium approaches somewhat to *E. variolaris* Brogn., from the Wenlock of England. The latter has nine to twelve annulations on the axis of the pygidium as compared with nine to fifteen in *E. indianensis*, and seven to eight pleura on the lateral lobes against nine to ten in the present species. The median annulations in *E. variolaris* (on the pygidium) have three tubercles, while the form here described has five except in the extreme posterior part, where the number is three.

Connor's Mill and Fishersburg (Hamilton County), Huntington, Little Deer Creek (Carroll County), and at Wabash.

Calymene cf. vogdesi Foerste.

Pl. XXIV, figs. 1-7.

Cephalon semicircular; surface granulose, most coarsely so on the cheeks. A wide, flat band forms the anterior margin. Glabella varying from moderately convex to strongly tumid; lateral lobes of the glabella in three pairs, the posterior twice the size of the median pair, and the anterior pair very small.

Thorax with ten segments, axial lobe convex and elevated above the lateral lobes. Each annulation bears a pair of strong nodes, just above the dorsal grooves. The pleuræ are horizontal for one-third their length from the dorsal groove, then they bend abruptly downward, terminating in broad paddle-shaped ends; pleuræ grooved four-fifths the distance to their outer extremities.

Pygidium with nearly straight postero-lateral sides, their union making an obtuse angle. Axial lobe tapering gradually to a smooth rounded extremity; annulations eight or nine, the anterior three or four showing small indistinct nodes at the dorsal furrows continuous with those of the thorax. Lateral lobes with five or six annulations. The annulations are directed backward and are grooved along the outer half of their length.

This species is rather common; Connor's Mill (Hamilton County), Georgetown, and at "Hanging Rock" (Wabash County).

Ceraurus (Crotalocephalus) niagarensis Hall.

Pl. XXIV, fig. 8; Pl. XXIII, figs. 1, 2.

This species is represented by three specimens showing the glabella and a portion of the fixed cheeks. The nearly straight anterior margin of the glabella shown by one of the figures is due to the imperfection of the specimen, the normal condition being rounded and tumid in front.

The specimen from Marion is of unusual size, the glabella measuring 50 mm. in length and 35 mm. in its greatest width.

Rare. Connor's Mill (Hamilton County), Marion and at Georgetown.

Sphaerexochus romingeri Hall.

Pl. XXII, figs. 8, 9, 12-15

Glabella very large, constituting the bulk of the head, spheroidal in form, surface smooth. The posterior glabella lobes, resembling large tubercles, are limited by a pair of deep, semicircular grooves; the lobes are separated by a space equal to one and a half to two times their width. The free cheeks are small, subtriangular pieces extending downwards from the base of the posterior glabella lobes. Two or three specimens show two pairs of shallow linear grooves anterior to the posterior glabella lobes which extend upward and forward from the antero-lateral margin of the glabella. The posterior pair is the longer of the two. The free cheeks have not been

observed. Occipital ring highly arched, limited by a deep furrow. The largest specimen observed has a width of 31 mm., and a length of 23 mm. Another very spherical cephalon measures in width 21 mm., length 18 mm., height from base of posterior glabella lobes to the highest part of the glabella is 14 mm. Thorax unknown.

Pygidium transversely elliptical in outline, axis terminating in a triangular-shaped piece, anterior to which are three strong annulations; the lateral lobes are divided into three broad, simple pleura, the posterior pair directed backwards.

The marble-shaped glabella of this species are among the most common and generally distributed fossils of the Niagara of northern Indiana. It is worthy of note that this species, so common throughout northern Indiana is entirely absent from the Niagara fauna in the vicinity of the Falls of the Ohio.

Phacops cf. pulchellus Foerste.

PL. XXIV, figs. 9, 12.

Cephalon ovate to semicircular in outline, proportions of length to breadth as five to eight. Anterior end with a narrow thickened border; genal angles rounded. Occipital groove well marked, with deep pits at the intersections with the dorsal furrows. A deep groove also terminating in pits in the dorsal furrows crosses the constricted base of the glabella; anterior to this groove, in some specimens two pairs of very weak lateral furrows mark the sides of the glabella, opposite the palpebral lobes. Most specimens show no trace of these furrows. The frequent absence of these furrows, and their slight development when present, constitute the principal difference between Foerste's species and the forms here described.

Thorax unknown. Pygidium semicircular in outline posteriorly, anterior margin slightly rounded. Axial lobe strongly elevated above the lateral lobes, width equal to three-fourths that of the lateral lobe; profile regularly arched from the anterior to the posterior extremities. The annulations on the axial lobe are about nine in number, and arch slightly backward in crossing the top of the lobe. The median row of tubercles characterizing the axial lobe of *P. pulchellus* is absent. Lateral lobes with five or six segments, each with a median groove; the pleuræ become indistinct posteriorly and the surface nearly smooth opposite the posterior end of the axis.

Rather common at Connor's Mill. Rare at each of the following localities: Georgetown, Pendleton, and Connor's Mill.

Dalmanites (Synphoria) vigilans Hall.

Pl. XXIV, fig. 20; Pl. XXIII, figs. 4-7.

Pygidium depressed, elongate triangular, terminating in a sharp point or spine. Axial lobe with ten to twelve annulations. Lateral lobes with about ten pleuræ directed backward, flattened and traversed by a median furrow.

The species is represented by a few fragmentary pygidia from Anderson, and by a cephalon from Pendleton.

TABLE SHOWING DISTRIBUTION OF NIAGARA FOSSILS IN NORTHERN INDIANA.*

	Little Deer Creek.	Georgetown.	Pendleton.	Wabash.	Delphi.	Huntington.	Connor's Mill.	Helm's Mill.	Fishersburg.	Bunker Hill.	Goodland.
1. Cornulites sp.....			+								
2. Spirorbis sp.....			+								
3. Dinobolus conradi.....			r			r					
4. Monomerella sp.....					r						
5. Trimerella sp.....					r						
6. Crania sp.....											
7. Stropheodonta cf. corrugata.....	r	r	+3								
8. Pholidostrophia niagarensis.....											
9. Strophonella cf. striata.....	+ r	c	r				c		+		
10. Strophonella williamsi.....		+ a	+ r		+		+ c				
11. Leptaena rhomboidalis.....									c		
12. Plectambonites cf. sericeus.....							r				
13. Orthothetes subplanus.....	c	+ r	r	r					+		
14. Chonetes cf. cornutus.....										a	
15. Orthis flabellites.....				c	r			+			
16. Orthis (?) subnodosa.....	r	c									
17. Dalmanella elegantula.....	r	+ r	+ c			r			c		
18. Rhipidomella hybrida.....			r	r	r		r				
19. Rhipidomella circulus(?).....	r	r									
20. Anastrophia internascens.....			r	r				r			
21. Conchidium laqueatum.....					a	c					
22. Conchidium cf. littoni.....			c								
23. Conchidium cf. multicoostatum.....						r					
24. Conchidium tritobatum.....						r					
25. Conchidium unguiformis (?).....	r										
26. Pentamerus oblongus var. compressa.....					c	c					
27. Pentamerus oblongus var. cylindricus.....					c	c					
28. Gypidula galeata.....	r	c	c	c	c			c	c		
29. Gypidula galeata var. nucleus.....	r	r	r								
30. Camarotoechia cf. acinus.....											
31. Camarotoechia sp. undet.....	r										
32. Wilsonia saffordi.....	r	c								+	
33. Eatonia goodlandensis.....											r
34. Atrypa calvini.....	r	a	r				+				
35. Atrypa reticularis.....	r	a	r	c		r	o	r	c		
36. Spirifer foggi.....		r	r								
37. Spirifer nobilis.....		r	r	c			+	o	r		
38. Spirifer radiatus.....	+	r		+	r		c	+	r		
39. Spirifer (Reticularia) crispa.....	+										
40. Spirifer (Reticularia) crispa var. simplex.....						r	+				
41. Reticularia proxima.....			c								
42. Cyrtia myrtila.....			+		r						
43. Whitfieldella nitida.....	+	+									
44. Nucleospira pisiformis.....			r								

*This list includes only those localities from which collections sufficiently full to be representative of the local faunules were obtained.

TABLE SHOWING DISTRIBUTION OF NIAGARA FOSSILS IN NORTHERN INDIANA—Continued.*

	Little Deer Creek.	Georgetown.	Pendleton.	Wabash.	Delphi.	Huntington.	Connor's Mill.	Helm's Mill.	Fishersburg.	Bunker Hill.	Goodland.
45. <i>Meristina maria</i>		c	o	r			+		c		
46. <i>Meristina cf. princeps</i>		c									
47. <i>Meristina rectirostris</i>		c									
48. <i>Whitella siluriana</i>				r							
49. <i>Cypricardina(?) sp.</i>				r							
50. <i>Pterinea sp.</i>				r							
51. <i>Amphicoelia neglecta</i>				r							
52. <i>Palaeopinna sp.</i>				r							
53. <i>Conocardium multistriatum</i>		r									
54. <i>Conocardium oweni</i>		r									
55. <i>Plethomytilus cuneatus</i>		r									
56. <i>Streptomytilus wabashensis</i>				r							
57. <i>Anodontopsis wabashensis</i>		c		r							
58. <i>Platyceras (Diaphrostoma) cornutum</i>		c		r							
59. <i>Bucania sp. undet.</i>		r									
60. <i>Trematonotus chicagocensis</i>											
61. <i>Pleurotomaria idia</i>						+	+				
62. <i>Pleurotomaria (?) hoyi</i>					r						
63. <i>Pleurotomaria (?) sp.</i>					r						
64. <i>Pleurotomaria pauper</i>					r		c				
65. <i>Pleurotomaria (Eotomaria) laphami</i>					r						
66. <i>Pleurotomaria (?) axion</i>					r						
67. <i>Pleurotomaria (Euomphalopterus) slatus var. americanum</i>	r										
68. <i>Pleurotomaria (Euomphalopterus) var. lima-toidea</i>											
69. <i>Pleurotomaria (?) eloroides</i>					c						
70. <i>Pleurotomaria (?) sp. cf. eloroides</i>					r						
71. <i>Murchisonia (Turritoma) laphami</i>					r	c	r				
72. <i>Murchisonia (Coelocaulus) bivittata</i>					r	c	r				
73. <i>Murchisonia (Coelocaulus) sp.</i>					r	c	r				
74. <i>Oriostoma huntingtonense</i>						+	+				
75. <i>Oriostoma huntingtonense var. alternatum</i>						+	+				
76. <i>Oriostoma plana</i>		r									
77. <i>Oriostoma sp. undet.</i>							+				
78. <i>Schizolopha sp.</i>					r						
79. <i>Cyclonema cancellata</i>	r										
80. <i>Cyclonema elevata</i>						c	r				
81. <i>Orthoceras medullare</i>											
82. <i>Orthoceras sp.</i>		r	r								
83. <i>Orthoceras (Dawsonoceras) cf. annulatum</i>						r					
84. <i>Kionoceras orus</i>						r					
85. <i>Kionoceras delphiensis</i>					r	r					
86. <i>Trochoceras cf. desplainense</i>					r	r					
87. <i>Lituites marshii</i>					r	r					
88. <i>Lituites (Ophidioceras) bickmoreanus</i>					r	r					
89. <i>Lituites (Ophidioceras) herculeus carrollensis</i>					r	r					
90. <i>Cyrtoceras gorbeyi</i>											
91. <i>Gomphoceras (Poterioceras) marcyae</i>	r					r					
92. <i>Trimeroceras gilberti</i>		r				r					
93. <i>Tetrameroceras cf. herzeri</i>						r	+	r	r		
94. <i>Phragmoceras parvum</i>						r					
95. <i>Phragmoceras ellipticum</i>	r					r					
96. <i>Illaenus armatus</i>					r						
97. <i>Illaenus insignis</i>	+	r	+		r		+	c		c	
98. <i>Illaenus ioxus</i>					r						
99. <i>Illaenus sp. undet.</i>					r						
100. <i>Ceratocephala gonata</i>			r								
101. <i>Odontopleura ortoni</i>		c	r			r	r			c	
102. <i>Enercinurus indianensis</i>		c	r			r	r			c	
103. <i>Calymene vogdesi</i>		c	r	+				c			
104. <i>Ceraurus (Crotalocephalus) niagarensis</i>		r			a	r					
105. <i>Sphaerexochus romingeri</i>		r							+	c	
106. <i>Phacops cf. pulchellus</i>								c			
107. <i>Dalmanites (Synphoria) vigilans</i>										+	

*This list includes only those localities from which collections sufficiently full to be representative of the local faunules were obtained.