

## VI.

### THE CLINTON GROUP OF OHIO.

BY A. F. FOERSTE.

#### *Prospectus.*

The title, as given above, does not correctly indicate the scope of the papers here presented, but will very well serve to designate the field which I have laid out before me, and which I expect to cover by means of a series of articles, of which the present paper is the first. Descriptions of all the important exposures in the state, sections of the strata, analyses of rock, and paleontological features will be furnished wherever practical. A collection of fossils, which already bids fair to rival those at Waldron, Indiana, is expected to furnish the basis of a description of the fossils of the group as presented in this State. It is also intended to identify in an independent manner the true relations of the geological strata usually included by the name Clinton Group, in our State and Indiana. Although it may be well to state at the outset that present indications seem to favor a closer relationship to Niagara strata, and especially those of the west, than is generally conceded; nevertheless this conclusion has not been hastily drawn, and is not irrevocably held. I shall only attempt to present the facts and state their probable bearing, and then allow the reader to draw his own conclusions. In order to determine more definitely the stratigraphical relations of the group with corresponding formations of the west, especially those of Indiana, a series of sections taken at different stations, from both Ohio and Indiana, will be undertaken at an early date. Although the project in some respects may seem rather extensive, the large amount of material already collected gives promise of its ultimate accomplishment.

## GEOLOGY.

In southwestern Ohio, immediately above the Cincinnati Group, lie a series of strata, formerly known, both scientifically and popularly, as the Cliff Limestone. They are so designated, for instance, in the second annual report of the Ohio Geological Survey, undertaken in 1838, by W. W. Mather. Many of the cliffs and cascades in this part of the State owe their origin to the peculiar characteristics of this formation. Later, however, a division into two groups was made, and after a more extended study by Prof. Edward Orton the upper section was identified with the Niagara Group, but the lower was called the Clinton. In the reports for 1869 and 1870, these distinctions were carefully made. At various times, however, authors have seen fit to express doubt of the correctness of the name employed for these strata, and Prof. James Hall, especially, has had occasion to do so in the 12th annual report of the Indiana Survey. For our purpose it will be well enough to retain the name, Clinton Group, at least for the present, but it is expected that after a presentation of all the facts, others, perhaps, will be ready to adopt some other term.

The Clinton is not a group of any great depth. For its western exposures in Ohio, ten to fifteen feet would be a fair estimate. In its eastern exposures in Highland and Adams counties "its *average thickness* is somewhat increased, but probably never exceeds 40 feet, and this thickness is sometimes attained in the northern district as a *maximum*, as for instance, at Yellow Springs, in Greene county." (Italics my own). A section of the geological series of Highland County gives a thickness of 50 feet to the Clinton Limestone. (Geo. Surv. Ohio, 1870, page 298 and section at page 310.)

The Clinton Limestone rarely affords any extended surface exposures, but is found like a narrow line separating the Cincinnati and Niagara Groups of the State, and usually is seen in close connection with both. A section of rock belonging to the Clinton age, therefore, generally also includes both the upper and lower strata.

The rocks of the Cincinnati Group, in Ohio, are quite level, showing no marked local variations in their dip. At their junction with the Clinton Group, however, they frequently become unfossiliferous, and the rock is replaced by less solid shales and bluish clays. The surface of the group also becomes very undulating in character, frequently attaining a dip of four feet in forty. As a consequence the superposed rocks of the Clinton Group are also very undulating.

They maintain, however, an average thickness, indicating that, whatever were the causes which had disturbed the bed of the Lower Silurian sea, these had disappeared by the time the strata of the Clinton Group were deposited.

In other words, at the close of the Lower Silurian age, the ocean became shallow; large valleys and gullies were washed out from the beds of the Cincinnati Group. The silt was deposited as a blue clay, which terminates the strata referred to this age. On this uneven and very undulating bed, the rocks of the Clinton Group were deposited. At this time a portion of the Lower Silurian rocks must have been exposed, as the researches of the last geological survey revealed evident shore markings in several places, containing the pebble-washed fragments of the Lower Silurian strata.

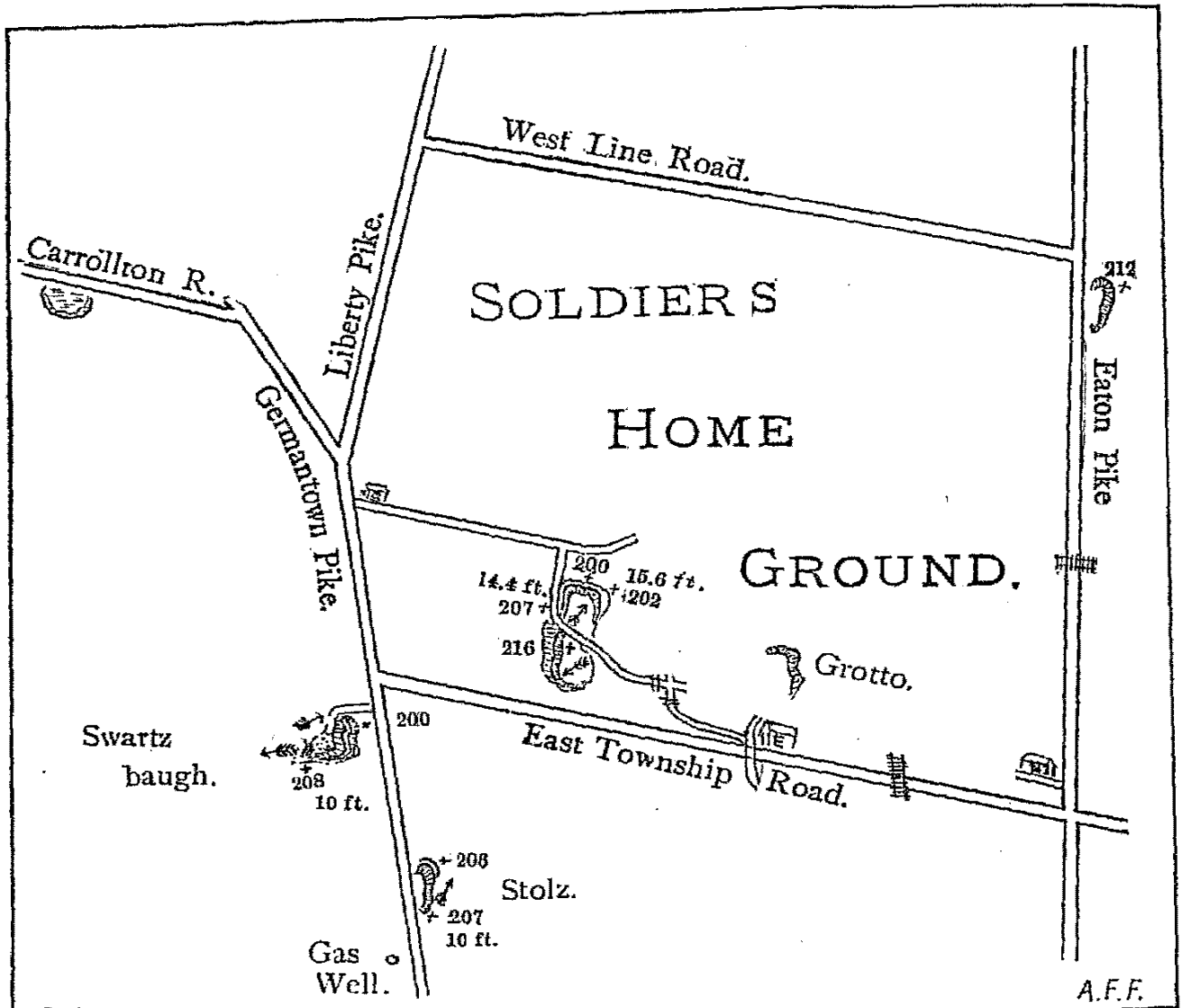
In fact, the very fragmentary condition of most of the fossils found in this group indicates the action of shore waves upon the accumulated deposits of this sea. The slight variation in the thickness of the group may readily be explained by the conditions brought about by its uneven bed. The washings of an otherwise shallow sea would naturally be very unequally deposited near the shore line. At a distance from the land the fine silt would be almost equally deposited, but near the shore the washings would accumulate most in the depressions of the ocean bed. And, although the inequality of deposition would of course not be very great over any large extent of territory, nevertheless it is sufficient to account for the variation observed. At Soldiers' Home, where there is a dip of seven feet in one hundred, the rock increases one foot in thickness. This is the most marked instance which has fallen under my observation.

The Clinton Group consists of a crystalline, crinoidal limestone of variable color, sustaining a high polish, extremely fossiliferous in places, differing in this particular from the Niagara strata immediately overlying it.

Between it and the Niagara Group is a fine clayey or marly bed, about nine inches thick, which in some places becomes quite hard, and in others is replaced by a soft blue clay. In connection with the Dayton limestone it usually attains the hardness of stone and is characterized by a number of minute species, which, considering the small attention hitherto paid to this course of stone, is unusually great. For the present it will be called the Beavertown marl, on account of

its prominent development near that village, and will be considered as a part of the Clinton Group.

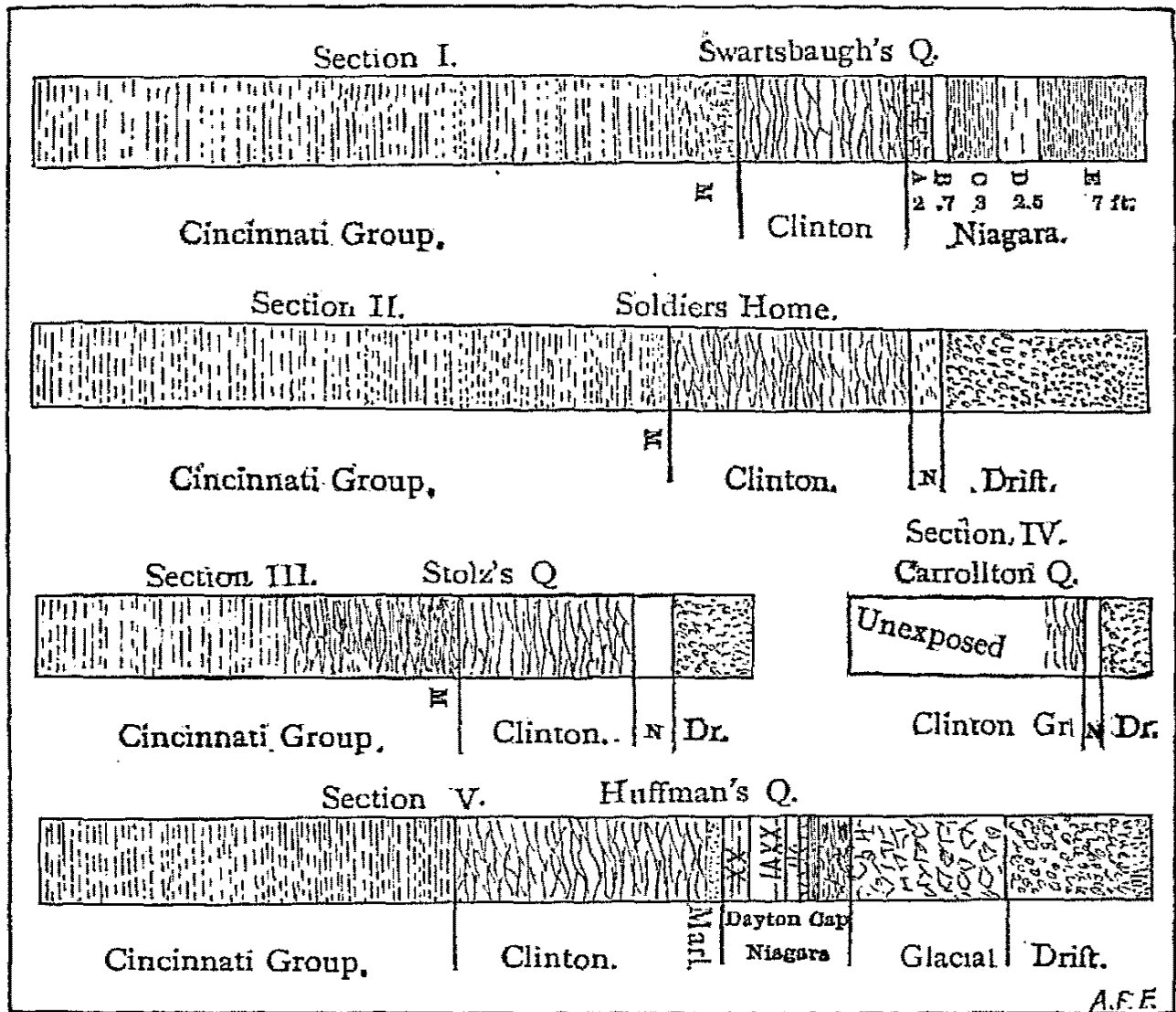
The first, and by far the most important series of exposures to be mentioned, are those included in the Soldiers' Home district.



### SOLDIERS' HOME QUARRIES.

The Soldiers' Home grounds, embracing about a square mile of land, are situated two and a half miles west of Dayton, on a series of hills overlooking the city. At their foot, exposures of the Lower Silurian strata are frequent, but at their top, rocks of the Upper Silurian age take their rise, and have a steady dip towards the west, bringing up, one after the other, the formations of a higher age,

About half a mile from the Home, at the side of the Germantown Pike, a well, driven for water, gave rise to a flow of gas, lasting some months. Owing to neglect or other causes, the supply has now ceased, evertheless, the existence of inflammable gas in the Lower Silurian rocks is of some interest.



*Stolz's Quarry, (Section III.)*

A short distance westward, the pike runs upon a bed of rock belonging to the Clinton Group. North of the road a quarry has been opened, which displays both the Niagara and Cincinnati Groups, nevertheless a satisfactory section of the Clinton Group has as yet not been attainable.

A.F.E.

All measurements of the elevation of rocks in the various sections are reckoned from the sidewalk at the Court House in Dayton. These measurements are due to the kindness of Mr. A. Kiehl, who aided me materially in this part of the work. The top of the Cincinnati Group is at 193.51 at the first station. In a section made near by the Cincinnati layer was not exposed but the lowest point in the Clinton was at 196.74; the top of the Clinton, 206.31; the top of the Niagara exposed, 208.68. The thickness of the Niagara was therefore 2 ft. 4.5 in.; and that of the Clinton, considering that the dip from the first named station, east of the section, was slight, but westward, a thickness of twelve feet would be more than conjectural. The rock is crystalline, consists of uneven "lenticular" layers, unequally fossiliferous, the fossils being found in "pockets" or special accumulations, irregularly disposed throughout the group. Numerous fine heads of *Dalmanites Werthneri* are quite abundant here, and for many things it ranks with the Soldiers' Home quarry itself in productiveness.

The Clinton ends in a top of blue clay containing large crinoid heads, free specimens of *Chactetes*, *Rhinopora*, &c. It is about five or six inches thick. Only the blue clay referred to the Cincinnati Group is exposed. The Niagara Group consists of a yellow limestone, unfossiliferous as far as known, lying in uneven broken courses from two to five inches thick. It has no commercial value, but the Clinton stone is much used for academizing roads and streets, and is profitable on a small scale, as a gain of \$492 with an expenditure of \$426 in one instance will show. During this year, 1885, up to August an expenditure of \$356 realized a gain of \$547, which is quite profitable considering the small amount of time put upon the quarry. The inferior quality of the Niagara limestone at this quarry is to be especially mentioned as it is the exact equivalent of the Dayton limestone and the succeeding quarries farther west gradually assume the characteristics of the Dayton stone, thus forming a complete and instructive series for comparison.

#### *Swartzbaugh's Quarry. (Section I.)*

On the same pike within a few hundred feet from the south-east corner of the Home grounds is a second quarry. It is placed behind a farm-house, dipping northward into the hill near the barn. The top of the Cincinnati Group is here represented by a bed of blue clay. In the sections made, however, this bed was not reached. The bot-

tom of the Clinton Group as far as worked was at 198.21 ft.; the top, at 208.04 ft.; but a conjectural thickness of twelve feet would not be far from correct. The stone presents the usual characteristics, but seems to be less fossiliferous than some of the neighboring quarries. It is peculiar in showing fissures, extending east and west, distant from each other about 9 feet, found at no other station in the Clinton Group. In the southern part of the quarry there is a sudden dip to the south and the stone is broken, as though the blue clay layer beneath had given way and permitted the stone to sink. The fissures in the rock are perhaps also explained in this manner.

The Niagara exposure is a little more than 15 feet in height. The base of the series is composed of broken, irregular, yellow layers of stone from two to five inches thick, making a total of 1.9 feet. Above is a 9 inch course of blue flagging stone, which was at one time quarried and sold in slabs for pavements. It resembles a fair quality of Dayton limestone of which it is the stratigraphical equivalent. Formerly when the Clinton stone was not exposed and the Cincinnati Group was in plain sight along the hill below, and the great dip of the rock had not yet been determined, the identity of this stone remained for a long time a puzzle. Above the blue flagging is a series of shales 3 ft. thick, varying in character, sometimes represented by broken courses of yellow limestone 2.5 ft. thick, composed of a nine inch layer above and below, with the intermediate layers more or less shaly in character. Sometimes the remainder also becomes somewhat shaly. Last in the series is a 7 ft. layer of yellow Niagara stone, formed of very broken, thin courses, from half an inch to two inches in thickness, frequently becoming shaly. The top of the blue flag layer in the southern part of the quarry is at 210.70; seventy-five feet north, at 204.10; fifty feet west, at 203.89. This would give a dip of 4 ft. 5 in. in fifty feet towards the north, and only 2.5 in. in the same distance, towards the west; the last dip is reliable, owing to the very even stratification of the blue flagging. At the same point the bottom of the heavy Niagara stone is reached at 206.92; the top at 209.49. Farther west the top is again reached at 207.87, and the summit of the thin shaly courses at 214.85. All the Niagara stone here exposed is unfossiliferous as far as known. In some parts of the quarry the Niagara stone is all tumbled together, destroying its original stratification. I presume that the action of ice during the glacial epoch could readily account for this, since all the quarries round about, where the

stone is hard enough, show evidence of this glacial action in the form of grooves, scratches and the planed surfaces of the stone.

*Carrollton Pike Quarry. (Section IV.)*

Along the Carrollton pike about half a mile from the Home Grounds, on the east side of the road, a quarry was opened, which developed a layer of Niagara flagging stone 5 or 6 inches thick. It was smoothed above by glacial action, was found within two feet of the surface, and hence was readily worked, and sold to advantage as a fair quality of Dayton limestone. In several places in Dayton it was used without extra preparation for sidewalk purposes. Beneath is a layer of thinner stone and then limestone of the Clinton Group, of little or no commercial value, and therefore, not quarried. Here specimens of *Orthis fausta* were found. This species has also been found at Swartzbaugh's quarry, in the same position, namely at the very summit of the Clinton Group.

*Eaton Pike Quarry.*

North-west of the Soldiers' Home grounds, on the north side of the Eaton pike the Clinton rock is quarried. Neither the top nor the bottom of the series is exposed but the two levels taken register 211.92 ft. and 205.50, which give a thickness of 6 ft. 5 in., but the real height of the strata is no doubt much greater. Numerous bryozoans are found here.

*The Grotto.*

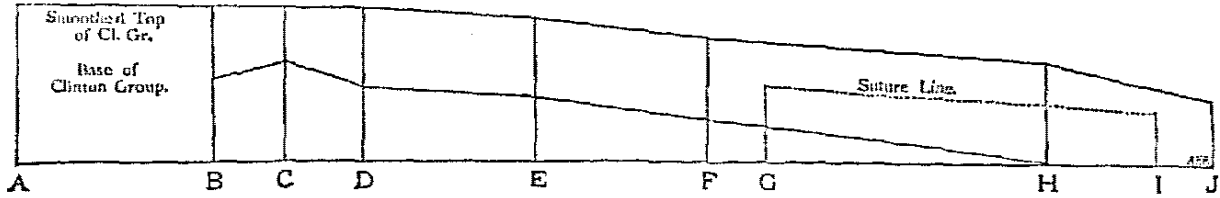
East of the Soldiers' Home along the railroad, a cut through rock of the Cincinnati Group displays the characteristic fossils of this group. South of the terminus of the railroad in the grounds are the so-called grottoes. These were formerly the site of an old quarry, and belong to rocks of the Clinton Group. Owing to the underlying bed of blue clay the Clinton Group is usually a great water bearer. At Soldiers' Home one of the grotto springs is fed in this way, and two springs of the same nature in the quarry south of the grotto give forth a steady flow of water all year. The grotto is now used for floral effects only.

*Soldiers' Home Quarries. (Section II.)*

The Soldiers' Home quarry is the finest exposure of the Clinton Group in the State. Being constantly in operation, it has proved the most productive place for fossil remains. Both the Niagara and Cin-



cinnati groups are shown in the same section, and the thickness of the Clinton Group as here obtained is strictly accurate.



Stations.	Top of Clinton Group.				Base of Clinton Group.				Stations.	Seam in Clinton.			
	Distances.	Height above Court House Corner.	Dip in feet.	Dip for 100 feet.	Distances.	Height above Court House Corner.	Dip in feet.	Dip for 100 feet.		Distances.	Height above Court House Corner.	Dip in feet.	Dip for 100 feet.
A	150	208.95	1.00	.67					G	175	198.08	3.29	1.88
B					30	198.94	*2.08	*6.03	I		194.79		
C					35	201.02	3.44	9.83					
D	75	207.95	1.38	1.84	75	197.58	1.17	1.56					
E	75	206.57	2.46	3.28	75	196.41	2.70	3.60					
F	150	204.11	3.19	2.16	150	193.71	5.54	3.69					
H	75	200.92	4.54	6.05		188.17							
J		196.38											

\*Dip towards the west.

A section of the eastern half of the quarry, beginning at A near Massachusetts Avenue, and extending to the eastern limit, is represented by the table and section just given. The distances are reckoned to the next succeeding station on the line; the height is calculated from the level of the side walk at the Dayton Court House; the first list of dips consists merely of differences of elevation between consecutive stations; in the second these are reduced to the standard of 100 feet. The dip unless marked by an \* is toward the east.

The difference in direction between the base and the top of the Clinton Group is quite evident, and is owing to the effects of glacial action which has planed off the stone without regard to its dip, or elevation, as shown for instance at station C. This is still more evident if the dip near the western end of the section be considered, where the base of the Clinton is 4 ft. below the same 40 feet north. The entire eastern half of the quarry shows glacial scratching, planing, and grooving.

It is frequently supposed that the Clinton contains no regular seams, separating the strata. Whereas this is true in a general sense, as compared for instance with Cincinnati or Niagara formations, nevertheless quite regular seams are occasionally found also in the Clinton group, especially in the section now under consideration. A long seam, followed with comparative ease for 175 ft. showed a dip of 3.29 ft. in this distance. A comparison of this line with the base of the group shows that the strata thicken in the depressions of the underlying bed. This is also shown in the western half of the quarry, where the group is 14.4 ft. thick at the spring, and 15.6 ft. at a point 150 ft. north-west of the same, showing an increase of 1 ft. 2.5 in. The elevations at the spring are: top of Cincinnati group 192.63; of Clinton group, 207.01. Along the western end of the quarry the elevations of the Clinton: are 202.73 at the S. W. corner, 200.07 at the middle, 202.15 at the N. W. corner, 202.36 at a point east of the latter. Here the top of the Niagara reached 204.26 showing a thickness of 1.9 ft.; it is a yellow, somewhat shaly stone, becoming frequently quite hard. Taking the Niagara stone as shown at the Soldiers' Home, Carrollton pike, and other quarries farther west, a good idea of the variability of the base of this group can be formed. In the western part of the quarry the base of the Clinton Group consists of a greyish or almost white stone, composed of finely comminuted organic remains, of which the structure has become more or less obscure. Here many bryozoans have been found in a fine condition. *Clathrapora Clintonensis* and *Retepora angulata* in fronds 2 feet and 1 foot in diameter respectively have been seen here. Other fossils, however, are rather scanty in this stone. Most of the group, however, is composed of a bluish solid limestone, becoming pinkish or red by oxidation, and abounding in fossil forms. The summit of the group in the north-western part of the quarry is especially prolific in various species of *Orthis*. The summit of the Cincinnati Group is composed of blue, clayey shales, several feet thick, and very undulating. The notable fact is that these undulations are mostly local, the strata taken as a whole, maintaining a comparatively even inclination, as will be seen by a reference to the map.

In the rocks of the Clinton Group, at Soldiers' Home, so many species are found, and so much work has been done, that it would be difficult to mention the prominent features. Bryozoans, found here in numbers, are said to be still more common at the Eaton pike quarry.

*Platystoma Niagarensis* is not unfrequent. Glabellæ and pygidia of two species of *Illænus*, are abundant, as are also various shells, corals, &c. The fossils are not equally distributed. Thin courses of rock are not apt to be very productive. In the thicker interspersed layers, however, which show external signs of fossils, considerable numbers are frequently developed by breaking the stone. Throughout the Clinton Group the fracture is irregular, and it is very difficult to obtain entire specimens. It is rarer still to obtain specimens completely loosened from the rock, as one or the other face is apt to be inseparably connected with it.

### DAYTON LIMESTONE QUARRIES.

South of Dayton a continuous series of quarries extends from Beavertown to a point about a mile and a half northeast of the Insane Asylum. Some of these have been abandoned, but in those now in operation the Dayton and overlying strata of the Niagara are shown in section, and small exposures of the Clinton are not infrequent. As a means of comparison with the district just described, a section of one of these quarries is given.

#### *Huffman's Quarry, (Section V.)*

About three quarters of a mile towards the southeast of the Asylum for the Insane, is a quarry, belonging to Mr. W. P. Huffman, of Dayton. A single section of the Clinton Group is said to have been obtained here, while constructing a drain. The strata were 13 feet thick; the color is light pink, and its fossils are rather few. The Niagara Group consists of the Dayton limestone, and a few layers of "blue cap." The Dayton limestone consists of a 20 in. course of stone, surmounted by a 26 in. and a 7 in. course. The 20 in. course separates into a 12 in. layer, succeeded by two 4 in. layers. The 26 in. course, even more readily, is divided into a 20 in. and a 6 in. layer. The 20 in. layer is naturally the most profitable, and is quarried in large slabs. The blue cap begins with a 10 in. course of poor quality, followed by an 8 in. course, still more inferior and often broken. Above this, 18 in. or more of thin slabs, usually in small pieces, may be found. The color of this blue cap is denoted by its name; its commercial value is destroyed by its poor weathering qualities and the irregular and broken condition of the stone. The quarry, therefore, presents four and a half feet of good Dayton limestone. The Ni-

agara cap is here unfossiliferous as far as known. The Dayton limestone contains corals and orthocerites. Between the Clinton strata and the Dayton limestone is a bed of blue marl, 9 in. thick, which is referred to the Clinton Group. It contains large crinoid beads, *Orthis biforata*, var. *lynx*, and various minute forms not known elsewhere in the series. The Clinton Group proper has furnished a pygidium referred, doubtfully perhaps, to *Illienus Madisonianus*. The marl is in this paper called Beavertown marl.

### CENTREVILLE QUARRIES.

Centreville, eight miles south of Dayton, is situated on an outlier of stone, composed of rocks belonging to the Clinton and Niagara groups. In some places that division of the Niagara Group known as the Dayton limestone or "marble" approaches within a few feet of the surface of the ground, and hence gives rare opportunities for good and readily worked quarries.

#### *Allen's Quarry.*

Several years ago, shortly after the construction of the Cincinnati Northern railroad, a quarry was opened on the farm of John E. Allen, about a half a mile east of Centreville. This quarry is probably the most easily worked and most accessible (for purposes of transportation) in the county. The Clinton rock is here of a pinkish or often dirty white color. It is exposed only by the removal of the overlying Niagara stone, or by the cutting of ditches. Yet many and often rare fossils have been found here. *Orthis Daytonensis*, with both valves preserved, has been discovered. A thin seam of bluish clay, between the Clinton and Niagara stone, furnished the large *Calymene*, to be described later. This clayey layer has not yet shown any of the curious little fossils found in the marl at Huffman's Quarry, although apparently its stratigraphical equivalent.

Beginning with the base of the Niagara exposure, the courses of Dayton stone run as follows: a 16, 18½, 6, 3½, 2¾, 4, 4¾, 2¼, 4¼ and a 1¼ in. course. Comparing these courses with those at Huffman's Quarry, it will be noticed that the 16 in. course corresponds to the 20 in. course of that quarry, and like it is divided into smaller layers: in this case into a 4 in. layer below and a 1½ in. layer above, the intermediate divisions, if any, not having been noted. The 18½ in. and 6 in. layers also correspond very nicely to the equivalent divisions

of the 26 in. layer in the other quarry; and the  $3\frac{1}{2}$  in. and  $2\frac{3}{4}$  in. layers might be combined so as to correspond to the 7 in. layer. Above this point comparisons would perhaps prove treacherous. Above the Dayton stone proper are found shaly layers, 50 in. and 9 in. thick, which do not sufficiently approach the crystalline character of the Dayton stone to be classed with it.

### MISCELLANEOUS QUARRIES.

In addition to the quarries just mentioned, one or two others are worthy of at least a slight reference in this paper.

#### *Fauver's Quarry.*

About two miles north of Dayton, some distance west of the Covington pike, is a quarry which displays both the Clinton and Niagara groups. The quarry presents some peculiar features which will be made a special object of investigation for the next paper. The Clinton ends above in a layer of blue clay, succeeded by a number of courses of Dayton limestone, none of which attain any great thickness. The blue clay layer, besides the usual fossils of the Clinton Group, has also furnished a specimen of *Eichwaldia reticulata*, Mr. E. M. Thresher being the collector.

#### *Fair Haven Quarry.*

In Preble county, half a mile north of the village of Fair Haven, in a stream entering Four Mile Creek, a quarry has been opened, giving an exposure of the Clinton. Here there have been found numerous corals so far not known elsewhere in this State, and also the usual Clinton forms. Among others, a form of *Clathropora Clintonensis*, with unusually large oval openings (passing entirely through the bryozoom and thus forming the branches of the reticulations,) deserves special mention. A species of *Ptychophyllum*, in a fine state of preservation, occurs here; a similar, if not identical form, being found at Allen's Quarry. The exposure does not give a complete section, but over four feet of the Clinton Group are exposed.

About two miles north, along Four Mile Creek, another quarry has exposed the higher strata of the Niagara group. Its peculiar feature is a seam of cherty limestone, about nine inches thick, containing *Atrypa reticularis* in well preserved specimens. No other fossils have so far been noticed.

## PALEONTOLOGY.

The Clinton Limestone of Ohio is very fossiliferous. The fossils, however, are often difficult to obtain on account of the hardness of the rock and its irregular fracture, when submitted to the blows of a geologist's hammer. For the same reasons the identification of gasteropods becomes extremely difficult, since their apertures are scarcely ever seen. In one form alone are they of common occurrence, *Cyclonema bilix*; this fossil is of rather frequent occurrence in the upper, shaly part of the group, from which it sometimes weathers with the neatness of Lower Silurian fossils in this State. Some forms of brachiopods preserve their outlines very indistinctly. This is true of *Orthis flabella* and the small form I have ventured to call *O. elegantula*, var. *parva*. Others are found only as single valves firmly held by the rock so that only one face, the external or internal, is presented. On this account it is difficult to associate dorsal with ventral valves, internal with external features. A few forms, however, occurring in the higher, more shaly strata, are frequently found well preserved, with both valves connected. Such are *Orthis hybrida*, *O. elegantula*, and *Rhynchonella scobina*. *O. biforata* f. *Clintonensis* and *Triplexia Ortoni* most frequently are found as fragments embracing that portion of the valves surrounding the beaks; these fragments show both the external and internal features. They are also, although not as frequently, found as entire shells, with both valves united. *Eichwaldia reticulata*, *Orthis fausta*, and *Meristella umbonata*, the last from the middle of the formation, have all been found as entire shells. The trilobites are usually found as fragments, the heads and tails being disconnected. In *Illenus* the movable cheeks and glabellæ are thus found separated. In only one specimen of *Dalmanites Werthneri* the intermediate articulations of the thorax were discovered. The association of glabellæ and pygidia, therefore, is somewhat difficult. Still with all these failings, the fossilized forms of the Clinton Group deserve careful study, and to the careful and painstaking collector they will form one of the most productive fields of labor in the State.

The fossils of the Clinton Group differ from the remains of the superposed Niagara formations of the State in this important particular, that, whereas the latter are most frequently found in the form of casts, the former almost always present the external features. Hence they are more readily determined and their structure can usually be easily studied by means of microscopic sections. In the following pages a full ac-

count will be given of the *Brachiopoda* and *Lamellibranchiata* of the group, as far as studied. To this are appended partial accounts of the *Gasteropoda* and *Trilobita* of the same. The next paper will contain a continuation of the account of the latter groups, with a study of the bryozoans and corals of the group. The latter present a few features of special importance in the identification of the stratigraphical relations of this group.

Great pains have been taken in the identification of specific forms, and new species have been formed only with reluctance, and when there seemed to be an absolute necessity for such a course. Nevertheless quite a large number managed to creep in. Of these the most interesting are the series of forms which have so far seemed characteristic of that portion of the Clinton Group, here called the Beavertown marl. They are to be specially noticed for their small size, being accompanied with only a few larger species.

If the writer has anywhere been deceived in his judgment, he would be glad to receive such information as would be useful in correcting the same, since upon the correctness of the identification of the fossil forms must depend the correctness of all discussions as to the stratigraphical relations of the Clinton Group of Ohio.

In the description of fossil forms the nomenclature used by Hall and Meek has been adopted, and where species are identified with, or described as closely related to forms already published by these or other authors, the description of Ohio forms has been as far as possible adapted to the original description. However, no statement has been repeated which is not fully vouched for by specimens on hand, and conformity means only an acknowledgement of the excellence of the descriptions taken as a model.

Most of the species described in this paper may be found in the writer's private collection. Valuable assistance, however, has been afforded by numerous friends, both in the loan of specimens and books, as well as in such general information as has proved valuable from time to time. Among others, the writer feels specially indebted to Mr. E. M. Thresher and Mr. Geo. Caswell, of Dayton—both active collectors of the Clinton fossils near that city. He also wishes to express his appreciation of the kindness and interest shown him by Prof. Edward Orton, of the Ohio Geological Survey, a man of eminent ability, and whose careful, painstaking work has justly won him a place among the most honored of American geologists.

## BRACHIOPODA.

I.	<i>Leptaena prolongata</i> ,	n. sp.
II.	<i>Strophomena patenta</i> ,	Hall.
III.	— <i>rhomboidalis</i> ,	Wilckens.
IV.	<i>Orthis biforata</i> , var. <i>lynx</i> . f. <i>reversata</i> .	
V.	— <i>biforata</i> , var. <i>lynx</i> . f. <i>Daytonensis</i> .	
VI.	— <i>flabella</i> ,	Sowerby.
VII.	— <i>hybrida</i> ,	Sowerby.
VIII.	— <i>elegantula</i> ,	Dalman.
IX.	— <i>elegantula</i> , var. <i>parva</i> ,	n. var.
X.	— <i>fausta</i> ,	n. sp.
XI.	— <i>Daytonensis</i> ,	n. sp.
XII.	<i>Meristella umbonata</i> ,	Billings.
XIII.	<i>Triplesia Ortoni</i> ,	Meek.
XIV.	——— <i>triplesiana</i> ,	n. sp.
XV.	<i>Rhynchonella scobina</i> ,	Meek.
XVI.	<i>Zygospira modesta</i> ,	Hall.
XVII.	<i>Atrypa nodostriata</i> ,	Hall.
XVIII.	<i>Eichwaldia reticulata</i> ,	Hall.

The Brachiopoda of the Clinton Group of Ohio seem to have their nearest relatives in the Niagara formations of other States. *Eichwaldia reticulata* is characteristic of the Waldron beds of Indiana. *Orthis hybrida* and *O. elegantula* are widely distributed Niagara forms. *Orthis flabella* and *Atrypa nodostriata* recall the Niagara fossils of New York. *Rhynchonella scobina* is closely related to *R. neglecta*, a Niagara fossil of considerable distribution. *Leptaena prolongata* recalls *L. transversalis* of New York. *Orthis fausta* finds its nearest relative, perhaps, in *O. Nisis*, of Kentucky strata, equivalent to Niagara formations. *Meristella umbonata* is found in the Middle Silurian of Anticosta. *Strophomena patenta*, however, is found in New York, in rocks undoubtedly Clinton. Three species, *Strophomena rhomboidalis*, *Orthis biforata* var. *lynx*, and apparently also *Zygospira modesta* extend from the Lower Silurian into the Clinton rocks of Ohio.

Of these, *Strophomena rhomboidalis* and *Orthis biforata*, var. *lynx*, have a great range vertically. *Strophomena patenta* differs from the New York types of this species in the finer and more numerous radiating striae. *Zygospira modesta*, as stated, has its relations in lower strata. The testimony of the other fossils seems to be more or less decidedly in favor of a relationship with Niagara forms.



## GENUS LEPTÆNA, Dalman.

I. LEPTÆNA PROLONGATA, *sp. n.**(Plate XIII, Figs. 5 a, b.)*

Shell of medium size, concavo-convex, semi-oval; hinge line prolonged, exceeding the width of the shell, lateral extremities acutely angular.

Ventral valve alone known, very convex, highest elevation at about one third the distance from the beak to the anterior margin, thence curving rapidly towards the anterior margin, and far more so towards the posterior margin or hinge line, which is inflected. There is a tendency towards a slight mesial elevation.

Surface marked by fine, close striæ, some of which are more prominent, the spaces between being puncto-striate. Interior of shell also striated in the same direction as the exterior surface, the reticulated structure of *L. transversalis* not observed.

This species is closely related to *L. transversalis*, from which it differs in its larger size, the lateral prolongation of the shell, especially along the hinge line, absence as far as known of reticulations among the interior striæ, and by the tendency towards a mesial fold. From *L. sericea* it can be distinguished by its great convexity from the anterior towards the posterior regions. (The specific term is intended to suggest the lateral prolongation of the shell.)

Length, 13 mm.; breadth, 25 mm.; convexity of the ventral valve, 5 to 6 mm.

*Locality and position.* Soldiers' Home, Clinton Group.

## GENUS STROPHOMENA. Rafinesque.

## II. STROPHOMENA PATENTA, Hall.

Shell described in Ohio Pal. Vol. II.

*Locality and position.* Soldiers' Home Quarries, Clinton Group: common.

## III. STROPHOMENA RHOMBOIDALIS, Wilckens (sp.).

Described in Ohio Pal. Vol. II.; variable.

*Locality and position.* Soldiers' Home and Huffman Quarries, Clinton Group.

## GENUS ORTHIS, Dalman.

## ORTHIS BIFORATA, var. LYNX, Von. Buch.

IV. forma *reversata*.

(Plate XIII, Fig. 7.)

Shell of the type known as var. *lynx*, especially those forms which show a greater number of plications on the mesial fold and in the sinus. The name given to the form here described is expected to have only a local use to distinguish it from the variety *lynx*, as described and figured in the Ohio Geological Reports from the strata of the Cincinnati formations. Typical specimens of the different varieties of *O. biforata* from the Lower Silurian formations of Ohio have an odd number of plications in the mesial sinus, and an even number on the mesial fold. Thus var. *lynx* has typically three in the sinus and four on the fold. When more than this number appear, the typical plications are the stronger. Typical specimens of *O. biforata* var. *lynx* in the Upper Silurian formations (Clinton Group), in the two forms known to me, have an even number of plications in the mesial sinus, and an odd number on the mesial fold. In the form *reversata* the plications branch frequently, but the typical arrangement remains clearly defined. Although these distinctions are not expected to be of value elsewhere, they are too well defined and of too much interest in our local formations, not to be noted.

Shell attaining a fair size, the dorsal valve a little larger; shell wider than long, with a sub-graduate outline; no very gibbous forms have as yet been found; hinge line less than the greatest breadth of the valves; cardinal extremities obtusely angular; lateral margins rather sinuous near the hinge line, rounding to the front, where it is somewhat sinuously rounded at the junction of the mesial sinus and fold. Beaks nearly equal, incurved and approximate, sometimes almost touching; cardinal areas nearly equal.

Dorsal valve more convex than the ventral, its greatest convexity being near the middle. Mesial fold rather rounded, arising near the beak, becoming more prominent as it extends forward, with rounded sides; beak projecting beyond the hinge margin, strongly incurved; cardinal area directed backward, somewhat incurved. Foramen broad, triangular and not closed by the cardinal process.

Ventral valve with a mesial sinus, beginning near the beak, ex-

tending forward, terminating in a rounded projection which continues the curvature of the shell and thus produces a sinuous outline for the front edge of the shell. Surface of the valve rounded into the moderately concave sinus. Beak less strongly incurved than that of the dorsal valve. Cardinal area incurved and directed backward, less, however, than that of the other valve. Foramen triangular, wider than high; hinge teeth moderately prominent and trigonal; muscular cavity oblong, little more than one third the length of the shell, lateral margins parallel, well defined by the dental ridges. On either side of this cavity are a number of short striae, which are arranged in longitudinal lines following about the direction of the plications.

Surface of each valve with rounded, radiating plications, from 24 to 36 in number, of which four to six occupy the mesial sinus, and five to seven (in one specimen ten or eleven) the mesial fold. In the sinus two plications begin at the beak, two additional ones are immediately added, and later one or two more at one third or one half the length of the shell from the beak. On the mesial fold three plications originate at the beak, to which two more are added at one fourth the length of the shell from the beak; later two more appear and in one specimen in hand ten or eleven plications are more or less distinctly shown. The plications in the sinus and on the fold branch in all specimens as described above; the lateral ones, 10-15 in number, are almost always simple. Lines of growth not shown in the specimens found. Well preserved specimens under the microscope show numerous minute granules, arranged in regular rows across the plications.

Length of the specimen figured, 24 mm.; breadth, 28 mm.; hinge line, 21 mm.; convexity, 18 mm.; breadth of largest specimen, 37 mm. Comparing this description with that given by Meek, in Pal. Ohio, Vol. I., it will be found to be about the same as that of var. *lynx*. (The name of the form is intended to suggest the fact that the odd and even number of mesial plications are found on valves opposite to those on which they occur in Lower Silurian forms, as though the shell had been *turned about*.)

*Locality and position.* Throughout the Clinton Group. Found entire in the Beavertown marl, generally in fragments in the rest of the group. Soldiers' Home, Centreville, Huffman's Quarries.

It may be interesting to notice in this connection that all the forms of *Orthis biforata* from the upper Niagara formations of Ohio, which I

have seen, belong to a smaller type of the var. *lynx*, and are characterized, like our Clinton specimens, by an even number of plications in the sinus, and odd number on the mesial fold.

#### V. Forma *Daytonensis*.

(*Plate XIII, Fig. 8.*)

This is another form belonging to the forms typified by the varieties of *O. biforata*, found in the Cincinnati formations. They bear considerable resemblance to the young of var. *lynx*, and in one case, having the hinge line greater than the breadth of the shell, it varies somewhat in the direction of var. *acutilirata*. The name is expected to have only a local use for the Clinton forms which have two plications in the mesial sinus, and three simple ones on the fold, all of which seem to originate at about the same distance from the beak.

Shell of small size, wider than long, with a subquadrate outline, hinge line usually shorter than or equaling the breadth of the valve, in one specimen exceeding it in size. The shells have their outline indistinctly preserved and are found only as single valves showing their exterior surface.

Ventral and dorsal valves with sinus and fold rounded, the plications also more rounded than those of Lower Silurian formations, simple.

These specimens could perhaps be considered as the young of the form *reversata*, were it not for the simple plications on both fold and sinus, which remain simple where on the corresponding places of the other form there would be several additional plications intercalated.

Length of medium sized specimen, 12 mm.; breadth, 18 mm.; convexity, as well as can be determined by a comparison of different single valves, 9 mm. Breadth of largest specimen, 24 mm. (The name of the form is taken from the locality where it is most frequent.

*Locality and position.* Soldiers' Home, Clinton Group.

#### VI. ORTHIS FLABELLA, *Sowerby*.

(*Plate XIII, Figs. 12 a, b.*)

Shell semi-oval; hinge line equal to the breadth of the valve or generally a little less. Shell wider than long, the dorsal valve much more convex than the other, very variable.

Dorsal valve very convex, the greatest convexity being near the beak ; beak much elevated, incurved.

Ventral valve flattened, with a shallow mesial sinus, more marked along the posterior half of the shell, towards the beak ; beak but slightly elevated.

Surface marked by twenty to twenty-four simple, strong, low, rounded, almost straight plications, equal to the broad, flattish spaces between them in width.

From the form as described above there are many variations. The middle plication of the dorsal valve frequently manifests a tendency towards becoming more elevated and almost forming a low carina towards the beak ; the other plications becoming more indistinct as they approach this point. They may also become more angular, more numerous, approaching thirty in number, and the spaces between them may become even narrower than the plications. Again, in a few specimens they divide dichotomously towards their extremities. The shells also vary considerably in size, from 18 to 43 mm. in breadth. Faint concentric striæ may also appear in the depression between the plications ; lines of growth are still more rare. The anterior and lateral margins of the shell are rarely well defined in our specimens.

Length, 18 mm. ; breadth, 26 mm. ; convexity, as nearly as can be determined by comparison of the separated valves, 8 to 9 mm., being accounted for mainly by the great convexity of the dorsal valve.

The shell has been found only in the form of separated valves, the exterior surface exposed, the cardinal area invisible ; however, the few simple plications usually equaling the flat depressions between sufficiently determine this species.

*Locality and position.* Soldiers' Home Quarries, Clinton Group ; very common in places.

#### VII. ORTHIS HYBRIDA, *Sowerby.*

(*Plate XIII, Figs. 10 a, b.*)

Shell lenticular, greatest diameter at one third the length of the shell from the beak, wider than long ; valves nearly equal, hinge line about half the width of the shell.

Dorsal valve convex, evenly rounded, beak less elevated than that of the ventral valve, cardinal area smaller, extending the length of the hinge line.

Ventral valve convex, with a broad, undefined depression extending from near the centre to the anterior margin; beak a little incurved, cardinal area directed backwards, incurved. Owing to the depression along the anterior portion of the ventral valve, the shell has a sinuous outline in front.

Surface marked by fine, close, branching striae, which are arched upwards along the postero-lateral margins; radiating striae crossed by several lines of growth. Concentric striae not distinguishable in the specimens at hand.

Length, 17 mm.; breadth, 19 mm.; convexity, 8 mm.; hinge line, 10 mm.

*Locality and position.* Soldiers' Home Quarry, in the upper, shaly courses of the Clinton Group.

#### VIII. ORTHIS ELEGANTULA, *Dalman.*

(*Plate XIII, Figs. 11 a, b.*)

Shell semi-oval; hinge line shorter than the width of the shell, exceeding the length of the cardinal area.

Dorsal valve almost flat, with a shallow depression extending from the beak to the anterior margin; more marked near the beak; beak not incurved.

Ventral valve convex, extremely elevated towards the beak; beak much exceeding that of ventral valve in length, and incurved over the cardinal area.

Surface marked by fine radiating striae, branching, curved upwards along the lateral and posterior margins; crossed by lines of growth, and fainter concentric striae.

This species may be readily distinguished from *O. hybrida* by the flat dorsal valve, and shallow depression extending from the beak to the anterior margin, also by the more quadrangular outline of the shell.

Length, 16 mm.; breadth, 17 mm.; convexity, 4 mm.; hinge line, 10 mm.

*Locality and position.* Soldiers' Home and Centreville Quarries, in the upper courses of the Clinton Group.

IX. var. *parva*, or young.

(*Plate XIII, Figs. 17 a, b.*)

Among the specimens of *Orthis* collected at the Soldiers' Home Quarries occur great numbers of a small form resembling *O. elegantula*. The ventral valve is exceedingly convex and the surface is marked by fine, numerous, indistinctly preserved striæ, being plainest at the lateral and anterior margins of the valve. The beak is very prominent and incurved.

An ordinary sized specimen of the ventral valve measured gave a length of 6 mm.; breadth, 7 mm.; convexity, 3 mm. The largest specimen observed does not exceed 10 mm. in breadth.

The variety occurs frequently in the limestone of the Clinton Group, whereas the species described above seems confined to the upper, shaly courses. The main reasons for separating it from the species are its smaller size, greater convexity, and different location. If not the young of *O. elegantula* it is certainly a well marked variety. Its general appearance is somewhat like that of *O. pisa* of New York strata, but our shell does not have both valves connected and the presence of an occasional dorsal valve having a low mesial depression, apparently to be associated with the ventral forms, would preclude such a determination. For the present it may be considered a variety of *O. elegantula*.

*Locality and position.* Widely distributed throughout the Soldiers' Home Quarries, in all except the uppermost layers of the Clinton Group.

X. ORTHIS FAUSTA, *sp. n.*

(*Plate XIII, Figs. 15 a, b, c, d; and Figs. 16 a, b.*)

Shell of medium size or often less, wider than long; hinge line not equaling the width of the shell; lateral margins rounded in front, posteriorly incurved, frequently expanding at the hinge line just enough to leave the postero-lateral margins extend a slight distance beyond the incurved portion of the same, like little ears. Convexity of the valves almost equal, that of the ventral valve being slightly the greater.

Dorsal valve convex, with a distinct mesial sinus extending from the beak to a point about one third the distance from the anterior margin, where it vanishes; the greatest convexity lies a little behind the

middle, on either side of the mesial sinus. Beak slightly elevated, scarcely incurved; foramen broad-triangular, width equal to twice the height. Cardinal process small, laterally compressed, not filling the foramen, in a line with the base of the cardinal area; cardinal area moderate, one third that of the ventral valve, equaling the hinge line, directed backwards, arched. Postero-lateral regions of the valve moderately compressed.

Ventral valve more convex, its greatest convexity about two-fifths the distance from the beak, sloping regularly to the lateral and anterior margins. Beak prominent, incurved, having two or three times the elevation of the dorsal valve; cardinal area corresponding, directed obliquely backwards, arched; foramen triangular.

Surface marked by 40 to 50 radiating striæ, which increase by frequent intercalations, and are crossed by distinct concentric striæ, giving the surface a beautifully ornate appearance, which will serve to readily distinguish it from the other species of *Orthis* found here. (Figs. 15 *a, b, c, d.*)

A form of this species occurs having the general shape and characteristics of the typical specimens, but the plications are more angular, sometimes almost acutely ridged, and crossed by concentric striæ, more closely arranged, and also much less distinct, not producing the ornate appearance characteristic of the typical form. For this reason I was once inclined to separate them under a different name, *acutoplicata*, but at present I am of the opinion that they are not sufficiently distinct to be placed even under a varietal name. (Fig. 16 *a, b.*)

Length of a specimen, 17 mm.; breadth, 21 mm.; convexity, 9 mm.; varying from this to specimens with a convexity of only 6 or 7 mm.

This species seems to be a form intermediate between *Orthis insculpta* and *O. bella-rugosa* of the Lower Silurian strata, and *O. Nisis* of the Niagara group of Kentucky. It differs from the last in the much smaller elevation of the ventral beak; from the second, in the coarser and broader appearance of its radiating striæ, the absence of an incurved anterior margin, and by the greater curve of its ventral beak; from the first it is chiefly distinguished by greater size and more numerous striæ.

*Locality and position.* Soldiers' Home Quarries, Clinton Group; the typical forms, in the upper part of the group; the variety with more acute plications, in the lower portions of the same.



XI. ORTHIS DAYTONENSIS, *sp. n.*

(Plate XIII, Figs. 13 a, b, c, d.; Figs. 20 a, b; and Fig. 21.)

Dorsal valve wider than long, very convex, greatest convexity being just behind the middle, thence sloping almost equally on all sides, except toward the postero-lateral regions, which are somewhat compressed; a faint mesial sinus towards the beak. Cardinal area narrow, foramen broadly triangular, cardinal process narrow, compressed laterally, and situated beyond a line connecting the lower edges of the cardinal area, or on the line itself; not filling the foramen.

Ventral valve flattish, its greatest convexity one fourth the distance from the beak or even closer; thence sloping towards the postero-lateral extremities and the anterior margin, causing the anterior portion of the valve to be depressed, and leaving that portion of the shell extending from the beak to about the middle of the lateral margins elevated above the other portions of the valve.

The interior of a ventral valve found will be sufficiently explained by Fig. 20 b, of Plate XIII. A single specimen with both valves united has been found presenting the characteristics of the valves just described, and furnishes my authority for uniting them under the same species. But as a curious matter of fact most of the ventral valves have been found at Allen's Quarry, and all the dorsal valves at the Soldiers' Home Quarries. The entire specimen is smaller in size than most of the single valves found.

Surface marked by 60 to 90 fine, radiating striæ; the branching is frequent and by intercalations. Concentric striæ distant from each other about the space between the radiating striæ, or more, giving sometimes the appearance of quadrangular punctæ between the striæ; concentric striæ usually best preserved in the spaces between the radiating striæ, often not very plain on the striæ themselves.

Length of a dorsal valve, 17 mm.; breadth, 21 mm.; convexity, 5 to 6 mm. Length of a ventral valve, 21 mm.; breadth, 26 mm.; convexity, 4 to 5 mm. Length of the only complete shell found, 18 mm.; breadth 23 mm.; convexity, 8 mm.; the relative elevation of the beaks in this specimen may be understood by examining Fig. 21, of Plate XIII.

*Locality and position.* Allen's and Soldiers' Home Quarries, Clinton Group.

## GENUS MERISTELLA, Hall.

XII. MERISTELLA UMBONATA, *Billings* (sp.).

(*Plate XIII, Figs. 2 a, b.*)

Shell elongate ovate, the sides forming a continuous curve from the umbo of the ventral valve to the front margin, with the exception of a very slight inward curve at the hinge extremities, not at all resembling those of the Ohio forms of *M. cylindrica*; front margin rounded.

Dorsal valve convex, greatest elevation at one third the distance from the beak, thence obtusely rounded towards the beak which is concealed by that of the ventral valve.

Ventral valve strongly convex, forming a continuous curve from the anterior margin to the beak, which is spirally incurved upon the beak of the dorsal valve, which it more or less conceals. The ventral valve considerably elevated above the beak of the dorsal, more so than would be indicated by the figures accompanying this description.

Surface smooth, the concentric striæ indistinct.

Length of dorsal valve, 14 mm.; of ventral valve in the same specimen, 17 mm.; breadth, 14 mm.; convexity, 12 mm. Length of dorsal valve in a small specimen, 10 mm.; ventral valve, 12 mm.; breadth, 8 mm.; convexity, 8 mm.

The first inclination was to place these specimens under *Meristella cylindrica*, but several reasons will not permit this: the size of the specimens is smaller, the elevation of the ventral valve is greater, the length of the shell is relatively smaller as compared with its breadth, and considered as young of *M. cylindrica*, their convexity is too great. On the other hand they are of the same size and outline as *M. umbonata*. Associated with the ordinary forms are also separated valves, broadly ovate in outline and more nearly resembling those forms described by Billings under the specific term *Prinstana*. Since the writer is of the opinion that this species is only another form of *M. umbonata*, its apparent occurrence in the same strata in Ohio with the form just described, seems to him an additional proof of its identity.

*Locality and position.* Soldiers' Home Quarry, Clinton Limestone. Specimens from this locality were kindly loaned by Mr. George Caswell, of Dayton.

## GENUS TRIPLESIA, Hall.

XIII. TRIPLESIA ORTONI, *Mceek.*

Described in Ohio Pal. Vol. I.

*Locality and position.* Soldiers' Home and Centreville Quarries, Clinton Group; the upper "shovel ends" are frequent in the upper shaly courses of the Group.

## GENUS —————

## XIV. ————— TRIPLESIANA, sp. n.

(*Plate XIV, Figs. 13 a, b; and Fig. 14.*)

The generic relations of the following shell I have been unable to determine satisfactorily, although the specimens are in a moderately good state of preservation. A specific name is merely suggested for the local use of collectors, and a description appended to give notification of at least the existence of such a shell. The specific name is intended to suggest its similarity in appearance to certain very flat forms of *Triplesia Ortoni* in which the cardinal area is not much developed.

Shell subquadrate, or rounded anteriorly and more oval in outline, medium or larger in size; cardinal area scarcely developed, very narrow, but apparently equalling the hinge line. Beaks approximate, with about the same elevation, scarcely elevated above the hinge line, not prominent.

One valve of the shell has a low mesial elevation of moderate breadth, corresponding to a mesial sinus on the other valve, which is shallow but equally distinct. The comparative breadth of the mesial fold and sinus, considering the general contour of the shell, although suggesting *Triplesia Ortoni*, is dissimilar. In other respects it suggests to me a strophomenoid shell.

Surface marked by broad, radiating, scarcely evident folds, and similar concentric elevations of growth, in addition to which, very fine, fibrous, radiating striæ are visible in the more or less silicified shell. Lateral margin meeting the hinge line at little more than an angle of ninety degrees, rounded anteriorly, slightly projecting at the middle.

Length, 27 mm.; breadth, 29 mm.; convexity, 12 mm. Length of another individual, 28 mm.; breadth, 30 mm.

*Locality and position.* Soldiers' Home Quarry, in the middle of the Clinton Group.

## GENUS RHYNCHONELLA, Fisher.

XV. RHYNCHONELLA SCOBINA, *Meek*.

Described in Ohio Pal. Vol. I and II.

*Locality and position.* Soldiers' Home, Huffman, and Centreville Quarries, Clinton Group; common.

## GENUS ZYGOSPIRA, Hall.

XVI. ZYGOSPIRA MODESTA, *Say* (*sp.*).

(*Plate XIII, Fig. 6.*)

Described in Ohio Pal. Vol. I., and mentioned as occurring in the Clinton Group. I have seen no specimens which could be referred without doubt to this species unless it be a dorsal valve of the following description.

Dorsal valve subquadrate orbicular; beak not elevated; marked by about twenty simple plications; with a shallow mesial sinus, occupied by three plications, the middle plication larger, the lateral ones smaller than the plications immediately adjacent.

Length, 7 mm.; width scarcely larger.

*Locality and position.* Beavertown marl, Huffman's Quarry, Clinton Group.

## GENUS ATRYPA, Dalman.

XVII. ATRYPA NODOSTRIATA, *Hall*.

(*Plate XIII, Fig. 9.*)

Shell described in Ohio Pal. Vol. II.

A small species of *Atrypa* referred here occurs sparingly, of the following description.

Shell oval, marked by plications, branching near the middle of the shell. Mesial sinus on the ventral valve plainly defined by the bordering plication on each side, containing three to five plications. Dorsal valve with mesial elevation, well defined by a more or less sharp sinus on each side, which is more marked towards the beak.

Length, 11 mm.; breadth, 11 mm.; convexity, 6 mm.

*Locality and position.* Soldiers' Home, Clinton Group.

## GENUS EICHWALDIA, Billings.

XVIII. EICHWALDIA RETICULATA, *Hall*.*(Plate XIII, Figs. 4 a, b.)*

Shell broadly triangular ovate, gibbous, cardinal slopes flattened.

Ventral beak small, acute, flattened on the back, closely incurved, the sinus extending from the beak to the anterior edge, broad, distinct.

Dorsal valve more convex, beak obtuse, strongly incurved, a low, fairly defined mesial fold extending from the beak to the anterior margin.

Surface covered by fine, hexagonal, reticulate markings, largest along the antero-lateral slopes, and decreasing in size towards the sinus and posterior regions. A small space near the ventral beak is destitute of markings.

Length, 8 mm.; breadth, 8 mm.; convexity, 6 mm.

*Locality and position.* Fauvers' Quarry north of Dayton, Clinton Group. Collection of Mr. E. M. Thresher.

## LAMELLIBRANCHIATA.

- |      |                                  |   |   |   |   |   |                     |
|------|----------------------------------|---|---|---|---|---|---------------------|
| I.   | <i>Pterinea brisa</i> ,          | - | - | - | - | - | Hall.               |
| II.  | <i>Grammysia Caswelli</i> ,      | - | - | - | - | - | n. sp.              |
| III. | <i>Cypricardites ferrugineum</i> | - | - | - | - | - | Hall and Whitfield. |
| IV.  | <i>Nucula minima</i> ,           | - | - | - | - | - | n. sp.              |

The *Lamellibranchiata* of the Clinton Group of Ohio are but few both in the number of species and in the frequency of their occurrence.

*Pterinea brisa*, if correctly identified, adds another link connecting this formation with the Niagara Group of the West. It occurs also at Waldron, Indiana, and Bridgeport, Illinois.

## GENUS PTERINEA, Goldfuss.

I. PTERINEA BRISA, *Hall*.*(Plate XIII. Figs. 14 a, b.)*

Left valve alone found. Body of the shell obliquely sub-ovate, extremely inequilateral; anterior wing moderately extended; sinuate at its junction with the body; posterior wing acutely extended a little beyond the posterior extremity of the shell; umbo prominent, beak rising a little above the hinge line, muscular impression in right valve unknown from want of specimens.

Surface marked by strong, radiating striæ, and less conspicuous concentric striæ.

The intercalation of radiating striæ in some cases gives rise to an appearance similar to the dentations and groovings figured in the Indiana reports, but not identical with them. The concentric striæ also are not so prominent. The crystallized character of our specimens will, perhaps, account in part for these discrepancies. Fig. 14 *b* represents a specimen with fewer radiating striæ, referred here.

Length, 16-17 mm.; height, 10-11 mm.; convexity of the left valve, about 2 mm.

*Locality and position.* Soldiers' Home Quarries, Clinton Group.

#### GENUS GRAMMYSIA, De Verneuil.

##### II. GRAMMYSIA CASWELLI, *sp. n.*

(*Plate XIV, Figs. 12 a, b.*)

Shell small, transversely sub-ovate; umbonal regions gibbous, anterior regions likewise; height at the beaks equalling about five-eighths of the length. Anterior end sloping abruptly from the beaks above, with a distinctly concave outline, to the lower end of the lunule, where it is met by the rounding base, forming more or less an angle at their junction; base forming a broad semi-elliptic curve; posterior end more compressed, the specimen at hand being too imperfect to determine whether it gaps at this extremity, although it is presumed to do so a little from the curvature of the better preserved valve; posterior end rounded, then curving upward and quite rapidly forward almost merging into the hinge line.

Cardinal margin indistinctly preserved, judged to be nearly horizontal, slightly concave in outline, and inflected along its entire length, forming a well defined escutcheon; lunule distinct, with an ob-ovate outline, quite deep. Beaks prominent, strongly incurved, obliquely to the hinge, directed a little forwards, posterior umbonal slopes prominently, yet rather broadly rounded.

Surface ornamented in the cast by well-defined concentric ridges and furrows, these in the specimen at hand crossed by fine parallel lines, almost vertical, directed a little backwards, and which may be accidental rather than a special feature of the shell. Ridges strongest

anteriorly, becoming less distinct posteriorly. A portion of the shell where preserved shows the ridges far less defined than on the cast.

Length, 37 mm.; height, 25 mm.; convexity, 25 mm.

*Locality and position.* Soldiers' Home, Clinton Group. Collection of Mr. Geo. Caswell.

GENUS CYPRICARDITES, Conrad.

III. CYPRICARDITES FERRUGINEUM, *Hall and Whitfield.*

Species described in Ohio Pal. Vol. II.

*Locality and position.* Wilmington, Clinton County, Ohio, Clinton Group. To my knowledge not found elsewhere.

GENUS NUCULA, Lamarck.

IV. NUCULA MINIMA, *sp. n.*

(*Plate XIV, Figs. 8 a, b, c.*)

Shell (presumably the cast) very small, ovoid, gibbous above the middle towards the beaks, outline curving to the base and posterior extremity, anteriorly curving more rapidly to the beaks above. Beaks, near the anterior extremity of the shell, incurved and inclined forwards. Hinge line at one-third the distance from the beak to its posterior extremity supplied on each side with a narrow fold, directed backwards, making a small angle with the hinge line, and vanishing at one-third the distance from the posterior extremity in the depressed regions formed by the raised postero-umbonal regions.

Near the beak on each valve are three to four radiating grooves, which are characteristic of this species and are evident under the microscope.

In addition to these grooves are three more or less clearly defined pits, one being placed in the anterior groove near the beak, and the two others in the second groove, one on each side, and at a greater distance from the beak. Along the hinge line, anterior to the beaks, are two or three more or less distinct crenulations, which appear a little like plications originating in the lunule near the beak and becoming more distinct at the hinge line.

Length, 2 mm.; height, 1.4 mm.; convexity, 1 mm.

*Locality and position.* Beavertown marl, Huffman's Quarry; not found elsewhere in the Clinton Group. Associated with many other

minute forms, apparently chiefly in the form of casts, among these a number of *Gasteropoda*.

## GASTEROPODA.

I.	<i>Cyclonema bilix</i> ,	Conrad (sp.).
II.	<i>Trochonema nana</i> ,	n. sp.
III.	<i>Raphistoma affinis</i> ,	n. sp.
IV.	<i>Pleurotomaria inexpectans</i> ,	Hall and Whitfield.
V.	<i>Cyclora alta</i> ,	n. sp.
VI.	<i>Strophostylus cyclostomus</i> ,	Hall.
VII.	<i>Platyostoma Niagarensis</i> ,	Hall.
VIII.	<i>Bucania exigua</i> ,	n. sp.
IX.	<i>Bellerophon fistello-striatus</i> ,	n. sp.

The *Gasteropoda* of the Clinton Group, identified with previously described forms, are too few to form any great basis of comparison, stratigraphically. *Cyclonema bilix* ranges from the Lower Silurian into the Upper. *Strophostylus cyclostomus* is found also at Waldron, Indiana. *Platyostoma Niagarensis* differs in size and expansion at the aperture from typical specimens, but its connection with them seems undoubted. At any rate its deviation from the typical forms is far less than the var. *trigonostoma* of Meek, and all these forms are typical of the Niagara.

## GENUS CYCLONEMA, Hall.

## I. CYCLONEMA BILIX, Conrad (sp.).

Shell described from the Lower Silurian in Ohio Pal. Vol. I.

*Locality and position.* Centreville and Soldiers' Home Quarries, frequent in the upper courses of the Clinton Group.

## GENUS TROCHONEMA, Salter.

II. TROCHONEMA NANA, *sp. n.*

(*Plate XIV, Fig. 16.*)

Shell oblong, the height about twice the breadth, in the specimen figured the carina being a little more prominent than is there indicated. Volutions about three, increasing rapidly in size, the last disproportionately so, forming the larger bulk of the shell, almost equaling two-thirds the height. Shell thin; it is impossible to trace the suture line,



but there is a carina where the volutions may be supposed to meet, this carina is distinctly grooved along the latter half of the last volution where it approaches the aperture of the shell; above the carina is a low shallow groove which in the last volution spreads so as to cover the entire volution. Surface smooth. Shell probably in the form of a cast.

Height, 3 mm.; breadth, 1.5 mm.; height of aperture, .9 mm. (?) breadth of aperture, .35 mm. (?) above, narrowing to .23 mm. (?) below. The measurements given for the aperture are liable to error, although there seem to be slight grooves and elevations at the close of the last volution, which look like an elongated aperture.

*Locality and position.* Beavertown marl, Huffman's Quarry, Clinton Group. (Name signifying dwarf.)

#### GENUS RAPHISTOMA, Hall.

#### III. RAPHISTOMA AFFINIS, *sp. n.*

(*Plate XIV, Fig. 18.*)

Shell lenticular; breadth a little more than twice the height; convexity moderate above, equally so below; volutions varying from two and a half to three and a half, with a moderate slope above, coincident with that of the spire; the last volution sharply carinate around the periphery, convex below, being more so at the umbilicus into which the slope is abrupt; suture distinct, forming a small groove between the volutions; umbilicus as wide as the outer volution; the last volution becoming transversely rhomboidal, the aperture itself not being preserved, the breadth about three times the height. Surface apparently smooth.

This species is almost in every respect identical with forms of *R. lenticularis* as known to me from the Lower Silurian formations. It is however a much smaller shell, with less numerous volutions, and apparently a distinct form.

Breadth of largest specimen, 7 mm.; height, 3 mm.; breadth of the end of the last volution, 3 mm.; height, 1.2 mm.; aperture not preserved.

*Locality and position.* Beavertown marl, Huffman's Quarry, Clinton Group. (Name signifying *related*, the shell being closely allied to the well known species, *R. lenticularis*.)

## GENUS PLEUROTOMARIA, De France.

IV. PLEUROTOMARIA INEXPECTANS, *Hall and Whitfield.*

Shell described in Ohio Pal. Vol. II.

*Locality and position.* Iron ore beds of Clinton County, Clinton Group.

## GENUS CYCLORA, Hall.

V. CYCLORA ALTA, *sp. n.*

(*Plate XIV, Figs. 17 a, b.*)

Shell very small, conoid subglobose; spire varying from two-thirds to slightly more than the diameter of the last volution; volutions three or four, increasing in size rapidly, but evenly; the last volution not so disproportionate in size to the rest of the shell as compared with the species so far described; suture deep; surface smooth; umbilicus small; aperture circular.

Height of largest specimen seen, 4 mm.; breadth, 3.5 mm. Height of a specimen of the usual size, 2 mm.; breadth, 2.75 mm. From this varying to specimens only 1 mm. broad.

This shell differs from the species of *Cyclora* so far described in its greater size, greater elevation of the spire, and the more regular increase of its volutions. Its general form approaches that of the closely related genus *Holopea*. Since the chief distinction, however, of the first genus is its diminutive size, it may be safe to refer to it also the specimens here described.

*Locality and position.* Beavertown marl, Huffman's Quarry, Clinton Group; not scarce (Name intended to suggest the height of the spire, as compared with other species of this genus.)

## GENUS STROPHOSTYLUS, Hall.

VI. STROPHOSTYLUS CYCLOSTOMUS, *Hall.*

(*Plate XIV, Fig. 15.*)

Shell transversely broad-oval. Spire moderately elevated; volutions in the specimen figured, three, a fourth having broken away; the last volution by far the largest, ventricose. Aperture not fully exposed, oblique to the axis, subcircular.

Surface marked by shallow, broad striæ and closer, finer striations crossing the volutions obliquely and in a direction opposed to them.

Diameter of volutions, measured in a plane vertical to the shell and passing through the aperture, 6, 17, and 44 mm.; elevation of the second and third volutions less than half the last.

The character and direction of the shell aperture, the relative size and position of the volutions seem to leave no doubt as to the identity of the specimen, and will at the same time serve to distinguish it from any other species of gasteropod found in Ohio.

*Locality and position.* Soldiers' Home Quarry, Clinton Group.

GENUS PLATYOSTOMA, Conrad.

VII. PLATYOSTOMA NIAGARENSE, *Hall*.

(*Plate XIII, Figs. 22 a, b; and Figs. 3 a, b.*)

Shell ovoid, volutions three to four, the last much increased in size, spire elevated above the plane of the outer volution, about one sixth of the height of the shell.

Apex minute, expanding symmetrically as far as the outer volution, which is ventricose, and somewhat straightened at the aperture, so as not to maintain the curvature of the coil; in one specimen marked on the upper and lower side by a groove along which the striæ are abruptly bent; peristome undulated.

Surface marked by fine undulating striæ of growth, cancellated by finer revolving striæ.

The specimens referred here are smaller in size than typical forms of this species from western localities, and they differ from them in the tendency for the last volution to lessen its rate of curvature and become somewhat straightened as it approaches the aperture. This straightened appearance is in part due to the slight expansion of the lip at the aperture. Nevertheless these variances seem too slight to give rise to any separation from the typical form under a new specific name.

Height of shell, 21 mm.; elevation of the first three volutions above the plane of the last, 3.2 mm.; greatest diameter (passing through the aperture), 26 mm.; diameter vertical to the same, 17 mm.; diameter of the second and third coils, 2.6 and 7 mm.

*Locality and position.* Brown's Quarry, New Carlisle, Clinton Group, kindly loaned from the collections of the Ohio State University, by Prof. Edward Orton.

In the Soldiers' Home Quarries occur specimens which have usual-

ly been referred to *Holopea*, both by collectors and writers on geology. They consist for the most part of the upper three, or three and a half volutions of a shell which seems identical with the form just described. The character of the volutions and surface striations are the same; the last volution is also expanded at the aperture, giving greater distinctness to the lip, and having the same straightening effect on the curvature of the shell at this point.

In the New Carlisle specimens, however, the upper side of the last third of the last volution is flattened above and quite evenly rounded on the sides, forming in this way a line of elevation along the upper side of the volution, where the gradual curvature of the sides meets the flattened portion above. In the Soldiers' Home specimen which is best preserved, there is no flattening along the upper plane of this last volution, but instead, there is an even curvature from the suture to the lower side, an elevation being thus formed at the umbilicus into which the side of the lower third of the volution bends abruptly.

The aperture of this specimen, therefore, is oblique to a vertical diameter of the shell, whereas, in the New Carlisle specimens the aperture seems to have its greatest diameter vertical to the shell. Other forms, however, occur at the Soldiers' Home, among which are some with deep sutures and less oblique apertures; some quite similar to the New Carlisle specimens, but much smaller; a specimen with its coils arranged somewhat like *P. plebium*, but only half its size (Fig. 3 b.); and a specimen varying to the opposite extreme, with the last volution extremely ventricose, the upper volution only moderately raised, the part towards the aperture, however, being lacking (Fig. 3a). All the forms from the Soldiers' Home differ from the New Carlisle specimens, however, in their smaller size, the New Carlisle specimens differing in turn from the typical western forms chiefly in their smaller size. All these Clinton forms differ from the western in the slight expansion of the lip at the aperture and the straightened appearance of the volutions at this point, the rate of curvature decreasing.

Specimens last described, at Soldiers' Home Quarries, Clinton Group.

(The variations here indicated will be carefully figured in the next paper.)

## GENUS BUCANIA, Hall.

VIII. BUCANIA EXIGUA, *sp. n.*

(*Plate XIII, Figs. 18 a, b, c, d.*)

Number of volutions not known, the last alone visible, increasing rapidly in size and expanding at the aperture; the exact character of the aperture not known from want of preservation, but is presumed to be similar to that of *B. bilobatus*. The outer volution rounded on the dorsum at its origin, a mesial carina gradually developing toward the aperture near which it becomes quite distinct, in some individuals, decidedly so. From this carina the sides slope evenly to the umbilicus, which they enter with a sudden curve, forming a low, indistinct, lateral carina, by the increase of curvature. Umbilicus apparently closed, the last volution alone being visible in the specimens examined. Surface of the cast smooth, traces of the original shell, however, seem to remain in a few spots, indicating a system of striæ curving from the mesial carina obliquely backwards, these apparently crossed by other striations. The usual form of the cast, however, is smooth, the shell being entirely removed.

Measurements, on account of the imperfect preservation of the shell towards the aperture, are of little value, still the following will serve to give a general idea of the proportions of the shell. Greatest diameter of the typical specimen (*Plate XIII, Figs. a, b.*), 9 mm.; diameter at right angles to this, 6.2 mm.; diameter of last volution at the point where it becomes visible, 3.5 mm.; broadest part of volution preserved, 7 mm. From this they vary in size from specimens which become almost minute to some having a greatest diameter of 22 mm.

*Locality and position.* Beavertown marl, Huffman's Quarry, Clinton Group. (Name signifying *quite small.*)

## GENUS BELLEROPHON, Montfort.

IX. BELLEROPHON FISCELLO-STRIATUS, *sp. n.*

(*Plate XIII, Figs. 19 a, b, c, d.*)

Shell sub-discoid; only the last volution known, increasing rapidly in size, being almost four times as large at the aperture as at the point where it first becomes visible; the increase in size is quite regular, except near the aperture where there is a moderate expansion of the vo-

lution; aperture not distinctly preserved, but apparently the aperture was dorsally sinuate, the sinuation being simple and broadly V-shaped; this, however, can not be conclusively determined. Umbilicus quite large,<sup>13</sup> and deeply defined. Dorsally the curvature of the shell toward each side is even and moderate, laterally the curvature is very sudden, the curvature of the sides into the umbilicus equaling or even exceeding the dorsal curvature of the shell; by this means the umbilicus is deepened and the sides of the shell appear raised, almost carinated towards the aperture.

Surface marked by fine longitudinal striæ, of which thirteen may be counted on each side of the carina as far as the beginning of the umbilicus, these are increased by intercalations with the age of the shell. Transverse striæ in the direction of the lines of growth, the striæ on opposite sides of the carina having an angle to each other equal to that which the sides of the sinus of the aperture seem to have. A third, less distinct system of striæ, originating at the carina, seems to make about the same angle with the longitudinal striæ as the transverse striæ just described. As a result of all these striations, the surface of the shell is divided up into many minute, many-sided polygons which give the shell a beautiful appearance. This is enhanced by a low, distinct carina, slightly raised at the sides and thus becoming grooved. Along the carina only a few, indistinct, longitudinal striæ are here and there visible, there are however many fine transverse striæ, bending backward into the groove of the carina.

Greatest diameter (extending through the aperture), 11 mm.; diameter transverse to this, 9 mm. Diameter of the last volution at its beginning, 2.5 mm.; at the aperture, the diameter passing through the dorsum is 5 mm.; the one transverse to this, 9 mm. The width of the carina, .4 to .5 mm.

*Locality and position.* Stolz's Quarry, Clinton Group.

#### CRUSTACEA.

- |      |           |               |   |   |   |                     |        |
|------|-----------|---------------|---|---|---|---------------------|--------|
| I.   | Acidaspis | ———,          | . | . | . | .                   | .      |
| II.  | Bathyrus, | ———,          | . | . | . | .                   | .      |
| III. | Illænus   | Daytonensis,  | . | . | . | Hall and Whitfield. | .      |
| IV.  | —         | Madisonianus, | . | . | . | Whitfield.          | .      |
| V.   | —         | ambiguus,     | . | . | . | .                   | n. sp. |
| VI.  | Calymene  | ———,          | . | . | . | .                   | .      |

- VII. *Calymene Blumenbachii*? . . . . . Brongniart.  
 VIII. *Lichas breviceps*, . . . . . Hall.  
 IX. *Arionellus*? ———, . . . . .  
 X. *Dalmanites Werthneri*, . . . . . n. sp.

The trilobites so far studied seem to be either identical with, or closely related to Niagara forms. Hall and Whitfield, in their description of *Illænus Daytonensis*, say that "specimens having the same features have been collected from the Niagara Group of Wisconsin and Illinois." *I. Madisonianus* is found in Wisconsin; however, I am unwilling to consider this as good evidence, since the identification is based upon one specimen, and that, the pygidium. *I. ambiguus* finds a close relation in *I. insignis*, a typical, western Niagara fossil. *Lichas breviceps* agrees quite closely in all important characteristics, especially those of the pygidium, with described forms of this species from Waldron, Indiana. *Dalmanites Werthneri* is closely related to *D. vigilans* and *D. verrucosus*, also from the Niagara strata of Indiana. Of the other species not much can be said in the present state of knowledge concerning them.

#### GENUS ACIDASPIS, Murchison.

##### I. ACIDASPIS ———.

(*Plate XIII, Fig. 23.*)

A fragment of a trilobite belonging to this genus has been found, presenting chiefly the movable cheek, but also portions of the glabella.

Glabella poorly preserved; including the occipital regions its breadth, as nearly as can be determined, is equal to about one third or two fifths its length, the widest part being behind the middle, between the eyes; lateral lobes apparently three on each side, the middle and posterior lateral lobes along one side of the glabella being distinctly defined in the specimen, the third, anterior lobe, less plainly, on account of the imperfect preservation of the fossil at this point. Lateral lobes of an almost oval outline, directed obliquely forward and outward, the posterior one larger than the middle lobe, separated by a distinct furrow from the cheeks and from themselves; there is a broad groove between the lateral lobes and the glabella proper, in addition to which the furrow between the middle and posterior lateral lobes and the occipital furrow rounding behind the posterior lateral lobe bend

towards one another between the posterior lateral lobe and the glabella, which they seem to connect by means of the raised portion left between them; this connection is not altogether destroyed by the low groove which separates them. The occipital regions curve strongly downwards towards each side, behind and below the posterior lateral lobe, then slightly outward and forward. On this account the posterior margin of the glabella is considerably deflected on either side, beginning a considerable distance beneath the surface of the lateral lobe and fixed cheek, thence rising to almost the level of the glabella and again descending on the other side, being gracefully undulated in this way. The occipital furrow extends from the lower part of the posterior lateral lobe, behind this lobe, as described above, reaching a little more than one third the distance across the glabella. The slope of the rear of the posterior lateral lobe to the occipital regions below is almost vertical.

Fixed cheek divided from the movable cheek by a furrow, which between the middle lateral lobe and the anterior lateral lobe approaches closely to the furrow dividing the lateral lobes from the cheek; thence the former is gradually separated from the latter until it meets the inner margin of the eye, behind which it seems to curve and then become indistinct. Anteriorly the fixed cheek slopes rapidly downward and forward, posteriorly it curves far more rapidly downwards, incurving a little below, so that a distinct furrow seems to separate it from the occipital regions of the glabella; another furrow, starting at the junction of the glabella and fixed cheek, curves around behind the eye, separating the raised portion of the cheek between the eye and the glabella, from the posterior margin of the cheek.

Eye not preserved, judging from indications they were small, placed in a line with the rear of the posterior lateral lobes.

Movable cheek grooved near the fixed cheek, the groove following the direction of the furrow separating the cheeks; that part of the movable cheek between the groove and the furrow following the curvature of the fixed cheek. From this groove there is a gradual downward and outward curvature of the cheek, the same being true of the portions at the side of the eye. Behind the eye, there is a more sudden downward and backward curvature, the groove above mentioned extending behind the raised regions about the eye near the posterior margin of the cheeks, spreading out and becoming indistinct towards the lateral



margin of the head. The posterior and lateral margins of the cheek are distinctly raised so as to form a ridge around the cheek. From the junction of the lateral and posterior ridge a long, sharp spine extends almost directly backward, and a little downward. Along the lateral ridge of the cheek are arranged a number of short spines about one third as long as the postero-lateral spine. The lateral spines curve obliquely backwards. They are apparently almost equidistant from each other and decrease in length anteriorly. There is a lateral spine at the origin of the postero-lateral spine, from this point to a point opposite to the groove between the middle and anterior dorsal furrow 10 spines may more or less distinctly be discerned.

The general curvature of the head is semi-circular from side to side, the convexity from the anterior portion to the posterior of the head being far less, although the exact amount can not be determined on account of the imperfect preservation of the middle and anterior portions of the glabella.

Surface, wherever preserved, distinctly pustulose.

Probable length of glabella, 14 mm.; breadth of the same, 19 mm.; height of the middle part of the occipital margin above its lateral extremities, 5 mm.; length of the lateral spines, 2.5 mm.; length of the postero-lateral spine, 7 mm. Height of the preserved part of the glabella above the margins of the head, 10-11 mm. Probable width of the entire head, 25 mm.

*Locality and position.* John Brown's Quarry, New Carlisle, Ohio, from the collection of the Ohio State University, kindly loaned by Prof. Edward Orton.

## GENUS BATHYURUS, Billings.

### II. BATHYURUS — — —.

(*Plate XIV, Fig. 5.*)

Only a single fragment known, whose relation to this genus is rather conjectural.

Glabella conical, convex, distinctly defined anteriorly and laterally by a continuous quite deep furrow. Posteriorly a small oval, almost triangular tubercle is inserted between the occipital furrow and both of the postero-lateral extremities of the glabella; owing to these tubercles the outline of this portion of the head (the regions of the glabella) seems to broaden at their insertion and then to contract suddenly be-

hind them, meeting the occipital furrow at a considerable angle, within a line directly behind the postero-lateral extremities of the glabella proper. Dorsal furrow well defined, running behind the tubercles, forward to a point almost even with the anterior margin of the tubercle, then back again on the other side. Posterior margin of the regions of the glabella an almost straight line running just behind the posterior ends of the tubercles. Glabella proper indistinctly marked by faint grooves. One of these grooves cuts off from the postero-lateral extremities of the glabella, parts somewhat larger than the tubercles. A second groove (also directed obliquely forward, but at a smaller angle) is placed a little anterior to the middle of the glabella, and extends about one third of the distance across the glabella. Anterior to this are one or two additional grooves, more faint, and also directed obliquely forwards, at a slightly greater angle than the last. All of these grooves are visible only after careful examination.

The anterior margin of the head curves quite rapidly downwards, so that the general shape of the preserved parts of the head is even more convex anteriorly than laterally or posteriorly. Anterior margin separated from the rim by a sort of furrow, from which the narrow rim rises up at an angle of about 45 degrees. The rim lies in a broad curve, passing within a short distance of the groove defining the anterior portion of the glabella. The facial sutures begin at the rim on a line about even with the lateral margins of the tubercles, thence extending inwards with a slow curvature, approaching within a very short distance of glabella behind its middle, and then apparently extending outwards where the outline is lost from want of preservation of the fossil. The antero-lateral extremities of the margin are therefore almost rectangularly pointed.

Length of the glabella to the occipital furrow, 7 mm.; to the posterior margin, 8.2 mm.; from the posterior margin to the anterior rim, 10 mm. Breadth of the glabella at its middle, 6.2 mm.; at its posterior, 6.9 mm.; across the tubercles, 7.4 mm. Distance between the tubercles, 4 mm. Length of the anterior rim, about 7.8 mm.

*Locality and position.* Soldiers' Home Quarry, Clinton Group.

GENUS ILLÆNUS, Dalman.

III. ILLÆNUS DAYTONENSIS, *Hall and Whitfield.*

(*Plate XIV, Figs. 4 a, b; Fig. 6; Figs. 7 a, b, c.*)

Species described by Hall and Whitfield in Ohio Pal. Vol. II.

Fixed cheeks one-third as wide as the space between the dorsal furrows. Palpebral lobes not coming to as sharp a point as figured in the Ohio report, but apparently a little rounded at their ends. Postero-lateral limb of the glabella beginning with a small groove at the base of the dorsal furrow which gradually widens towards the suture line, where it extends from the palpebral lobe to the occipital margin. Posterior portion of the facial suture curves outward from the posterior of the palpebral lobe, cutting the occipital margin at, or slightly beyond a line vertical to it and drawn from the most prominent part of the palpebral lobe.

Anterior margin of the pygidium trilobate, the middle lobe projecting a little, the lateral ones slightly curved at first, almost straight, then bending strongly and obliquely backwards, more or less angular at this point; then curving around and after a slightly angular deflection coalescing with the lateral margin. Antero-lateral angles never so prominent as those figured in the Ohio Report, although somewhat approaching them in this feature.

Movable cheeks small, greatest elevation at the upper posterior margin, making a large sweeping curve as it passes from the posterior to the lower or lateral margin. The facial suture before the eye making an angle of 30 degrees with the lateral line. Since this suture line agrees with the corresponding part of the glabella, these separated cheeks have been referred here.

Glabellae, pygidia, and movable cheeks so far not found in connection. The association of the glabellae and pygidia may be considered certain from their relative frequency and similarity to nearly related species. The cheeks are more conjectural in their relationship, although tolerably certain from their form.

Smallest glabella, 9x11 mm. One of larger size, 40 mm. broad at the palpebral lobes, 30 mm. long, 13 mm. high. Smallest pygidium, 4x5 mm. One of larger size, 34 mm. broad, 25 mm. long, 5 mm. high. Movable cheeks 7-8 mm. broad, 12 mm. long to the point where it disappears beneath the glabella. Eyes two mm. long in the small specimens found.

*Locality and position.* Soldiers' Home, Fair Haven, Preble county, Clinton Group, abundant.

IV. ILLÆNUS MADISONIANUS, *Whitfield*.

(*Plate XIV, Figs. 1 a, b; Figs. 2 a, b.*)

Pygidium paraboloid in outline, its anterior margin arching strongly forward in the middle, and its surface very convex. Lateral margin spreading, forming a broad shallow furrow around the sides and behind, just within the edge; anteriorly this furrow extends up the articulating slope or facet of the pygidium, leaving it at about half the distance from the top of the anterior margin. Anterior margin with a rounded ungrooved edge, its corners just without the lateral furrows deflected downwards and forwards. A narrow faint ridge running from the posterior edge, half way up the pygidium. Entire surface minutely punctate with small pits .1 mm. in diameter, these interspersed with others of still smaller size.

Length, 30 mm.; breadth, 38 mm.; height 14 mm.; extension of the anterior margin forward beyond a line connecting the antero-lateral extremities, 9 mm. At the middle of this line is found the greatest elevation of the pygidium.

Our specimen is less abrupt at the sides than the one figured by Whitfield and has a smaller elevation along its posterior portion, but the general characters agree very closely with the published description and figures of the original. The recurved spreading margin seems to distinguish it from *I. insignis* of Hall, the nearest related species.

*Locality and position.* Clinton Group, Huffman's Quarry.

Another individual from the Soldiers' Home Quarries is proportionately broader, more depressed, less extended anteriorly, and provided at the anterior margin with a groove. Otherwise it agrees closely with the above form.

V. ILLÆNUS AMBIGUUS, *sp. n.*

(*Plate XIV, Figs. 9 a, b; Figs. 10 a, b, c; Fig. 11.*)

Glabella regularly arcuate from front to base; anterior border with the margin neatly rounded. Occipital furrow well defined, with a faint upward extension at its middle, barely visible, within which is a minute granule, which can readily be recognized on wetting the specimens. Extending towards the anterior margin from this part is an indistinct ridge, which can be recognized only with difficulty, except in an occasional specimen where it may become moderately distinct.

This corresponds to a much more evident (although narrow) ridge, on the pygidium associated with these glabellae. In the occipital furrow at about two-thirds the distance of its postero-lateral margin from the granule is a deep, very distinct pit becoming shallow in older specimens.

From this the dorsal furrow extends inwards as a deep groove forming a broad, oval depression opposite the palpebral lobe, thence it extends as a shallow groove, rapidly becoming indistinct, in an outward direction, terminating in a small pit, which can be easily recognized even in specimens which do not show the connecting part of the groove distinctly, as is usually the case. This pit contains a minute granule. It is situated at two-thirds the distance of the anterior margin from the palpebral lobe. Half way between this pit and the anterior margin is a minute granule, easily visible on wetting the specimen. Widest part of the glabella lies between the palpebral lobes, anterior to which it becomes narrower and again widens reaching almost the same width at a point just behind the junction of the facial suture with the anterior margin. Facial suture extending from the edge with a distinct outward curvature to a point opposite the terminal pit of the dorsal furrow where it makes a rapid curve inwards to its junction with the anterior margin, in which the facial suture seems to terminate without any break. Palpebral lobe rounded. Facial suture behind the palpebral lobe starts from the posterior incurved extremity of each eye, and curves rapidly outward, cutting the margin directly behind or a slight distance beyond a vertical line drawn from the most prominent part of the palpebral lobe to the occipital line. Greatest elevation of the glabella lies between the palpebral lobes.

Pygidium semi-circular in outline, becoming slightly paraboloid in larger specimens, with a narrow more or less strongly marked ridge. Ridge extending from the posterior margin upwards, usually not reaching the middle of the pygidium. It can always be recognized. Along the anterior margin lies a groove, which is somewhat straight along its middle third, a small inward curvature near the middle, being very slight, aids in this appearance. At either side the groove makes a short curve inwards, and then outwards, approaching the lateral margin, along which it extends for a short distance, rapidly becoming obsolete. The deflection of the antero-lateral border causes a raised, ridge-like eminence to remain between it and the antero-lateral portion of the marginal groove. Pygidium flattish along the upper anterior

surface; greatest elevation at one-third the distance from the posterior margin, from this point rapidly curving downwards to the posterior margin, less rapidly towards the side and anterior portion.

Movable cheeks broadest at the posterior end of the eyes, with a deep-rounded furrow around the base of the eye. In large specimens rounded above. The facial suture inclining at an angle of sixty degrees to the lateral margin in front and meeting it at an angle behind which might be called a right angle, with the vertex rounded. It has also quite a sharp edge along its posterior margin, where the cheek makes a curve beneath the glabella. Since the angle made by the facial suture anterior to the eye corresponds to that made by the suture anterior to the palpebral lobe in the glabella, the cheeks are associated with this species. Eyes placed almost parallel with the upper part of the movable cheeks, lunate, forming about one-third of a circle. Lenses minute, about 17 to a millimeter. In the specimen examined they were only fairly preserved but there were about 20 in the vertical rows and perhaps 125 in the horizontal ones.

Glabella, pygidia and movable cheeks so far not found in connection. The association of the glabella and pygidia may be considered tolerably certain from the great abundance of both as compared with those of *I. Daytonensis*, the only other species found here in abundance. The association of the movable cheeks with these forms is more conjectural.

Smallest glabella, 8x10 mm. Ordinary sized specimen, 38 mm. broad across the palpebral lobes; 35 mm. across the anterior pits of the dorsal furrows. Direct length of glabella from anterior to occipital margins, 23 mm.; from anterior margin to a line drawn from the occipital margin perpendicular to the plane of the lateral margin, 20 mm.; height, 14 mm. A few large forms have been found which I refer to this species. The largest and most perfect of these is in the collection of Ira Crawford. It measures 60 mm. across the palpebral lobes and 54 mm. in a direct line from the anterior to the occipital margin; height, 30 mm. Smallest pygidium 10x13 mm. Ordinary sized specimen, 29 mm. broad at the antero-lateral margins; 24 mm. from posterior to articulating margin; 8 mm. high. A single large pygidium referred here measures 52 mm. in width; 44 mm. in length; 16 mm. in height. Movable cheeks, large specimen, length, 31 mm.; breadth, 20 mm.; length of eye, 7 mm. Smaller specimens proportionate.

Usually in the form of casts, surface where preserved apparently striated concentrically, at least around the edges, and dotted with small, shallow pits.

*Locality and position.* Soldiers' Home and vicinity. Clinton Group. Abundant.

GENUS CALYMENE, Brongniart.

VI. CALYMENE ———.

(*Plate XIII, Fig. 24.*)

Portions only of the head found, as fragments; the figure partly a restoration effected by a comparison of numerous fragmentary specimens. A fuller description will be given in the next paper if better material be found.

Glabella more prominent than the cheeks, very strongly defined from them by a deep, flat, longitudinal depression, which extends from the tip of the middle lateral lobe forward, forming an almost straight line along the line of separation from the fixed cheek, and terminating near the anterior end of the glabella, the side towards the fixed cheek being somewhat pointed. A similar depression behind the middle lateral lobes separates the posterior lobes from the surrounding portions of the head, its curvature being about that of the margins of the posterior lobes. The anterior border of the head is *broad* and *flat*, and directed upwards, with no arching along the middle as in specimens of *Calymene Niagarensis*. The anterior rim of this border has a slow curvature, appearing more like a straight line in some specimens than any species I am acquainted with. In other specimens, however, there is a somewhat greater curvature to the anterior rim. The facial sutures beginning with a slight outward curve for a small distance become almost parallel to each other as far as the eyes (which I now believe are incorrectly indicated in the drawing). Occipital furrow and as much of the fixed cheeks as is preserved, seem similar to the corresponding regions of *C. Niagarensis*.

Measurements are not given, on account of the unsatisfactory condition of the specimens. The figure is based upon a specimen preserving the glabella, anterior border and portions of the fixed cheeks, (all of the cheek anterior to the middle lateral lobe on one side of the glabella.) The rest of the figure is the result of comparison. The description is given mainly to note the existence of a form which has

a broad, flat, anterior border, with no arching in the middle, and with almost parallel facial sutures anterior to the eyes. It will be made the object of future study.

*Locality and position.* Soldiers' Home Quarries, Clinton Group; not rare.

## VII. CALYMENE BLUMENBACHII? Brongniart.

(Plate XIII, Fig. 25.)

General form broadly oblong.

Cephalic shield short and broad, the width twice as great as the length. Glabella quite prominent, projecting above the rest of the head; its general form, including the lateral lobes, conical, widest across the posterior lobes, the width at this point slightly more than its length excluding the occipital ring, and only four-fifths its length including the same. Glabella supplied with three more or less distinct lobes laterally, the posterior lobes large and prominent, equal in elevation to the glabella between them, although they seem to rise above it, on account of its downward slope posteriorly; the middle pair of lobes about half their size, the anterior pair small, indistinct. The middle and posterior pairs of lobes separated from themselves by deep grooves, from the glabella by grooves becoming shallow at the point of union of the lobes with the glabella, and from the cheeks by grooves of less depth, becoming shallow at the middle lobe; a slight groove anterior to the occipital furrow connects the deepened grooves extending along the anterior edge of the posterior lobes. The anterior part of the glabella quite regularly rounded. The curvature of the glabella towards each side much larger than along its length, the latter being almost regular along the middle of the glabella. Occipital furrow very distinct, arched forward along the centre, curving forward also at each side, around the posterior lobe; the posterior edge following about the direction of the occipital furrow. Anterior border of the head forming a broad and even curve about the head, the border *fairly broad, flat, turned a little upward, not arched in the middle*, somewhat like the species last described. Facial suture beginning with a slight outward curvature at its very origin, then a gradual inward curvature as far as the eye, then it curves around the eye, and posteriorly to it takes an almost lateral direction as far as the edge of the elevated regions of the head, along this edge it is directed to the



postero-lateral edge of the head. Palpebral lobe fairly prominent. Fixed cheeks provided with a very deep and broad furrow close to the posterior margin, following its direction. Movable cheeks with thick, rounded lateral margins, defined by a distinct, rounded, lateral furrow, above which the remaining portion of the cheek is decidedly elevated. The curvature of the anterior and lateral margins of the head is quite regular, with the exception of a slight more or less evident inward curvature just behind the origin of the facial suture.

Thorax not entirely preserved, the number of articulations not known. Central lobe of the articulations elevated above the lateral lobes, more arched than the lateral lobes, separated from them by a distinct longitudinal furrow. Segment of the middle lobe arched forward along the middle, also bent a little forward at the sides, where they show a low, nodal thickening. The grooves separating the segments deeper at the sides, leaving a sort of axis along the centre of the middle lobe. The articulations of the lateral lobes extend laterally for a short distance and then are deflected posteriorly to their ends. A longitudinal furrow extends along each articulation dividing off its anterior part by a deeper and broader furrow than that which separates the articulations from each other.

Width of the head, about 64 mm.; length, 30 mm. Width of the glabella across the posterior lobes, 21 mm.; length, not including the neck segment, 19 mm.; including the same, 24 mm. Distance between the points of union of the facial sutures and the lateral margins, 19 mm.; forward extension of the anterior border, 6.5 mm. Probable length of the entire specimen, 105 mm.

*Locality and position.* Allen's Quarry, Clinton Group, in the upper shaly course. The specimen crumbled partially away on removal.

Fragments of glabellae and surrounding portions belonging to this species are found at the Soldiers' Home Quarries, also near the top of the group, in the upper shaly courses. Associated with these are pygidia, which seem to belong to this species, the connection is, however, rather conjectural than otherwise.

Pygidium wider than long, the posterior edge making a very broad curve, almost straight along the middle. The anterior and lateral margins as far as preserved having an almost semi-circular outline. Middle lobe rapidly tapering posteriorly, segments about eight, the tip

of the lobe (for an extent corresponding to about two segments) not divided, rounded posteriorly, the segments nearest the thorax similar to the segments there found. The more posterior segments have their ends curved decidedly backward, so as to follow the general semi-circular arrangement of the articulations of the lateral lobes. Lateral lobes divided from the mesial lobe by a distinct, quite deep furrow, broadening posteriorly. Articulations about six. The anterior articulations together with the segments of the mesial lobe forming a semi-circular curve. The posterior articulations become less curved and take a more decidedly backward direction. The last pair of articulations in this way become almost parallel to one another and together with the posterior edge of the pygidium form a sort of box into which the unsegmented portion of the mesial lobe enters from above. The articulations of the lateral lobes are furrowed above along the middle, the furrows extending almost to the edge of the pygidium.

Surface of the pygidia, and the head and thorax described above, finely granulated.

Width of pygidium, 37 mm.; length, 25 mm.; width of the anterior end of the mesial lobe, 15 mm.; width at the beginning of the unsegmented posterior portion, 6 mm.

*Locality and position.* Allen's and Soldiers' Home Quarries, in the upper, shaly courses of the Clinton Group.

#### GENUS LICHAS, Dalman.

#### VIII. LICHAS BREVICEPS, *Hall.*

(*Plate XIII, Figs. 26 a, b, c, d.*)

Glabella (Fig. 26 b) of one specimen convex. The middle lobe rounded in front, on each side suddenly and deeply incurved by the introduction of two lateral lobes, the sides almost parallel for a short distance posteriorly, then curving for a short distance outwards so as to meet the occipital furrow; at the point where the last curvature begins the posterior part of the lobe is 2.5 mm. broad, along the occipital furrow, 5 mm.; the width of the lobe is exactly equal to its length. Lateral lobes sub-reniform, almost twice as long as wide, separated from the middle lobe by sharp grooves evenly curved except at the posterior end where the expansion of the posterior end of the middle lobe causes a slight irregularity of curvature; anteriorly the lateral

edges of the lateral lobes continue the curvature of the anterior edge of the middle lobe, then they make a slow broad inward curvature, the posterior edge of the lobes being bounded by a groove continuing that part of the occipital furrow extending beneath the middle lobe. Within the inward curve of each reniform lateral lobe lies another lobe which I shall here call the *postero-lateral* lobe. Postero-lateral lobe separated from the lateral lobe by a sharp groove, its posterior edge is defined by a continuation of the groove behind the lateral lobes, directed a little backwards, however; from the palpebral lobe it is separated by a distinct groove curved outward and then inward, the curve disposed to be angular at its middle. Palpebral lobe preserved only anteriorly, its outer lateral edge elevated above the inner, the whole palpebral lobe having evidently been elevated along its outer surface. Postero-lateral tubercles transversely oblong lanceolate, inserted beneath the lateral and postero-lateral lobes, posteriorly they are bounded by the occipital furrow which bends somewhat backwards from the postero-lateral edges of the middle lobe so as to define the edges of the tubercles. The posterior edge of the neck segment has a very slight forward curvature towards the middle. Anterior margin of the head narrow. Surface irregularly pustulose.

Width across the widest part of the middle lobes, 8.6 mm.; across the lateral lobes, 9.5 mm.; across the postero-lateral lobes, 11.5 mm.; across the postero-lateral tubercles, 8 mm. Distance between the tubercles, 4 mm. Length of the middle lobe, 8.6; including the neck segment, 10 mm. Stolz's quarry.

Another glabella shows only middle, lateral, postero-lateral and palpebral lobes, with only a little of the neck segment nearest to the occipital lobe. It agrees with the foregoing specimen in all particulars as far as can be seen, except in the existence of a low groove across the posterior end of the middle lobe where it begins to take an outward curvature. This groove is parallel with the occipital furrow just behind it. The palpebral lobe is also better preserved and shows a regularly rounded outer edge, the surface elevated along the outer margin. Surface of the glabella irregularly pustulose. John Brown's Quarry, New Carlisle. Specimen almost twice the size of the last.

A third specimen (Fig. 26 a) differs widely from the two above in some things. It is far more convex, and proportionately wider. The grooves about the glabella and the lobes into which it is divided also differ materially, more so than the figure intimates, but a fuller

description will be deferred until more and better material is at hand for accurate description. Stolz's Quarry.

Pygidium, general form semi-elliptical, quite straight along the anterior border, rapidly curved at its antero-lateral extremities. Axial lobe broad and strong, very prominent in the anterior part, rapidly narrowing and becoming low in the middle, and again widening posteriorly, but not equaling its anterior width; its width at the anterior margin one third the width of the pygidium; one distinct anterior annulation, with apparently a faint indication of a second. Lateral lobe with three segments on each side, and each marked by a distinct, longitudinal furrow along its middle. At their posterior side the two anterior lobes project a little beyond the margin of the pygidium, the rest of the outline being regularly rounded. The two anterior segments directed backwards, the posterior segment bent first a little outward then backward, filling up the outline along the contracted middle of the axial lobe. Under the exterior crust of the pygidium are a series of lamellose striations following the posterior and lateral outline of the pygidium and reaching about one-third the length of the pygidium towards the centre. Surface pustulose as in the first described glabella; having been found in the same piece of rock, it is supposed to be the pygidium of this species.

Length of the pygidium, 17 mm.; width, 24 mm. Width of the axial lobe anteriorly, 8 mm.; along the contracted portion, 4 mm.; at its greatest expansion posteriorly, about 6.5 mm. Stolz's Quarry. Other pygidia presenting the same features found here.

*Locality and position.* Stolz's Quarry, both glabellae and pygidia; John Brown's Quarry, New Carlisle, a glabella, kindly loaned from the collection of the Ohio State University, by Prof. Edward Orton. Clinton Group.

#### GENUS ARIONELLUS, Barrande.

#### IX. ARIONELLUS ———.

(*Plate XIV, Fig. 3.*)

It would be difficult to tell why the species here described should be placed under the generic name above mentioned, differing, as it does,

in almost every important characteristic; nevertheless in some respects it seemed to me to be as closely related to this genus as to any other, and until further study may lead me to a more definite result, I concluded to leave it here:

Glabella very convex towards the anterior margin, which is rounded; less convex laterally; separated from the cheeks by almost straight furrows, converging behind to about four sevenths the width of the glabella at its broadest part. At about half the length of the glabella, on each side, are two grooves. The middle pair are broadly crescent shaped, the points directed downward, distant from one another about two fifths the width of the glabella at that point, their general direction being lateral; they do not quite reach the lateral margins, however. From the ends of these, a second pair of crescent shaped grooves extend forward and laterally, reaching the furrows which define the lateral sides of the glabella. The second pair does not merge into the first at their adjacent extremities. Behind these grooves a third pair, distant from each other about two fifths the width of the glabella at that point, cut off about one third of the lower half of the glabella; they are directed obliquely backwards, at an angle of about sixty degrees with a line extending lengthwise along the glabella; their curvature is first a little backwards, then more laterally, then a little backwards again, making a gracefully undulated curve which does not quite reach the lateral margin of the glabella; a fourth pair of grooves, cutting off the last third of the lower half of the glabella, is similar to this pair. The occipital furrow is scarcely preserved but seems to have been regularly curved, the middle of the curve being directed forward.

Fixed cheeks, at least as far as preserved, highest anteriorly, where their convexity is also the greatest. The front margin beginning just behind the first pair of grooves on the glabella is curved postero-laterally, then backward and slightly inward, lastly, again postero-laterally to the postero-lateral corner of the cheek. The occipital furrow extends laterally along the posterior border of the cheek near the margin as a deep furrow. Surface smooth.

Length of the glabella, 4.1 mm.; width at the broadest part, 4.1 mm.; at the narrowed posterior extremity, 2.4 mm.; width of that part of the head included between the postero-lateral corners of the fixed cheeks, 5.4 mm.; length of the fixed cheeks, 2.2 mm.

*Locality and position.* Soldiers' Home Quarry, Clinton Group.

## GENUS DALMANITES, Emmrich.

X. DALMANITES WERTHNERI, *sp. n.*

General form of the body elongate-ovate, greatest breadth across the posterior part of the cephalic shield.

Head convex, semi-circular, breadth about five-thirds as great as the length; border extended in front into a semi-circular process, which varies from forms in which it is scarcely evident, to those in which it equals about two-fifths of the breadth of the anterior border in its projection beyond the curve of the border itself, never as distinct as in *D. vigilans*; base about one-fourth as broad as the greatest width of the glabella, or even less; lateral borders broad, separated from the cheeks by a distinct groove, produced posteriorly into rather long and slender curving spines, which continue the curvature of the lateral borders of the glabella.

Glabella large, depressed convex, widening in front to almost twice its width at the posterior margin, divided into lobes by three pairs of transverse furrows in addition to the occipital furrow, which is distinct and continuous. All three furrows distinct at the sides, not extending entirely across the glabella except in some specimens as a faint depression. Anterior furrows deeper, situated a little anterior to the eyes, giving to the frontal lobe a transversely elliptical outline; occipital ring narrow, without a spine as far as known. Eyes very prominent, short reniform, containing about thirty-five vertical ranges of lenses, the middle ranges having six to seven each; palpebral lobe depressed, giving great prominence to the rim of the eyes. Cheeks small, anteriorly quite prominent, posteriorly marked by a deep, bordering groove, the continuation of the occipital furrow, margin flat.

Thorax with the axial lobe convex, widest at the sixth segment, its greatest width about two-thirds that of the lateral lobe, or a little larger. The articulations curve forward a little near the middle and at their junction with the lateral lobes; articulations of the lateral lobes traversed by a deep longitudinal furrow extending from the junction of the anterior margin with the axial lobe, backwards along the anterior margin of the articulation, at about one third the width of the articulation, leaving it towards the extremities. From the imperfect preservation, the exact method of leaving can not be determined.

Pygidium broadly ovate-triangular, the lateral borders flattened, axial lobe regularly tapering posteriorly, marked by about thirteen annulations, which gradually decrease in size posteriorly and end in a spinose elevation. This spinose elevation is often accompanied by an upward deflection of the border posteriorly and terminates in a minute point at the end of the border. Although the pygidia are very abundant no spinose projection beyond the border has so far been observed. Antero-lateral margin of pygidium rounded, lateral articulations about ten in number, all, except the last three, grooved like the articulations of the thorax, becoming indistinct on the margin of the pygidium.

Head irregularly pustulate (pustules small) except the anterior and lateral borders of the head, which are minutely granular. Remainder of the body irregularly pustulate, pustules small, a single pustule slightly larger in size on each segment of the axial lobe of the pygidium, inconspicuous.

Small specimen, length of body, about 25 mm.; breadth, 16 mm.; length of head, 9 mm., breadth, 15 mm. Head (of usual proportions), length, 12 mm.; breadth, 20 mm.; convexity, 4 mm.; breadth of anterior lobe of the glabella, 10 mm.; of the posterior lobe,  $5\frac{1}{2}$  mm. Pygidium, length, 17 mm.; breadth, 22 mm.; breadth of axial lobe anteriorly, 6 mm.

The furrows across the axial lobe are much more distinct at the sides than at the middle, especially in the pygidium. The anterior lobe of the glabella has near its posterior extremity a distinct, elongated pit, which seems to be characteristic of this species.

*Locality and position.* Soldiers' Home Quarries. Clinton Group. (Named in honor of Mr. W. B. Werthner, who was present at the first discovery of this species. Abundant in some localities.)

In connection with the minute forms described above from the Beavertown marl, the following will be of interest:

GENUS ORTHOCERAS, Breynius.

ORTHOCERAS INCEPTUM, *sp. n.*

(*Plate XIII, Figs. 1 a, b, c.*)

Shell very small and slender, enlarging from below upwards gradually, in one specimen from 4 to 5 mm. in a length of 10 mm., in others more slowly. Transverse section almost circular, one diameter slight-

ly longer, or more elliptical; length of the outer chamber not determined. Septa concave—six chambers occupying a length of 10 mm. in the specimen above mentioned. Siphuncle eccentric, nearer to the centre than to the margin, narrow at the septa, expanding within the chambers.

Surface apparently not preserved, specimens in the form of casts. There are indications of longitudinal striæ, preserved with various degrees of distinctness, in some worn specimens looking like rows of small pits. Along one side of the shell, nearest the position of the siphuncle is a narrow, raised, longitudinal line, laterally defined by grooves which more or less coalesce anteriorly towards the annular rings (septa), and thus produce interruptions along the line. The distinctness of this longitudinal line is extremely variable, or perhaps is due to the removal of some of the surface matter, because some of the best preserved specimens are smooth, whereas those which are worn are apt to present these features. (Cf. *O. Duseri*, Hall and Whitfield.)

*Locality and position.* Beavertown marl, Clinton Group. A specimen in the Ohio State collection, from Wilmington, Ohio, I refer to this species.

#### EXPLANATION OF PLATES.

##### *Plate XIII.*

*Fig. 1.* *Orthoceras inceptum*, n. sp.; a, lateral views; b, views showing the position of the siphuncle; c, vertical section through the siphuncle.

*Fig. 2.* *Meristella umbonata*, Billings (sp.); a, lateral view; b, dorsal valve.

*Fig. 3.* *Platyostoma Niagarensis*, Hall; a, b, specimens referred to the Ohio forms considered identical with the Indiana species, having the aspect of *Holopea*.

*Fig. 4.* *Eichwaldia reticulata*, Hall; a, dorsal valve; b, ventral valve.

*Fig. 5.* *Leptæna prolongata*, n. sp.; a, ventral valve; b, lateral view, outline.

*Fig. 6.* *Zygospira modesta*, Say (sp.); dorsal valve.

*Fig. 7.* *Orthis biforata*, var. *lynx* (Von Buch), forma *reversata*; ventral valve.

*Fig. 8.* *Orthis biforata*, var. *lynx* (Von Buch), forma *Daytonensis*; ventral valve.

*Fig. 9.* *Atrypa nodostriata*, Hall; ventral valve.

*Fig. 10.* *Orthis hybrida*, Sowerby; a, dorsal valve; b, lateral view, drawn for the outline only.

*Fig. 11.* *Orthis elegantula*, Dalman; a, dorsal view; b, lateral view, drawn for the outline only.

*Fig. 12.* *Orthis flabella*, Sowerby; a, ventral valve; b, dorsal valve.

*Fig. 13.* *Orthis Daytonensis*, n. sp.; a, dorsal valve; b, lateral view, drawn for



outline only; c, a few of the radiating striæ; d, occasional appearance of the surface characters.

*Fig. 14. Pterinea brisa, Hall; a, b, views of different left valves referred to this species; b, taken from a cast.*

*Fig. 15. Orthis fausta, n. sp.; a, dorsal valve; b, ventral valve; c, lateral view; d, a few of the striæ.*

*Fig. 16. Orthis fausta, n. sp.; a, dorsal valve; b, some of the striæ of the form acuto-plicata.*

*Fig. 17. Orthis elegantula, var. parva, n. var.; a, ventral valve; b, lateral view of the same.*

*Fig. 18. Bucania exigua, n. sp.; a, view from above; b, lateral view, the expansion of the aperture not well brought out; c, lateral view of another specimen; d, another view of the same.*

*Fig. 19. Bellerophon fuscello-striatus, n. sp.; a, lateral view; b, c, d, views of the same; e, a part of the carina, with a few of the nearest striæ.*

*Fig. 20. Orthis Daytonensis, n. sp.; a, ventral view; b, interior view of the same.*

*Fig. 21. Orthis Daytonensis, n. sp.; lateral view of a specimen presenting both valves.*

*Fig. 22. Platystoma Niagarensis, Hall; a, lateral view; b, view from above.*

*Fig. 23. Acidaspis; part of the head.*

*Fig. 24. Calymene; part of the head, partially restored.*

*Fig. 25. Calymene Blumenbachii? Brongniart; head with a few of the thoracic articulations attached.*

*Fig. 26. Lichas breviceps, Hall; a, glabella, not typical; b, typical glabella of Ohio form; c, surface of the latter, variously magnified; d, pygidium; e, glabella of a specimen from New Carlisle.*

#### Plate XIV.

*Fig. 1. Ilkenus Madisonianus, Whitfield; a, view of a pygidium from above; b, lateral view of the same.*

*Fig. 2. Ilkenus; a, view of pygidium similar in some respects to that of I. Madisonianus; b, lateral view of the same.*

*Fig. 3. Arionellus?; view of the glabella and fixed cheeks.*

*Fig. 4. Ilkenus Daytonensis, Hall and Whitfield; a, view of a pygidium; b, lateral view of the same.*

*Fig. 5. Bathyrurus; view of a glabella, the curvature of the rim of the anterior border not represented.*

*Fig. 6. Ilkenus Daytonensis, H. and W.; movable cheek, view obliquely from below.*

*Fig. 7. Ilkenus Daytonensis, H. and W.; a, lateral view of a head, the associated movable cheek figured; b, view of the glabella from above; c, view of the same from behind.*

*Fig. 8. Nucula minima, n. sp.; a, view of the anterior regions; b, lateral*

view; c, view of the regions posterior to the beaks; all views magnified six diameters.

*Fig. 9. Illeenus ambiguus, n. sp.*; a, view of a pygidium seen from above; b, lateral view of the same.

*Fig. 10. Illeenus ambiguus, n. sp.*; a, lateral view of a head, the associated movable cheek figured; b, posterior view of the glabella; c, view of the same from above.

*Fig. 11. Illeenus ambiguus, n. sp.*; movable cheek of unusually large proportions.

*Fig. 12. Grammysia Caswelli, n. sp.*; a, lateral view of the shell, anterior definition too sharp; b, view of the same from above.

*Fig. 13. ——— triplesianus, n. sp.*; a, view of one of the valves; b, lateral view of the same shell.

*Fig. 14. ——— triplesianus, n. sp.*; view of the other valve from a different specimen.

*Fig. 15. Strophostylus cyclostomus, Hall*; lateral view of a specimen.

*Fig. 16. Trochonema nana, n. sp.*; two views, magnified to eight-thirds and four-thirds of the original size respectively.

*Fig. 17. Cyclora alta, n. sp.*; a, lateral views of specimens showing variations in the elevation of the spire; b, view of the umbilicus of a specimen; all views magnified two diameters.

*Fig. 18. Raphistoma affinis, n. sp.*; view from above, and also a lateral view, the umbilicus being directed upwards.

*Monoclinic Habitus.*

cleavage || O and i-i'; angle about 90°.

TABLE XIII.

Colors of Polarization.	Color.	Structure.	Association.	Inclusions.	Alterations.	Occurrence.	Remarks.
Rather brilliant, but less than as quartz. In thin sections often less brilliant, bluish gray as in nepheline	Generally cloudy white or gray. rarely clear. Colored red by limonite.	In large crystals or grains of the first order, more rarely in small grains or rods in eruptive rocks. Often coalesced with plagioclase. Zonary structure is rare as is zonal arrangement of inclusions.	With quartz, biotite, muscovite, hornblende and rarely with augite, plagioclase and clacolite.	In general poor. Specular iron, biotite scales, fluid inclusions, needles of apatite, zircon.	Kaolinization with formation. of muscovite or epidote.	One of the most abundant components in granular and porphyritic older eruptives. Essential comp. in granite, syenite, quartz porphyry and accessory in nearly all plagioclase rocks. Also in crystalline slates as gneiss, here often glassy like sanidine	Large crystals may be recognized by twinning in sections parallel to O and i-i' and by the oblique extinction parallel i-i'. Minute rods of it and sanidine in the magma of rocks often greatly resemble nepheline and certain melilites, Orthoclase lacks, however, the isotropous hexagonal sections.
	Colorless clear. $\beta \rho = 1.5237$	In eruptive rocks as large crystals of first order and minute rods second order. The large crystals often fractured. Zonary structure.	As orthoclase also with nepheline and leucite but never with muscovite.	Very rich. Glass inclusions, usually zonal in arrangement. augite micro-lites and needles of apatite	Almost always unaltered. Into opal in andesites and trachytes	Essential comp. (primary) in trachytes, rhyolites, phonolite, and the glass of orthoclase rocks. In nearly all later plagioclase rocks.	From plagioclase it may be distinguished by absence of the polysynthetic twins of the latter.

bb. Optical axial plane  $\parallel$   $i-i'$ ; perfect cleavage in  $I=87^\circ$ .

Name.	Chemical comp. and reactions.	Specif. Grav.	Cleavage.	Unusual combinations & form of sections.	Twins.	Optical determinants.	Double refraction.
1. <i>Monoclinic Augite Group</i> a. <i>Common and basaltic augite.</i>	R Si O <sub>3</sub> R=Mg. Ca, Fe, and Fe <sub>2</sub> O <sub>3</sub> Al <sub>2</sub> O <sub>3</sub> According to Tschermak a mixture of Ca Mg Si <sub>2</sub> O <sub>6</sub> +Ca Fe Si <sub>2</sub> O <sub>6</sub> +Mg Al <sub>2</sub> Si O <sub>6</sub> Scarcely attacked by acids.	3.17-3.41  3.34-3.38.	Perfect I	Rarely in grains crystals I. $i-i$ , $i-i'$ $r$ and $r-i$ . O, — $r$ . $I=87^\circ$ . Sections perpendicular to $c$ octagonal with evident prismatic cleavage. Longitudinal section distorted hexagonal, with cleavage lines parallel to $i-i'$ quadrangular often rhombic.	Very frequent. twinning plane $i-i$ , also in polysynthetic twins. More rarely interpenetrating twins in a plane of $-i-i$ or $i-2'$ .	Optical axis plane $\parallel$ $i-i'$ , acute bisectrix $=c$ in the obtuse angle $\beta$ . $b=b'$ . The positive axial angle enlarges with the amount of iron in rhombic augite, about $60^\circ$ . Sections $\parallel$ $i-i$ and perpendicular to $c$ show the disappearance of an optical axis in almost the middle of the field.	Positive, strong. Extinction in sections $\parallel$ $b$ perpendicular; in sections inclined to $i-i'$ $c$ : $c$ becomes smaller until it reaches 0 when parallel to $i-i$ . In sections $\parallel$ $i-i'$ $c$ : $c=39^\circ$ $54^\circ$ $\alpha:a=22^\circ$ .
b. <i>Diallage.</i>	do	3.23-3.34	$I(87^\circ)$ , shelly fracture in $i-i$ .		do	do	do
c. <i>Omphacite.</i>	do with more Al <sub>2</sub> O <sub>3</sub>	3.3	As in augite, fracture less perfect than in diallage.	Only in grains.	rare	do	do
d. <i>Diopside.</i>	more CaO than MgO poor in Al <sub>2</sub> O <sub>3</sub>	do		do	do	do	do
e. <i>Saite.</i>	poor in iron.	3.2-3.33.	Fracture in O besides the above.	Also in long columns with transverse fracture, usually not terminated. Section as in augite.	do	do	do

TABLE XIV.

Colors of polarization.	Color and Refraction	Structure.	Association	Inclusions.	Decomposition.	Occurrence.	Remarks.
Very brilliant, especially in the light colored.	In section green to brown, often violet brown in basalt. The same crystal often exhibiting several colors. Pleochroism usually feeble. In phonolite it may be strong. $c > a > b$ .	In large crystals (I. O.) with zonal alternating colors. In twins these bands pass through both. Often with so-called "hour-glass" form when sections parallel to $i-i$ fall into 4 areas. Also in columns and micro-lites (II. O.) crystals often in large aggregates & radial groups	Chiefly with plagioclase, nepheline, leucite, with or without olivine and biotite. Rarely with orthoclase, hornblende, and quartz.	Abundant glass inclusions, apatite needles and magnetite.	Into chlorite, calcite, limonite, epidote and quartz, pseudomorphs of any of these after augite. Into opal. More rarely into hornblende, the form being retained but the cleavage that of hornblende. Into serpentine with talc and chlorite.	Later porphyritic eruptives as essential and primary, in diabase, augite andesite, and all basalts, also andesites, trachytes, phonolites. Rarely in large grains in older eruptives and crystalline slates.	Easily recognized by obliquity of extinction of $c$ , the prismatic cleavage with angle of $87^\circ$ , especially in cross section. Liable to be confused with hornblende in sections inclined to $c$ . When augite is nearly colorless its polarization colors are vivid and like olivine.
do	Greenish brown. Pleochroism very feeble.	Only as large irregular grains. In inclusions, in fibrous and twinning characters much as bronzite. Often coalesced with ordinary augite, hornblende or mica.	With plagioclase, common augite, olivine, hornblende, and rarely with quartz.	Like bronzite with inclusions of brown scales of goethite? parallel to $i-i$ , otherwise poor in inclusions.	At the ends changes into dark green strongly pleochroic hornblende fibres. Into viridite, also serpentine with formation of chlorite and talc.	Primary abundant in gabbro, norite, rare porphyritic eruptives. In olivine stone and serpentine. Rare in crystalline slates.	Often similar to bronzite in sections or plates parallel to $i-i$ easily recognized.
do	Grass green.	Only in unaltered grains poor in inclusions. Often coalesced with hornblende.	(c) With quartz, hornblende, garnet, zoisite, disphenite, and rutile. (d) With olivine, chromite, diallage, & rhombic augite. (e) quartz, hornblende, scapolite, plagioclase, and titanite.	(c) Rare, fluid and rutile needles. (d) Rarely glass inclusions.		(c) In eclogite and amphibolite (d) In olivine stone (primary) rarely secondary alteration of garnet. (e) In crystalline slates.	Colors lighter than in augite proper (less iron). Differ from diallage in absence of complete fracture in $i-i$ .
Very brilliant.	Light green—colorless. Relief strong.						

