ART. LIII.—*The Meso-Silurian Deposits of Maryland;*
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THE present article discusses briefly the lithological and faunal characteristics of the deposits in the state of Maryland lying between the massive Tuscarora (White Medina) sandstone below and the Salina formation above. These deposits are approximately eight hundred feet in thickness and represent the lower and middle portion of the Meso-Silurian series as shown in western New York. The lower portion corresponds to the pre-Rochester Silurian, the Clinton of common usage, while the upper portion is the approximate equivalent of the Rochester, or the lower division of the Niagara group of common usage.

It is moreover probable that these deposits are equivalent to the typical Clinton of Hall exposed at Clinton, Oneida County, N. Y. The latter, according to both E. O. Ulrich† of the U. S. Geological Survey and to C. A. Hartnagel† of the New York Survey, contains in its upper portion a fauna equivalent to the Rochester or Lower Niagara fauna of western New York. It is very unfortunate that the fauna of the typical Clinton should have gone so long unstudied, thus allowing at the present a double meaning of the term Clinton, as seen below.

The Meso-Silurian deposits of western New York and the interior may be subdivided as follows :

Meso-Silurian {	{	B. Niagara {	3. Guelph
			2. Lockport
			1. Rochester
	{	A. Clinton	

while the Meso-Silurian deposits of eastern New York, Pennsylvania, Maryland, etc., may be subdivided as follows :

Meso-Silurian {	{	A. Typical Clinton	2. Rochester of common usage
			1. <i>Clinton</i> of common usage

I shall not enter into a discussion of the nomenclature, but shall use the term *Clinton* in the restricted sense to include only the portion below the Rochester.

In the study of the Maryland Meso-Silurian deposits all the important exposures in the state have been visited and at each

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† From letters of recent date.

place careful measured sections and fossil collections have been made. With the exception of the Ostracods and Bryozoa, the fossil study has been practically completed. In the pursuance of his work the author has had access to the collections of the National Museum, the New York Museum of Natural History, the New York State Collection at Albany, and several smaller and private collections. He is also greatly indebted to Prof. Schuchert of Yale University, Dr. E. O. Ulrich of the U. S. Geological Survey, Dr. C. K. Swartz of Johns Hopkins University, and others for assistance. He is further indebted to the Director of the Maryland Geological Survey for the privilege of publishing this article.

Before turning to the present discussion of the Meso-Silurian in Maryland, let us make a brief historical review of what has already been done in this area and what have been and are the views held concerning it.

Historical Review.—Nearly fifty years ago Philip Tyson, the state agricultural chemist of Maryland, published* the first report of importance dealing with the geology of western Maryland. He touched but briefly upon the formations under consideration, using terms, "the Clinton" for the pre-Rochester Meso-Silurian and "the Onondaga" for the remainder of the Meso-Silurian and the Cayugan. In 1874 Prof. James Hall of New York, who had worked in Maryland, especially in the Lower Helderberg, did not recognize the presence of Niagara. It appears that he later did, as he cites *Spirifer crispus* and *Homeospira apriniformis* from the "Niagara" of Maryland.

In 1893 a preliminary geological map† of the state showed the whole Meso-Silurian deposits under the name "Rockwood." James D. Dana‡ in 1895 recognized in Pennsylvania, immediately north of Maryland, a commingling of Clinton and Niagara fossils in the upper Clinton beds, and states that there frequently occur some distance above the top Clinton iron-ore, a succession of thin limestones which in many places contain Niagara fossils.

The author of the Piedmont Folio§ discussed a part of the Maryland area, using the terms Rockwood-(Clinton or pre-Rochester Meso-Silurian) and Lewiston (later Meso-Silurian, Cayugan and Lower Helderberg). There is here a preliminary discussion of the two formations as Rockwood and the lower part of the Lewiston.

The first detailed lithological study, however, of the Meso-

* Geological Map and Report, 1861.

† Map to accompany "Maryland: Its Resources, Industries, and Institutions." G. H. Williams and W. B. Clark.

‡ Manual, 4th edition, 1895.

§ Geol. Survey Atlas, Folio No. 28, 1896.

Silurian of Maryland was made in 1900 by C. C. O'Harra.* He used the terms Clinton and Niagara, correlating the formations in Maryland with those in western New York.

It has long been known by all geologists working in the Appalachian districts that there is a marked stratigraphic change as one passes westward over the protaxis of these mountains. For the explanation of this fact the theory of a profound fault was suggested by some but accepted by few. Sir William Logan of the Canadian Survey, in 1866, suggested the possible existence of a narrow basin of deposition west of the protaxis to account for the stratigraphic break.

It has also long been recognized that there exists a faunal difference in some of the deposits west of the protaxis in the Appalachians and in those west of the Alleghany Mountains in New York and the interior. The explanation of this fact was little dwelt upon until recently, when E. O. Ulrich and Charles Schuchert, after careful investigation and faunal study, put forward a most admirably developed theory† to account for the apparent condition. They conclude from paleontological evidence that there existed a barrier of great length, which separated from the interior sea a long and narrow body of water lying in the Appalachian region, the "Cumberland basin," in which sediments were deposited bearing fauna more closely related to the east Canada and European deposits than to those of the interior sea; that the Atlantic crossed over the barrier forming the eastern side of this basin in about Beekmantown time, but was restrained by the western barrier of this basin from mingling with the interior sea, possibly from Clinton but certainly from Niagara time well into Oriskany time. The barrier forming the western side of the Cumberland Basin extended, according to Ulrich and Schuchert, from the region of Cayuga Lake, N. Y., southward to west of Altoona, Pa., thence parallel to the trend of the Appalachian Mountains through central West Virginia into eastern Tennessee. In discussing the fauna of the Cumberland Basin, Ulrich and Schuchert state that few species are identical with those of the interior sea, and that the earlier fauna recalls the Clinton, while it passes above into one which may be compared to the Niagara.

Charles Schuchert, in a later publication,‡ speaking of the Maryland deposits which include the Clinton and Niagara, says that save *Atrypa reticularis* and *Leptaena rhomboidalis* all the species appear to be new. Further, he directs attention to the absence of such characteristic forms of the western or

* The Geology of Alleghany Co., Md.; Md. Geol. Survey Rept., pp. 57-164, 1900.

† Paleozoic Seas and Barriers in Eastern North America. N. Y. State Mus. Bul. No. 52, 1902.

‡ Lower Devonian and Ontario Formations of Maryland, 1903.

Mississippian sea as *Spirifer radiatus*, *Spirifer Niagarensis*, *Spirifer Crispus*, *Spirifer sulcatus*, *Pentamerus oblongus*, *Caryocrinus*, and *Eucalyptocrinus*. Of these, *Spirifer radiatus* and *Spirifer crispus* are now known to occur in the Cum-

berland Basin.

Mr. C. A. Hartnagel of New York, in an article* in 1902, shows, however, that the western or Helderbergian barrier was not continuously and completely effective from Clinton to Oriskany time, since the mingling of Guelph and Cobleskill fauna evidence the crossing of the barrier during Cobleskill time.

Up to the present less than half a dozen species of fossils have been definitely described from the Maryland, Clinton, and later Meso-Silurian.

General Description.—The outcrop of the Meso-Silurian rock in Maryland is limited entirely to the region of the Alleghany Ridges proper, in Washington and Allegany Counties. The area covered is about twenty-four square miles, of which the Clinton occupies fifteen and the Later Meso-Silurian about

FIG. 1.

Dotted areas are Meso-Silurian. Scale 1 in. = 16 miles.

nine. As would be expected from the general Appalachian structure, the rocks under discussion flank anticlinal folds which

* Preliminary Observations on the Cobleskill Limestone of New York. Rept. N. Y. State Paleont. for 1902, p. 1156.

have a general trend N. 20°–30° E. There are six such folds exposing these strata in Maryland: three in Allegany County and three in Washington County (see map, fig. 1). The axes of the anticlines are formed by the very resistant "Tuscarora" or "white Medina" sandstone. Nearly all the folds are unsymmetrical, giving a much narrower outcrop on the west than on the east side.

GENERAL CHARACTER OF THE DEPOSITS.

Clinton Formation.

The rocks of this age in Maryland consist essentially of reddish and olive to grayish and brown argillaceous shales which are slightly lighter in color and less fossiliferous toward the bottom. The exposed surfaces of this shale often show a deep scarlet color. Thin sandstone bands occur at irregular intervals throughout nearly the whole formation and become more numerous toward the bottom, giving the formation the appearance of grading into the Tuscarora quartzite. These thin sandstone bands were in general originally more calcareous than at present and are uniformly more fossiliferous than the shale in which they occur. Toward the top of the formation limestone bands become numerous and replace the sandstone layers. They seldom exceed six inches in thickness, and in some localities are very fossiliferous. Immediately overlying the limestone-bearing shales throughout the region there occurs a quartzitic sandstone, of variable thickness, which in character resembles very closely the Tuscarora. This sandstone thickens markedly toward the east, increasing from ten feet in thickness near Cumberland to nearly seventy feet in some eastern exposures. In the top portion of this sandstone is found the so-called top Clinton iron-ore, usually not more than a foot in thickness and commonly of too low a grade to work. In places, however, it is thicker and has been enriched so that in the past it has served as an ore and might at present locally be so called were it more accessible to the railroad. In this latter respect the top Clinton ore differs markedly from the so-called bottom Clinton ore which occurs throughout the Maryland area from one hundred and twenty to one hundred and sixty feet from the bottom of the formation and which, though it sometimes attains forty feet in thickness, is not sufficiently high in iron to be valuable as an ore. This lower *iron sandstone* occurs in two beds separated by from six inches to six feet of olive shale. Both the bottom and top "ore" bodies contain numerous though very poorly preserved fossils.

The olive shales and thin crystalline limestone bands imme-

diately above the top Clinton iron-ore sandstone contain a greater percentage of Rochester fossils than of those of the pre-Rochester Meso-Silurian, and consequently it would appear that the lower limit of the Rochester should be drawn at the top of the heavy sandstone layer. The thickness of the Clinton does not vary far from five hundred and fifty feet.

The Later Meso-Silurian (Rochester).

The rocks of the Later Meso-Silurian formation, as herein discussed, include those lying between the heavy band of sandstone bearing the top Clinton iron-ore and the bed of disintegrated yellow rock full of *Leperditia* which marks the base of the overlying Cayugan, and are composed for the most part of thin-bedded limestones with shale partings. For a short distance above the bottom and for a greater thickness near the top the shales increase and preponderate over the limestone. The lowest limestone layers are grayish blue in color and, together with the shales which immediately overlie the Clinton sandstone layer, are very fossiliferous. The upper limestones are uniformly of a darker color and more compact, sometimes occurring in more or less lenticular beds with thin shale partings. In general the middle limestones and shales contain few fossils, with the exception of Ostracods and a few Favosites and Orthoceras. Toward the top, however, the brachiopod life begins again to abound and some beds are very fossiliferous. The upper shales are usually darker in color than those below and often become arenaceous, bearing thin sandstone lenses, while the top of the formation is often formed by a bed of sandstone of variable thickness which is often very ferruginous. These upper dark shales usually carry a great number of Ostracods and poorly preserved Bryozoa.

Going toward the east, one generally finds that both the lower shales and the upper ferruginous sandstone layers increase in thickness. The thickness of the formation is in general not far from three hundred feet. At Pinto, where the most accurate measurements were made, though they are not entirely satisfactory because of some faulting, these rocks show a thickness of two hundred and eighty-eight feet.

General Lithological Relations.

It is concluded from a comparative study of the different exposures in the state that during the deposition of these sediments there existed a shore line not far to the east, and a gradual deepening of the waters toward the west as far as the section exposed at Pinto (see section, fig. 2 and map, fig. 1). The

main facts supporting this conclusion are: the top Clinton sandstone increases gradually in thickness from seven feet at Pinto to some sixty-five or seventy feet in the eastern exposures; the bottom Rochester shales increase in thickness and the bottom limestones consequently decrease in thickness in passing from west to east; the top Rochester sandstone, like the top Clinton sandstone, thickens from eight feet at Pinto to some fifty feet or more in the eastern exposures. If we assume then

that the Maryland Meso-Silurian deposits were laid down in a narrow basin of deposition, then Pinto must be east of the central axis of the basin or else the western shore line of this narrow sea must have been much lower than the eastern land was. It is not improbable that both these conditions were true.

Fossil Zones.

In Clinton.—

The Clinton formation, so far as studied, has not shown any well-marked continuous fossil zones. Portions of the strata are much more fossiliferous, however, than others, and the formation as a whole is naturally divisible into four parts:

(1) a lower relatively barren division including the shales and sandstones up to within some thirty feet of the lower "iron ore," which bears locally at its base a few plant remains, the ostracod *Berichia lata* and the brachiopod *Anoplothea hemispherica*; (2) a lower fossiliferous division, including the remaining shales below the bottom "iron ore," the ore bed and some fifty to eighty feet of the overlying shales and sandstones; (3) a middle barren division, including some two hundred feet of relatively barren shales and sandstones; and (4) an upper fossiliferous division, including about one hundred feet of shales and interbedded sandstones, replaced by thin-bedded limestone toward the top, about which occurs the very slightly fossiliferous top Clinton sandstone (see sect. fig. 3).

Of the two fossiliferous divisions, the lower is characterized by a large number of tentaculites and ostracods and two species of trilobites. The upper fossiliferous

division, on the other hand, is characterized by its brachiopod fauna.

The forms noted in the two fossiliferous divisions are as follows:

From the lower fossiliferous division:

Buthotrephis gracilis var. *intermedia* Hall

* *Anoplothea hemispherica* (Sowerby)

Stropheodonta corrugata (Conrad)

† *Tentaculites* sp.

Clidophorus sp.

* *Calymene blumenbachii*

* *Calymene* sp. nov.

* *Ostracods*

From upper fossiliferous division:

† *Atrypa reticularis* (Linnaeus)

* *Leptaena rhomboidalis* (Wilckens)

Camarotoechia neglecta Hall

* *Chonetes cornutus* (Hall)

* *Chonetes novascoticus* (Hall)

* *Chonetes tenuistriatus* Hall

Spirifer radiatus (Sowerby)

Bucanella trilobata (Conrad)

Calymene clintoni (Vanuxem)

In Upper Meso-Silurian.—

While the Clinton fossils seem to have a rather extended range vertically and a more or less local distribution, making a close zonal study of this formation seemingly impracticable, the overlying Meso-Silurian may be divided into five portions, three of which are well-marked faunal zones. Immediately overlying the top Clinton sandstone and extending vertically sometimes 30 feet, though usually more restricted, is a very prolific faunule, marking a zone called from one of its most widespread and characteristic fossils, the *Dalmanites limulurus* zone. This zone includes more than one-half of the species described from the whole Meso-Silurian series of Maryland. At Cumberland, where this zone was most studied, the following species were observed:

Fauna of the Dalmanites limulurus Zone.

Anoplothea hemispherica (Sowerby)

* *Atrypa reticularis* (Linnaeus)

Camarotoechia neglecta Hall

Dalmanella elegantula (Dalman)

† *Dalmanella elegantula* var. nov.

* *Leptaena rhomboidalis* (Wilckens)

Reticularis bicostata var. nov.

* Abundant.

† Very abundant.

- * *Rhipidomella subcirculus* (Simpson)
- Rhipidomella hybrida* (Sowerby)
- † *Rhynchonella (tennesseensis)*? Roemer
- Schuchertella supblana* (Conrad)
- Schuchertella tenuis* Hall
- Spirifer crispus* (Hisinger)
- Stropheodonta corrugata* (Conrad)
- Stropheodonta corrugata* var. *pleuristriata* (Foerste)
- Stropheodonta* sp. nov.
- Stropheodonta* sp. nov.
- Ctenodonta* sp. nov.
- Pterinea emacerata* (Conrad)
- Bucanella trilobata* (Conrad)
- Conularia* sp.
- * *Diaphorostoma niagarensis* Hall
- Platyceras* sp. nov.
- Platyceras niagarensis* Hall
- Trochoceras* sp.
- † *Dalmanites limulurus* (Green)
- * *Homalonotus delphinocephalus* (Green)
- Cornulites* sp. nov.

Immediately overlying the *Dalmanites limulurus* zone there is a fossiliferous horizon of some 3 to 15 feet in width, which contains great numbers of *Nucleospira pisiformis* and sometimes a few *Schuchertella* sp. nov. This *Nucleospira pisiformis* zone, which occurs in the calcareous shale and limestone layers, is overlain by some 150 feet of limestone and shales in which the fossils are fewer and more scattered.

This latter division has given us the following species:

- Buthotrephis gracilis* var. *intermedia* Hall
- * *Favosites niagarensis* Hall
- Camarotoechia neglecta* Hall
- * *Homeospira evax* var. nov.
- Lingula* sp. nov.
- Orbiculoidea* sp. nov.
- Clidophorus* sp. nov.
- Hormatoma* sp. nov.
- † *Hormatoma* sp. nov.

Near the top of the formation and usually between 50 and 80 feet below the "disintegrated yellow rock" of the Salina (the Niagara-Salina line) there occurs a band some 30 feet in thickness which is here called the *Camarotoechia* sp. nov. zone. It has yielded the following species:

- † *Camarotoechia* sp. nov.
- † *Camarotoechia obtusiplicata* Hall
- Camarotoechia neglecta* Hall
- Lingula lamellata* Hall
- Spirifer* sp. nov.
- Clidophorus* sp. nov.
- Cuneamra* sp. nov.

* Abundant.

† Very abundant.

Above the preceding there is a zone two feet in thickness in which occur great numbers of *Camarotoechia obtusiplicata* mingled with *C. sp. nov.* and *Cuneanra sp. nov.*

The uppermost 50 feet of the Meso-Silurian rocks are in general largely shale and sandstone. They contain very abundant Ostracods and poorly-preserved Bryozoa and, in addition, so far as studied, only two fossils:

Homeospira evax var. nov.

Ctenodonta sp. nov.

Table Showing Number, General Relation and Affinities of Maryland Meso-Silurian Fossils.

Number of forms studied:

Number of species and varieties studied	56
Number of species previously described	32
Number of new species	20
Number of new varieties	4

Percentage of new forms

Percentage of new species	35.7
Percentage of new varieties	7.1
Percentage of new species and new varieties	42.8

Occurrence elsewhere:

Number of species occurring in Arisaig	10
“ “ “ English Silurian	8
“ “ “ Anticosti	5
“ “ “ Ohio Clinton	1
“ “ “ “ Niagara	15
“ “ “ Indiana “	16
“ “ “ “ Clinton	1
“ “ “ New York Rochester	12
“ “ “ New York Lockport	3
“ “ “ Rochester and Lockport	2
“ “ “ Niagara and not referred to either Rochester or Lockport	3

One-fourth (8) of all the previously described species occur in the European deposits, of which species seven are also found in the middle United States.

Number of different species cited from either Anticosti, Arisaig or English deposits	18
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Number of these cited from either Indiana or Ohio	12
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From a study of the foregoing fossil lists and the above table one is impressed with the marked faunal difference between the Meso-Silurian deposits of Maryland and those of Western New York and the interior. The fact that there are so many new species (42 per cent of all studied) argues very strongly in favor of the supposition that the Maryland Meso-Silurian deposits were laid down in a sea distinct from that of Western New York and the interior. This argument is further strengthened by the fact that several of the most prominent species of the interior Meso-Silurian sea are not repre-

sented in Maryland. That there were short periods, however, when the low barrier separating this Cumberland Gulf from the interior epicontinental sea was ineffective, is shown by a few zones in the Maryland Meso-Silurian which have a prolific development of certain of the more important Western New York forms, as for instance the *Dalmanites limulurus* zone, the *Nucleospira pisiformis* zone and the *Camarotoechia obtusiplicata* zone. (See fig. 3.)

The great coral development of the western upper Niagara is entirely lacking in the Maryland deposits. In fact there are practically no fossils which belong distinctively to the Lockport or Guelph formation, and it is probable that during the greater part of these two periods there was little or no sedimentation in the Maryland area. The Meso-Silurian sea may have continued to exist in the Cumberland Gulf in early Lockport time, but if so, seemingly for a short period only.

It is further interesting to note that one fourth of all the previously described forms are of world-wide distribution; that six of the old forms are characteristic of the deposits of Anticosti, Arisaig or the English Silurian, while fourteen are characteristic of the western interior. This last result is, however, of little value in showing the relative ease of communication between the Cumberland basin and the epicontinental sea to the west and the Canadian deposits to the north and east, since the Canadian deposits have not been studied as well as have those of the interior United States.

Summary.

The Meso-Silurian deposits of Maryland, lying between the Tuscarora and the Salina formation, are about 800' in thickness and are composed for the most part of shales and thin-bedded sandstones below and of shales and limestone above. This series can be divided into two formations, corresponding in time approximately to the Clinton, accorded to the common usage, and the Rochester of New York. They are, moreover, taken together, the probable equivalent of Hall's typical Clinton as represented at Clinton, Oneida Co., N. Y.

These Meso-Silurian rocks outcrop in the western part of Maryland in Allegany and Washington Counties in six anticlinal folds with typical Appalachian structure. The thickening of the coarser sediments from the western to the eastern exposures indicate the proximity of a shore line toward the east. That a shore line or barrier existed not far to the west of the exposed Maryland Meso-Silurian deposits is not evidenced by a lithological study, but is sufficiently indicated by the fossil study. This barrier must, however, have been low and at periods ineffective, especially during Rochester time, when, to a greater extent than in the Clinton, well marked fossil zones appear, making a prolific development of some of the more important species of western New York.