MARYLAND
GEOLOGICAL
SURVEY

CAMBRIAN
AND
ORDOVICIAN

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BALTIMORE
THE JOHNS HOPKINS PRESS
1919

The Lord Baltimore Press
BALTIMORE, MD., U. S. A.

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LETTER OF TRANSMITTAL

To His Excellency EMERSON C. HARRINGTON,

Governor of Maryland and President of the Geological Survey Commission,

Sir:—I have the honor to present herewith the seventh of a series of reports dealing with the systematic geology and paleontology of Maryland. The preceding reports of this series have dealt with the Devonian, Lower Cretaceous, Upper Cretaceous, Eocene, Miocene, and Plio-Pleistocene deposits and the remains of animal and plant life which they contain. The present volume treats of the Cambrian and Ordovician deposits and their contained life. These rocks comprise the oldest fossiliferous rocks of the state, a knowledge of which is extremely important from a scientific, educational, and economic standpoint. I am,

Very respectfully,

EDWARD BENNETT MATHEWS,

State Geologist.

JOHNS HOPKINS UNIVERSITY,

BALTIMORE, *September*, 1919.

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PREFACE

The present volume is the seventh of a series of reports dealing with the systematic geology and paleontology of Maryland, the Devonian, Lower Cretaceous, Upper Cretaceous, Eocene, Miocene and Plio-Pleistocene deposits having already been fully described.

This volume is devoted to a consideration of the Cambrian and Ordovician deposits and their contained faunas. The calcareous strata making up a considerable part of these two systems are so intimately united in the Appalachians that they have long remained unseparated under the name Cambro-Ordovician limestone, or, as in Maryland and Virginia, the Shenandoah limestone. It was therefore thought eminently fitting to combine their consideration in one volume and to disregard in the title the Ozarkian, the Canadian, and other possible systems which have been suggested in recent years.

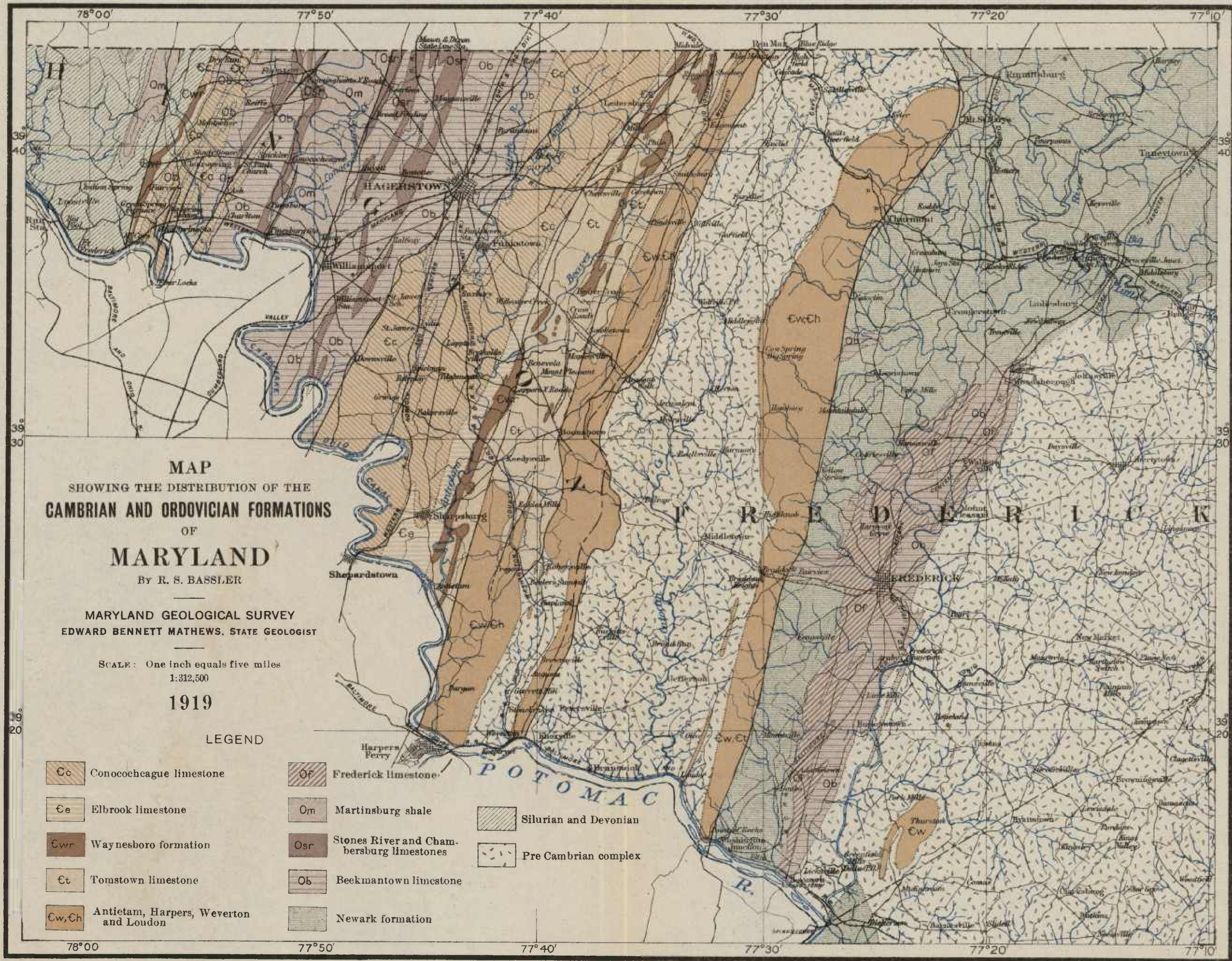
Upon the completion of studies on the Cambrian and Ordovician rocks of Virginia in 1909, published as Bulletin 2A of the Virginia Geological Survey under the title "Cement Resources of Virginia west of the Blue Ridge," the writer, upon the invitation of the late Dr. William Bullock Clark, undertook the preparation of the Maryland volume dealing with the systematic geology and paleontology of the Cambrian and Ordovician systems. As this work included the mapping of these strata in areas both west and east of the Blue Ridge, and as only a few weeks were available each summer for the necessary field work, the volume has been long delayed. However, this delay has proved fortunate, for during the interval of its preparation the knowledge of Cambrian and Ordovician stratigraphy has progressed so much that it is hoped fewer mistakes will now be recorded.

During the preparation of the Mercersburg-Chambersburg folio descriptive of the region in Pennsylvania, just north of the Maryland state line, the writer had the advantage of association with E. O. Ulrich and George W. Stose in their studies of the stratigraphy and paleontology of that area. He thus helped to collect the data and became acquainted with the Cambrian and Ordovician faunas and sections which are so well displayed there, but not as well developed in Maryland.

Dr. Richard C. Williams, while a graduate student at Johns Hopkins University, assisted in the mapping of the Cambrian and Ordovician strata, especially in the Hagerstown area. The Maryland Geological Survey has also had the coöperation of the U. S. Geological Survey, Mr. George W. Stose of that organization being associated in the field work in the Williamsport quadrangle in the area west of the Martinsburg shale belt.

The Survey is also indebted to Dr. E. O. Ulrich of the U. S. Geological Survey for permission to incorporate in this volume a set of his paleogeographic maps covering the Cambrian and Ordovician formations.

THE CAMBRIAN AND ORDOVICIAN DEPOSITS OF MARYLAND



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THE CAMBRIAN AND ORDOVICIAN DEPOSITS OF MARYLAND

BY

R. S. BASSLER

INTRODUCTION

The Cambrian and Ordovician deposits of Maryland can only be interpreted through an understanding of the geology of the extensive province extending from eastern Canada to Alabama, of which the State of Maryland forms a part. The Cambrian and Ordovician formations of Maryland extend far beyond the confines of the state and in adjacent areas to the north or south frequently afford more satisfactory evidence of their character and fossil content than they do in Maryland.

The Physiography

The region here considered forms a small portion of the Atlantic slope, which stretches from the crest of the Alleghanies to the sea, and which is divided into three more or less sharply defined physiographic regions known as the Appalachian Region, the Piedmont Plateau, and the Coastal Plain. These three districts follow the Atlantic border of the United States in three belts of varying width from New England southwestward to the Gulf states.

The Appalachian Region extends from beyond the western limits of the state eastward to the Blue Ridge and is divided into three districts known as the Alleghany Plateau, the Greater Appalachian Valley, and the Blue Ridge District. The first is west of the Alleghany Front and contains rocks younger than Ordovician. Extending along the eastern border of the Alleghany Front is the district known as the Greater Appalachian Valley which admits of a twofold division into the zone of Alleghany

Ridges on the west and the Great Valley on the east, the latter known as the Hagerstown Valley in Maryland, the Cumberland Valley in Pennsylvania, and the Shenandoah Valley in Virginia. The Great Valley is a broad lowland with an elevation averaging between 500 and 600 feet and gradually increasing in height to the northward. It extends from New York state to Alabama and in Maryland lies between North Mountain on the west and the Blue Ridge on the east. The Blue Ridge district consists of the Blue Ridge and Catoctin mountains which unite immediately north of the Maryland-Pennsylvania boundary to form the greater highland known as South Mountain.

The Piedmont Plateau borders the Blue Ridge district on the east and comprises the hill country of ancient rocks lying between the Blue Ridge on the west and the Coastal Plain district on the east—the latter district sloping gradually to the southeast and becoming submerged beneath the Atlantic. The Piedmont Plateau is divided into an Eastern Division and a Western Division by the upland known as Parr's Ridge which forms the low divide at an average elevation of between 800 and 900 feet of the streams flowing directly into Chesapeake Bay and those flowing into Potomac River. The Western Division in Maryland corresponds rather closely to what is known as the Frederick Valley.

THE GEOLOGY

The Cambrian and Ordovician formations in Maryland are confined to the eastern division of the Appalachian Region, previously described as the Great Valley and Blue Ridge, and to the western division of the Piedmont Plateau Region.

The Cambrian formations consist of shales, limestones, and sandstones of sedimentary origin which have been subjected to much metamorphism and marked structural disturbances since they were deposited. They cover considerable areas in Washington and Frederick counties. The Ordovician formations are found in association with the Cambrian in the Great Valley and Blue Ridge regions and also in the Frederick Valley. The Ordovician sediments have been much folded and faulted, but they are, on the whole, less metamorphosed than those of Cambrian age.

HISTORICAL REVIEW

It will be remembered that previous to 1830 geologists grouped into a single large and indefinite "Transition Series" all of the sedimentary and interbedded volcanic rocks of Great Britain older than the Carboniferous. Immediately underlying the Carboniferous was the great mass of red sandstones and marls first designated the Old Red sandstone and later determined as of Devonian age. In 1831, Sir Roderick I. Murchison and Professor Adam Sedgwick attacked the problem of the division of the remaining underlying strata, confining their studies to the rocks of western England and eastern and southeastern Wales. Murchison undertook this study under favorable circumstances, as he began his researches at the upper end of the series where fossils abound and the structure is simple. He found that the different members of the upper part of this great series could be recognized by the fossils as easily as more recent strata, and he continued to discover fossiliferous zones lower and lower in the series. He first designated these strata as the "fossiliferous graywacke series," but in 1835 he changed this to the "Silurian System," named after the Silures, a tribe of ancient Britons. Sedgwick, on the other hand, attempted the division of the transition series in the Snowdon district of Wales where the complicated structure and highly altered nature of the rocks, and consequent scarcity of fossils, made the problem an extremely difficult one. In 1835 he proposed the name "Cambrian Series" for the lower, older member, taking the name from Cambria, the Roman name for northern Wales.

Murchison divided his Silurian system into an upper and lower portion which were separated from each other, as pointed out by Sedgwick, by an angular unconformity marking the boundary between the Caradoc and the Llandovery groups. The lower limit of his Silurian was not defined, but he finally included all of the fossiliferous strata of Sedgwick's Cambrian.

Murchison, in his volume on the Silurian system published in 1839, recognized the Cambrian series, and up to this point the two workers agreed. However, in 1842, in his presidential address to the Geological Society of London, he stated that the Cambrian fossils did not differ from those of the Lower Silurian, an opinion eminently correct because, as just noted, he had included in it all of the fossiliferous Cambrian. In the publication of his Siluria several years later, Murchison still regarded Sedgwick's Cambrian system as simply a local facies of the Silurian system. The historic but unfortunate controversy on this question now ensued. Murchison, by means of his influential official and social position, was able to dominate the subject and most of the rocks now recognized as Cambrian, Ordovician, and Silurian were marked Silurian on the British geological maps, and in both America and Europe fossils collected from the equivalent of the "Transition Series" were almost invariably classed as Silurian. The term Cambrian was practically discarded because, according to Murchison, it was impossible to recognize the strata on account of their supposed lack of characteristic fossils.

In 1879 Professor Lapworth of Birmingham University, England, proposed that Murchison's term Lower Silurian be replaced by the name Ordovician, after the Ordovices, a tribe which lived in Wales at the time of the Romans. Sedgwick in his writings continued to insist that the Cambrian system was an independent group of rocks and proposed to limit the Silurian to the Ludlow and the Wenlock, with the Mayhill sandstone at the base. In his introduction to Salter's Catalogue of Cambrian and Silurian fossils, published in 1873, the year of his death, he held to this same view. As practically all of the faunas which he considered as Cambrian and the main mass of the rocks included by him in the Cambrian system are now recognized as typical Ordovician, it is evident that the present-day usage of the term Cambrian does not follow the intentions of its author. The upper, typical portion of the Silurian system, to which the name Silurian was restricted when Lapworth introduced the new name Ordovician for the Lower Silurian, was named Murchisonian by d'Orbigny in 1850, but this term never received a wide acceptance.

With the adoption of the terms Ordovician and Silurian by many geologists the name Cambrian was finally retained for the lower, much more sparingly, unfossiliferous rocks of the original Cambrian of Sedgwick—a most unfair procedure and one to which that author objected vigorously in his lifetime. Still another classification of pre-Devonian Paleozoic rocks is that of De Lapparent who recognized the Silurian for the entire interval, with the three divisions—Cambrian, Ordovician, and Bohemian or Gothlandian.

Another term which enters into this controversy is that of the Taconic system. The Taconic question was the basis of a controversy in America similar to that of the Silurian in Great Britain. In 1838 Emmons noted that the Potsdam sandstone was the oldest sedimentary rock in the vicinity of Potsdam, New York, as it here rested upon pre-Paleozoic crystallines, an observation still recognized as correct. Overlying the Potsdam sandstone, he found the Calciferous sandrock, the Chazy, Birdseye, and Trenton limestones, and the Utica and Hudson River shales. In western Massachusetts at the foot of the Hoosac Mountains he found an entirely different series resting directly upon the gneiss. Emmons believed this series to be older than the Potsdam and in 1841 he applied to it the name Taconic system, after the Taconic range. The controversy which arose over the reality of his system lasted over half a century, and although Emmons defended his opinion until the day of his death, stratigraphic geology had then not proceeded far enough to recognize the real value of the Taconic rocks in classification. It is now known that the greater portion of the Taconic is of Cambrian age. With slight emendations the term Taconic could in all fairness have been recognized for the Cambrian or for a portion of it just as Sedgwick's term Cambrian should have been applied to the rocks now called Ordovician.

During the quarter of a century or more following Lapworth's definition of the Ordovician system and the recognition in America of the Cambrian, Ordovician, and Silurian, with the limits generally accepted to-day, no controversial matters of especial importance arose in Early Paleozoic stratigraphy. Most students of the subject believed that Early Paleozoic sedimentation took place in quiet continental seas which were often of considerable depth. It was thought that sedimentation endured without interruption either through a single period or sometimes through several periods, until finally there was land elevation and withdrawal of the sea. Then after extensive erosion, the sinking of the land and incursion of the sea inaugurated another period of geological history. Faunal differences in apparently contemporaneous strata were attributed to the different habitats of the organisms, while the absence of certain strata over wide areas was explained by the erosion during the land interval. The great changes in lithological character from place to place depended upon the topography of the land masses bordering the continental seas.

In the last decade so many new stratigraphic and paleontologic facts have come to light that the old conceptions regarding stratigraphic correlation and the ideas concerning the character and extent of the ancient continental seas have been greatly modified and often discredited. The lifelong studies of E. O. Ulrich upon the stratigraphy and paleontology of the American Paleozoic have brought to light new criteria for systemic delimitation, and caused him to propose a revision of the Paleozoic systems based upon these new conceptions. According to his views there never was a vast continental sea of considerable depth enduring through any great period of deposition, nor was there ever any considerable elevation of the adjacent land masses with the consequent erosion, except for comparatively brief periods. In his work in collaboration with Professor Charles Schuchert, published in Bulletin 52 of the New York State Museum under the title "Paleozoic seas and barriers in eastern North America," it was brought out that the diastrophic movements producing deformation of the land masses, manifested themselves not only between the larger divisions of geologic time, but even between formations. These movements resulted in a north and south warping of the continent with the formation of narrow structural troughs whose position was determined by their location in areas with a predisposition to sink. These troughs or negative areas were separated more or less completely by anticlinal areas which had a positive tendency to remain above sea level in all except the periods of most general submergence.

These positive and negative areas were discussed in more detail by Schuchert in his great work on the Paleogeography of North America, published in 1910 in the Bulletin of the Geological Society of America.

The positive areas were seldom elevated enough to have great erosive activity and the land masses were generally quite low. As a result there are certain limestone formations which hold their lithologic character for hundreds of miles.

In his epoch-making work on the Revision of the Paleozoic Systems, published in volume 22 of the Bulletin of the Geological Society of America, in 1911, Ulrich has given a very detailed account of the diastrophic and faunal criteria employed by him in his studies on stratigraphic classification, and he has devoted much attention to the oscillatory character of continental seas. The northeast-southwest troughs, separated by barriers or areas around which warping took place, were invaded by the sea many times during the course of a period. Other barriers or areas extending at approximate right angles to these troughs, separated them into basins. The general idea was that the sea advanced and retreated many times during the course of a period within these comparatively restricted basins. With each successive invasion sediments were deposited over a larger area so that the final result was a series of overlapping deposits thinning out on the sides of the trough. Each trough or basin would contain series of formations marked off by diastrophic and faunal evidence and a formation would be lithologically and faunally similar only in its own basin, except in periods of great submergence when the sea advanced over the barriers. As the different basins of sedimentation at times connected with different oceanic areas, the marine forms of life in them would consequently be different. Therefore, formations of the same age in adjoining basins may differ totally not only in their lithologic characters, but also in their faunal contents. These troughs of deposition, with their separating barriers, were greatly influenced by later and later periods of diastrophism with the result that in the Appalachians, where folding occurred, the barrier or anticlinal structure is now much diminished in width and is often represented by an overthrust fault.

In addition to the north and south structural lines it has been found that there were definite east and west lines or axes which serve as pivots of oscillation for the continent. The formations thin from either side along these lines just as in the north and south structural troughs they thin along the edges of the trough.

The greatest sea withdrawal marks the systemic boundaries, but the advance and retreat of the seas within the systems would naturally not be uniform throughout the basins of deposition. Therefore one area will have deposits which are represented in another area by a stratigraphic hiatus. As a result of this, the complete section cannot be found at any one place but it is a composite one made up of units from many places. The disregard of this fact has delayed the recognition of many new formations heretofore, as in the case of the so-called Ozarkian.

Under the conception of little elevation and often slight erosion of the Eopaleozoic land masses, the stratigraphic unconformities are not strongly marked even though the time interval may have been great. The bedding planes of strata belonging to distinct formations are usually parallel and the detection of such unconformities is most difficult. The faunal method of discrimination is a sure one, provided the occurrence and range of the faunas are well known. Another method is in the comparison of detached sections and noting the gradual interpolation of other strata between two formations with persistent lithologic characters. In the discrimination of the Ordovician rocks of Maryland, this latter method is extremely useful, as several of the formations developed in states to the north and south are represented here only by their overlapping margins.

In the classification of Paleozoic rocks, as commonly recognized, the Cambrian and Ordovician systems forming the subject of this volume comprise the Eopaleozoic. In his revision of the Paleozoic systems, Ulrich has proposed and defined two new systems, the Ozarkian and Canadian, which occupy the interval between a slightly restricted Cambrian and a more modified Ordovician system. Brief descriptions of these new systems were read at the Baltimore meeting of the Geological Society of America in 1909, but were not published until 1911. In 1910, in his Paleogeography of North America, Schuchert adopted both of the new systems, crediting them to Ulrich, and introduced a third for the Cincinnatian rocks hitherto classified at the top of the Ordovician. The principles upon which the Ozarkian and Canadian have been founded are discussed in great detail in the Revision and their author has a monographic study on their paleontology and stratigraphy in the course of preparation. Although each of the new systems (Ozarkian and Canadian) contains strata heretofore in the one case referred to the underlying Cambrian and in the other to the overlying Ordovician, much the greater part of each system is composed of thick formations whose actual distinctness from the typical Cambrian and Ordovician has never been appreciated. In short these two systems, like the Cambrian, Ordovician and all well-founded geologic systems, are based on a certain sequence of diastrophic events and a sufficient thickness of marine deposits to represent a period of geologic time approximating in length that represented by such other well-established systems as the Silurian and Devonian. They were not founded primarily on fossil evidence, but on the physical criteria of great series of marine deposits found wedging in between the underlying uneven top of older formations, which contain the now well-known and altogether characteristic Upper Cambrian fauna, and the similarly uneven base of another system that comprises the bulk and most characteristic parts of the Ordovician system of the literature. The fossil contents of the two new systems were, of course, immediately utilized in recognizing the several formations from place to place. But the Ozarkian and the Canadian faunas as such could be appreciated only after the systems themselves had been discriminated by physical criteria. So far as these faunas have been worked out they are clearly distinguishable and as different from each other and from the preceding Cambrian and the succeeding Ordovician faunas as are the organic remains in any succeeding contiguous pair of systems. In other words the Ozarkian fauna as shown in Ulrich's collections in the U. S. National Museum is more radically different from the life of the Upper Cambrian seas than is the Silurian from the Ordovician, the Devonian from the Silurian, or the Mississippian from the Devonian. The most striking feature of the difference between the Ozarkian and the Cambrian is the strong development of straight and curved cephalopods, and numerous coiled gastropods—types which, up to the present, are entirely absent in Cambrian faunas. The Canadian faunas introduce a wealth of graptolites, true orthoids as distinguished from Billingsellidae brachiopods, the first ostracods, and the first of the coiled cephalopods. The Ordovician fauna is at once distinguished from the Canadian by the first appearance of pelecypods, the first of the unquestionable bryozoans. and the first true crinoids.

The following table is introduced to illustrate graphically the various usages of the Silurian and related terms concerned in this volume:

Although the list of papers dealing with the geology of the parts of Maryland concerned in this volume is quite lengthy, the number of students whose observations have advanced the knowledge of the stratigraphy and paleontology of the region is comparatively small.

In 1885, Mr. H. R. Geiger began the study of the Paleozoic rocks along the Potomac River in western Maryland and West Virginia and in 1886 and 1887 extended his work eastward down the Potomac River and for some distance southward over the Great Valley region of Virginia. In 1888 he began work on the Harper's Ferry quadrangle and after several months study came to certain conclusions regarding the relations of the sandstones and associated formations in the Blue Ridge and South Mountain to the limestones of the Great Valley which are not held to-day.

In 1890 Mr. Arthur Keith undertook a reëxamination of the Harper's Ferry quadrangle and as a preliminary result of his studies read a paper in joint authorship with Mr. H. R. Geiger, before the Geological Society of America on "The Structure of the Blue Ridge near Harper's Ferry."[1] The next year he published a short notice on "The Geologic Structure of the Blue Ridge in Maryland and Virginia,"[2] and his final results appeared in the Harper's Ferry folio No. 10, Geologic Atlas of the United States.

In 1892 Mr. Charles D. Walcott made an examination of the Blue Ridge and South Mountain region and definitely determined the Cambrian age of its quartzites. A statement of the results of this investigation

[1] Bull. Geol. Soc. America, vol. ii, 1891, pp. 155-164, pls. iv, v.
[2] American Geologist, vol. x, 1892, pp. 362-368.

USAGES OF SILURIAN AND RELATED TERMS

<table>
<tr><th>Murchison</th><th>Sedgwick</th><th>Lapworth</th><th>Emmons</th><th>Dana (1862)</th><th>Dana (1895)</th><th colspan="2">De Lapparent</th><th>New York Survey</th><th colspan="2">Present common usage</th><th>Schuchert (1910)</th><th>Ulrich (1911)</th><th colspan="2">Schuchert (1915)</th></tr>
<tr><td rowspan="5">Silurian</td><td rowspan="5">Silurian</td><td>Silurian (Salopian)</td><td>Ontario</td><td rowspan="8">Silurian</td><td>Upper Silurian</td><td rowspan="8">Silurian</td><td>Gothlandian</td><td>Ontaric</td><td colspan="2">Silurian</td><td>Siluric</td><td>Silurian</td><td colspan="2">Silurian</td></tr>
<tr><td rowspan="4">Ordovician</td><td rowspan="4">Champlain</td><td rowspan="4">Lower Silurian</td><td rowspan="4">Ordovician</td><td rowspan="4">Champlainic</td><td colspan="2" rowspan="4">Ordovician</td><td>Cincinnatic</td><td rowspan="2">Ordovician</td><td rowspan="4">Ordovician</td><td>Cincinnatian</td></tr>
<tr><td>Ordovicic</td><td>Champlainian</td></tr>
<tr><td>Canadic*</td><td>Canadian</td><td>Canadian</td></tr>
<tr><td>Ozarkic* or Cambric</td><td>Ozarkian</td><td>Ozarkian</td></tr>
<tr><td rowspan="3">?Cambrian</td><td rowspan="3">Cambrian</td><td rowspan="3">Cambrian</td><td rowspan="3">Taconic</td><td rowspan="3">Cambrian</td><td rowspan="3">Cambrian</td><td rowspan="3">Cambric</td><td rowspan="3">Cambrian</td><td>Upper</td><td rowspan="2">Acadic</td><td rowspan="3">Cambrian</td><td rowspan="3">Cambrian</td><td>Croixian</td></tr>
<tr><td>Middle</td><td>Acadian</td></tr>
<tr><td>Lower</td><td>Georgic</td><td>Waucobian</td></tr>
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* New systems credited to Ulrich.

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was set forth in two papers, one entitled "Notes on the Cambrian Rocks of Pennsylvania and Maryland from the Susquehanna to the Potomac,"[1] and the other "The Geologist at Blue Mountain, Maryland."[2]

Mr. Keith continued his studies of South Mountain and Blue Ridge geology into Virginia and in 1894 published a report on the "Geology of the Catoctin Belt."[3] This report describes the Blue Ridge, South Mountain, and Catoctin belts from northern Virginia through Maryland into Pennsylvania and was an important addition to the geologic knowledge of this area east of the Great Valley.

The discovery of fossils in the Frederick Valley limestone was announced by Charles R. Keyes in 1890[4] in an article in which he included a geologic section across the valley. The next contribution in which fossils were mentioned was by Charles S. Prosser in 1900,[5] who described the Shenandoah limestone and Martinsburg shale in a general way.

The most important contributions to the early Paleozoic stratigraphy of this region appeared in 1910 in the description of the Mercersburg-Chambersburg district of Pennsylvania by George W. Stose[6] in which E. O. Ulrich collaborated in the study of the Shenandoah limestone and Martinsburg shale. Further stratigraphic and paleontologic details of these rocks were given by E. O. Ulrich in his "Revision of the Paleozoic System" in 1911.[7]

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JEFFERSON, THOMAS. Notes on the State of Virginia. Phila., 1788. Sm. 8vo. 244 pp.

The author gives many interesting facts and speculations concerning the geology about Harper's Ferry. Fully ten editions of this book were published in different places between 1782 and 1832, each with different number of pages.

[1] Amer. Jour. Sci., 3d series, vol. xliv, pp. 469-482.

[2] Nat. Geog. Mag., vol. v, pp. 84-88; Sci. Am. Supp., vol. xxxvii, pp. 14753-14754.

[3] Fourteenth Ann. Rep. U. S. Geol. Surv., part ii, 1894, pp. 285-395, pls. xix-xxxix.

[4] Johns Hopkins University Circular No. 84, vol. x, 1890, p. 32.

[5] Journal Geology, vol. viii, pp. 655-663, figs. 1-4.

[6] U. S. Geol. Survey, Geol. Atlas No. 170, 1910.

[7] Bull. Geol. Soc. America, vol. xxii, No. 3, pp. 281-680, 5 pls., 1911.

1809

MACLURE, WM. Observations on the Geology of the United States, explanatory of a Geological Map. (Read Jan. 20, 1809.)

Trans. Amer. Phil. Soc., o. s. vol. vi, 1809, pp. 411-428.

Broad correlations and generalizations only.

1814

MITCHILL, SAML. L. A Sketch of the Scenery in the region around Harper's Ferry where the ridge of the Blue Mountains is penetrated by the joint waters of the Potomac and Shenandoah rivers. In a letter to the editor; dated Harper's Ferry, July 4, 1812. Bruce's Amer. Min. Jour., vol. i, New York, 1814. pp. 211-218.

The author discusses the geology and stratigraphy along the Potomac between Harper's Ferry and Washington and regards the slates as older than the limestones.

1817

MACLURE, WM. Observations on the Geology of the United States of America, with some remarks on the effect produced on the nature and fertility of soils by the decomposition of the different classes of rocks. With two plates. 12mo. Phila., 1817.

(Republished in 1818, Trans. Amer. Phil. Soc., vol. i, n. s., pp. 1-91.)

A classic work giving many references to the limits and character of the geological formations in Maryland. The text and map (120 m. to the inch) represent the Cretaceous extending southwest to the Susquehanna only. All land to the southeast of "Primitive" is "Alluvium" in Maryland. Pages 105-107 deal especially with Maryland.

1834

AIKIN, WILLIAM E. A. Some notices of the Geology of the Country between Baltimore and the Ohio River, with a section illustrating the superposition of the rocks.

Amer. Jour. Sci., vol. xxvi, 1834, pp. 219-232, plate.

The most complete description of the geology of central and western Maryland published up to the time of its appearance.

DUCATEL, J. T., and ALEXANDER, J. H. Report on the Projected Survey of the State of Maryland, pursuant to a resolution of the General Assembly. 8vo. 39 pp. and map. Annapolis, 1834.

Maryland House of Delegates, Dec. Sess., 1833, 8vo., 39 pp.
Another edition, Annapolis, 1834, 8vo., 58 pp. and map.
Another edition, Annapolis, 1834, 8vo., 43 pp., and folded table.
Amer. Jour. Sci., vol. xxvii, 1835, pp. 1-38.

Results of a preliminary survey of the state. The area and formations of the state are divided into three divisions corresponding to the present Coastal Plain, Piedmont Plateau and Appalachian areas. Many local descriptions and references are given with marked tendency towards economic point of view.

1835

TAYLOR, RICHARD C. Review of Geological Phenomena and the deductions derivable therefrom in two hundred and fifty miles of sections in parts of Virginia and Maryland.

Trans. Geol. Soc. Penn., vol. i, 1835, pp. 314-325 (with colored sections).

The paper describes various sections, one of which extends from Winchester to Harper's Ferry and thence east to within 30 miles of Baltimore. This section is pl. xvii, fig. 1.

1841

DUCATEL, J. T. Annual Report of the Geologist of Maryland, 1840. 8vo. 46 pp. (Annapolis, 1840.) Map and sections.

Another edition, 8vo., 59 pp. and 3 plates, also Md. House of Delegates, Dec. Sess., 1840, n. d., 8vo., 43 pp., 3 plates.

Considers the physical geography and geology of Allegany and Washington counties, with notes on the copper mining about Frederick.

1853

MARCOU, JULES. A Geological Map of the United States and the British Provinces of North America, with an explanatory text (etc.). 8vo. Boston, 1853.

Represents no Cretaceous on Western Shore; most of the Eastern Shore as Alluvium and the rest of the state covered successively by bands of Metamorphic, New Red, Metamorphic, Silurian and Devonian. No Carboniferous is represented within the limits of the state (?).

1855

MARCOU, J. Resumé explicatif d'un carte géologique des États-Unis et des provinces anglaises de l'Amérique.

Bull. Soc. Géol. Fr., 2 ser., tome xii, 1855, pp. 813-936; colored geological map.

Explanation of map itself, so far as related to Maryland, apparently based on Maclure.

1856

HITCHCOCK, E. Outline of the Geology of the Globe and of the United States in particular, with geological maps, etc. 8vo. Boston, 1856. (3d ed.)

In discussing the areal distribution of the different formations he frequently mentions Maryland, giving reasons for location of the lines on his maps.

1858

ROGERS, H. D. The Geology of Pennsylvania. 2 vols. (Vol. II in two parts) and maps. 4to. Phila., 1858.

This work containing frequent references to the Maryland extension of formations studied in Pennsylvania, besides giving the typical sections, terms, fossils, etc.

1860

TYSON, P. T. First Report of Philip T. Tyson, State Agricultural Chemist, to the House of Delegates of Maryland. Jan., 1860. 8vo. 145 pp. Annapolis, 1860. Maps.

Md. Sen. Doc. (E). Md. House Doc. (C).

Deals with the rocks and soils, fertilizers, etc., and explains the accompanying geological map.

1875

FONTAINE, WM. M. On some Points in the Geology of the Blue Ridge in Virginia.

Amer. Jour. Sci., 3d ser., vol. ix, 1875, pp. 14-22, 93-101. (Abst.) Geol. Record, 1875, London, 1877, p. 119.

Includes a few notes on Catoctin Mt., and the argillites of Point of Rocks and Harper's Ferry, pp. 15-17. The first paper deals with some of the general problems involved in a study of the Blue Ridge, and the illustrations are mostly taken from that portion of the range, near the Potomac River. The second paper deals with the area about Lynchburg and southward.

———. On the Primordial Strata of Virginia.

Amer. Jour. Sci., 3d ser., vol. ix, 1875, pp. 361-369, 416-428, 3 figures.

(Abst.) Geol. Record, 1875, London, 1877, p. 119.

Refers briefly to the geology of Harper's Ferry (p. 362) and to the folds at "Cement Mill" near Hancock (p. 364). Geology of the Harper's Ferry region, pp. 422-423.

1876

HUNT, T. STERRY. Geology of Eastern Pennsylvania.

Proc. Amer. Assoc. Adv. Sci., vol. xxv, 1876, pp. 208-212.

Considers the Blue Ridge in Maryland to be Montalban and Huronian with no Laurentian.

1879

FRAZER, PERSIFOR, JR. Fossil (?) Forms in the Quartzose Rocks of the Lower Susquehanna, with plate. (Read April 4, 1879.)

Proc. Amer. Phil. Soc., vol. xviii, 1880, pp. 277-279.

Deals with some curious indeterminate forms from Frazier's Point, Cecil County. Letters by Whitfield and Hall.

1880

DANA, J. D. Manual of Geology. 3d ed.

Maryland, pp. 236, 243, 419, 455, 490, 494-5.

FRAZER, PERSIFOR, JR. The Geology of Lancaster County, Pa.

Rept. 2d Geol. Surv., Pa., ccc. Harrisburg, 1880 atlas.

Deals with the geological formations along the border of the state and their extension into Maryland.

LESLEY, J. P. On a slab of roofing slate covered with casts of *Buthotrephis flexuosa* from the Peach Bottom Slate Quarries. (Read Dec., 1879.)

Proc. Amer. Phil. Soc., vol. xviii, 1880, pp. 364-369.

This paper gives the history of the find, its determination by Lesquereux, analysis of slate and remarks by Frazer.

———. A Hudson River fossil plant in the roofing slate that is associated with the chlorite slate and metamorphic limestone in Maryland, adjoining York and Lancaster counties, Pennsylvania.

Amer. Jour. Sci., 3d ser., vol. xix, 1880, pp. 71-72.

Buthotrephis flexuosa (determined by Lesquereux) in the Peach Bottom slates, Silurian age inferred. Extract from a letter.

1882

SCHARF, J. T. History of Western Maryland, being a history of Frederick, Montgomery, Carroll, Washington, Allegany, and Garrett counties from the earliest period to the present day. 2 vols. 4to. Phila., 1882. Topography and Geology by P. R. Uhler. pp. 13-46.

1884

FRAZER, P., JR. The Peach Bottom Slates of Southeastern York and Southern Lancaster counties.

Trans. Amer. Inst. Min. Eng., vol. xii, 1884, pp. 355-358. Plates and section.
(Abst.) Amer. Jour. Sci., 3 ser., vol. xxix, 1884, p. 70.

Discussion of a section along the Susquehanna River northward from the Maryland line. Also a letter from Prof. James Hall regarding the probable age of the slates, which he considers are either the Hudson River or the Quebec group from the presence of forms allied to Holymenites, Lamnantes lagranger and graptolithus.

ROGERS, WILLIAM BARTON. A reprint of Annual Reports and other papers on the Geology of the Virginias. Sm. 8vo. Appleton, 1884.

WALLING, H. F. Topographical Indications of a Fault near Harper's Ferry.

(Abst.) Bull. Phil. Soc., Washington, vol. vi, 1884, pp. 30-32.

Mentions the discontinuous extension of the Blue Ridge at Harper's Ferry in support of increased corrugation and steepness of dip eastward with reversed folding. The downthrow to the west.

1886

FRAZER, PERSIFOR, JR. General Notes. · Sketch on the Geology of York County, Pennsylvania. (Read Dec. 4, 1885.)

Proc. Amer. Phil. Soc., Phila., vol. xxiii, 1886, pp. 391-410.

Discussion of the general structure equally applicable to Maryland.

1890

KEYES, CHARLES ROLLIN. Discovery of fossils in the limestone of Frederick County, Maryland.

Johns Hopkins Univ. Cir. No. 84, vol. x, 1890, p. 32.

Gives a geological section and description of Frederick Valley and enumerates the fossils found there.

MACFARLANE, J. R. An American Geological Railway Guide. 2d ed. 8vo. 426 pp. Appleton, 1890.

Maryland notes based on data from Uhler, Williams, Fontaine and Chester.

1891

GEIGER, H. R., and KEITH, ARTHUR. The Structure of the Blue Ridge near Harper's Ferry. (Read Dec., 1890.)

Bull. Geol. Soc. Amer., vol. ii, 1891, pp. 155-164, plates iv and v.

(Abst.) Amer. Geol., vol. vii, 1891, p. 262; Amer. Nat., vol. xxv, 1891, p. 658.

The authors conclude that the sandstones are not Potsdam, as previously considered, but Upper Silurian. The paper is accompanied by geological map and sections.

KEYES, CHARLES ROLLIN. Paleozoic fossils of Maryland.

Johns Hopkins Univ. Cir. No. 94, vol. xi, 1891, pp. 28-29.

Enumerates the fossils and type localities.

———. A Geologic Section across the Piedmont Plateau in Maryland.

Bull. Geol. Soc. Amer., vol. ii, 1891, pp. 319-322. (Published separately, 1890.)

(Abst.) Amer. Geol., vol. viii, 1891, p. 331.

Besides the general treatment of the structure from Washington to Catoctin Mt., there is a very brief discussion of structure of Sugar Loaf Mt. p. 322.

WALCOTT, C. D. Correlation Papers—Cambrian.

Bull. U. S. Geol. Surv., No. 81, 1891.

House Misc. Doc., 52d Cong., 1st sess., vol. xx, No. 25.

Based chiefly on Tyson's Report, pp. 133, 287, 290. For problems unsolved see pp. 328-383.

1892

KEITH, ARTHUR. The Geologic Structure of the Blue Ridge in Maryland and Virginia.

Amer. Geol., vol. x, 1892, pp. 362-368.

Broadly considered, the region is an anticline, where an arch is crumpled into several synclines and broken by faults till the resultant structure is quite complicated.

LESLEY, J. P. A Summary description of the Geology of Pennsylvania. 3 vols. Harrisburg, 1892.

Numerous references to formations passing southwards into Maryland.

WALCOTT, C. D. The Geologist at Blue Mountain, Maryland.

Nat. Geog. Mag., vol. 5, 1892, pp. 84-88.

Sci. Amer. Supp., vol. 37, 1892, pp. 14753-14754.

———. Notes on the Cambrian Rocks of Pennsylvania and Maryland from the Susquehanna to the Potomac.

Amer. Jour. Sci., 3d ser., vol. xliv, 1892, pp. 469-482.

The portion of Maryland studied lies in the Blue Ridge and Catoctin mountains from Mechanicstown (Thurmont) to Monterey, Pa., along the W. M. R. R. and southward to Harper's Ferry, W. Va.

1893

WILLIAMS, G. H. (The Appalachian Region and the Itinerary from Washington, D. C., to Cumberland, Maryland.)

Geological Guidebook of the Rocky Mt. Excursion, Compte Rendu de la 5me Ses. Congrès Geolog. Internat. Washington, 1893, pp. 268-279.

House Misc. Doc., 53d Cong., 2d sess., vol. xiii, No. 107, pp. 268-279.

Summary of the local geology along the route.

WILLIAMS, G. H., and CLARK, W. B. Geology of Maryland.

Maryland, its Resources, Industries and Institutions, Baltimore, 1893, pp. 55-89.

A general summary of the geology of Maryland with many illustrations and local references.

WILLIS, BAILEY. The Mechanics of Appalachian Structure.

13th Ann. Rept. U. S. Geol. Surv., 1891-92, pt. 2, Washington, 1893, pp. 211-281, plates and maps.

The discussion includes illustrations from Maryland, and its conclusions are applicable to the western portion of the state.

1894

KEITH, ARTHUR. Geology of the Catoctin Belt.

14th Ann. Rept. U. S. Geol. Surv., 1892-93, Washington, 1894, pt. ii, pp. 285-395, maps and plates.

House Exec. Doc., 53d Cong., 2d sess., vol. xvii, p. 285.

(Rev.) Sciences, n. s., vol. ii, 1895, p. 97.

A full discussion of the area studied.

———. Harper's Ferry Folio, Explanatory Sheets.

U. S. Geol. Surv. Geol. Atlas, folio No. 10, Washington, 1894.

Brief epitomized discussion of the local geology, structure and geological history of the area included.

1896

DORSEY, CLARENCE W. The Soils of the Hagerstown Valley.

Md. Agr. Exp. Sta. Bull. No. 44, College Park, 1896.

A study of the soils resulting from the disintegration of the Cambrian sandstone, Hudson River shales and Trenton limestones. Distinguished five types.

WALCOTT, C. D. The Cambrian Rocks of Pennsylvania.

Bull. U. S. Geol. Surv. No. 134, 1896.

House Misc. Doc., 54th Cong., 2d sess., No. 24.

Contains incidental reference to his work with Keith in Frederick County and also to the southern continuation of Pennsylvania formations.

WILLIS, BAILEY. The Northern Appalachians.

The Physiography of the United States.

Geographic Monographs I, American Book Company, 169 pp., 1896.

A study of the present topography and its origin.

1897

CLARK, WILLIAM BULLOCK. Historical sketch embracing an account of the progress of investigation concerning the physical features and natural resources of Maryland.

Md. Geol. Surv., vol. i, pp. 43-138, pls. ii-v, 1897.

———. Outline of present knowledge of the physical features of Maryland, embracing an account of the physiography, geology, and mineral resources.

Md. Geol. Surv., vol. i, pp. 141-228, pls. vi-xiii, 1897.

Description of the physiographic features of the state, the character and distribution of the igneous and sedimentary rocks, and the mineral resources.

1899

ABBE, CLEVELAND, JR. A general report on the physiography of Maryland.

Md. Weather Service, vol. i, pp. 41-216, pls. iii-xix, figs. 1-20, 1899.

Discusses the physiographic features of the Piedmont Plateau and Appalachian provinces in Maryland.

CLARK, WILLIAM BULLOCK. The relations of Maryland topography, climate, and geology to highway construction.

Md. Geol. Surv., vol. iii, pp. 47-106, pls. iii-xi, figs. 1-3, 1899.

1900

PROSSER, CHARLES S. The Shenandoah limestone and Martinsburg shale.

Jour. Geol., vol. viii, pp. 655-663, figs. 1-4, 1900.

Describes the lithologic and faunal characters of the formations in adjacent portions of Maryland and West Virginia.

ULRICH, E. O., and SCHUCHERT, CHARLES. Paleozoic Seas and barriers in eastern North America.

N. Y. State Mus., Bull. No. 52, pp. 633-663, 1 pl.

1906

CLARK, WILLIAM BULLOCK. Report on the physical features of Maryland, together with an account of the exhibits of Maryland mineral resources made by the Maryland Geological Survey.

Maryland Geol. Survey (Special Publications, vol. vi, pts. 1 and 2), 284 pp., 30 pls., 19 figs., geol. map. (in pocket), 1906.

A general account of the physiography, geology and mineral resources of the state.

1907

MARYLAND GEOLOGICAL SURVEY.

(Geological) map of Maryland, prepared by Maryland Geological Survey, Wm. Bullock Clark, State Geologist, 1907, Scale 1: 187, 500.

BASSLER, RAY S. Cement and cement materials (of Virginia).

In Watson, T. L., Mineral Resources of Virginia, pp. 86-167, 10 pls., 14 figs., 1907.

1908

STOSE, GEORGE W. The Cambro-Ordovician limestones of the Appalachian Valley in southern Pennsylvania.

Jour. Geology, vol. xvi, No. 8, pp. 698-914, 1908.

BASSLER, RAY S. Cement materials of Western Virginia.

Econ. Geology, vol. iii, No. 6, pp. 503-524, 4 figs., 1908.

PEABODY, CHARLES. The exploration of Bushey cavern, near Cavetown, Maryland.

Phillips Academy, Andover, Massachusetts, Dept. of Archaeology, Bull. iv, pt. 1, pp. 3-25, 8 pls., 1908.

1909

MATHEWS, EDWARD BENNETT, and GRASTY, JOHN SHARSHALL. Report on the limestones of Maryland, with special reference to their use in the manufacture of lime and cement.

Maryland Geol. Survey, vol. viii, pp. 225-477, 14 pls., 12 figs., 1909.

BASSLER, RAY S. The Cement Resources of Virginia west of the Blue Ridge.

Virginia Geol. Surv., Bull No. 2A, 309 pp., 30 pls., 30 figs., 1909.

1910

SCHUCHERT, CHARLES. Paleogeography of North America.

Geol. Soc. America Bull., vol. xx, pp. 427-606, 56 pls.

STOSE, GEORGE W. Description of the Mercersburg-Chambersburg district, Pennsylvania.

U. S. Geological Survey, Geol. Atlas U. S., Mercersburg-Chambersburg folio (No. 170), library edition, 19 pp., 8 pls. (maps, sections, and illustrations sheets), 5 figs., 1909; field edition, 144 pp., 6 folded maps, 10 pls., 4 figs., 1910.

Describes the topographic features, the general geology, the occurrence, character, and relations of pre-Cambrian volcanic rocks, and of Cambrian, Ordovician, Silurian and Devonian formations, and geologic structure, the geologic history, and the economic resources.

1911

ULRICH, EDWARD O. Revision of the Paleozoic Systems.

Geol. Soc. America, Bull. vol. xxii, No. 3, pp. 281-680, 5 pls.

1912

EATON, H. N. The geology of South Mountain at the junction of Berks, Lebanon, and Lancaster counties, Pennsylvania.

Jour. Geology, vol. xx, No. 4, pp. 331-343, 2 figs., May-June, 1912.

Describes the occurrence, character and relation of pre-Cambrian, Cambrian, Ordovician and Triassic strata and the structural conditions.

JANDORF, MORTON LEHMAYER. Preliminary report on the York Valley limestone belt in York County.

Pennsylvania Topog. and Geol. Survey, Rept. 1910-1912, pp. 50-129, 14 pls. (incl. maps), 1912.

MOORE, ELWOOD S. Siliceous oolites and other concretionary structures in the vicinity of State College, Pennsylvania.

Jour. Geology, vol. xx, No. 3, pp. 259-269, 7 figs., April-May, 1912: Abstract, British Assoc. Adv. Sci., Rept. 81st Meeting, p. 390, 1912.

Describes the occurrence and geologic relations and discusses the origin of siliceous oolites.

STOSE, GEORGE W., and SWARTZ, CHARLES K. Description of the Pawpaw and Hancock quadrangles (Maryland-West Virginia-Pennsylvania).

U. S. Geol. Survey, Geol. Atlas U. S. Pawpaw-Hancock folio (No. 179), 24 pp., 11 figs., 9 pls. (maps, sections, and illustrations), 1912; field edition, 176 pp., 11 figs., 20 pls., 6 folded maps (in pocket), 1912.

Abstract, Washington Acad. Sci. Jour., vol. ii, No. 16, p. 410, October 4, 1912.

Describes the topography, the character, occurrence, and relations of Cambrian, Ordovician, Silurian, Devonian, and Carboniferous formations, and of Tertiary, and Quaternary deposits, the geologic structure, the geologic history, and the mineral resources.

WILLIS, BAILEY. Index to the stratigraphy of North America.

U. S. Geological Survey, Prof. Paper, 71, 894 pp., 1 pl. (geological map in 4 sheets in separate case).

Brief notes on Maryland stratigraphy are given in the compilation of data used in the preparation of the geologic map of North America.

1913

BROWN, THOMAS C. Notes on the origin of certain Paleozoic sediments, illustrated by the Cambrian and Ordovician rocks of Center County, Pennsylvania.

Jour. Geology, vol. xxi, No. 3, pp. 232-250, 7 figs., 1913; (Abst.), Geol. Soc. America, Bull. vol. xxiv, No. 1, p. 112, March 24, 1913.

Discusses the origin of conglomerates, oolites, and sandstones of Ordovician and Cambrian age.

PALEOGEOGRAPHY OF THE CAMBRIAN AND ORDOVICIAN

The subject of ancient or geologic geography for which the term "paleogeography" was proposed in 1872 by T. Sterry Hunt and was prominently employed by Robert Etheridge, the English paleontologist, in 1881, has become such an important branch of stratigraphic geology that to-day no general stratigraphic discussion is complete without an attempt to indicate the distribution of the land and water of the time. Since 1896 when Canu published his "Essai de paleogeographie" the term has been frequently employed.

Paleogeographic maps have been prepared in America since 1863 when James D. Dana published several generalized sketches of the Azoic, Cretaceous, and early Tertiary periods, in the first edition of his Manual of Geology. Since then over 500 paleogeographic maps have appeared, about one-half of which refer to North America. Until recent years most of these maps were subject to the criticism that they covered too much time and therefore were too generalized.

Schuchert, in 1908, in his "Paleogeography of North America," published a series of maps based upon the most precise correlations and the narrowest time limits that had hitherto been attempted. This work, which was prepared in collaboration with all the leading American stratigraphers and paleontologists, brought out with excellent clearness many new features, especially the oscillatory nature of the continental seas. This publication marks a great advance in the science of paleogeography. In spite of efforts to the contrary, some of these maps, as was recognized by their author, covered too long a time period, and are subject to the criticism just mentioned.

Since 1908 a great amount of new data on the stratigraphy and paleontology of American early Paleozoic formations has been accumulated and to-day maps covering the geography of a single formation are possible. Maps illustrating the early Paleozoic divisions of the geological column were prepared by E. O. Ulrich and revised at frequent intervals as new facts were obtained. But few of these have hitherto been published, but the writer has obtained permission to reproduce in this volume all of the maps covering the formations here under discussion. These are inserted in their appropriate place in the text.

It must be remembered that in these maps the shore lines are more or less hypothetical and do not show the bays and other features of present-day strands. It must also be remembered that the present-day base maps do not accurately represent the continents of past times, because the latter, especially in the mountainous areas, have suffered great compression.

Although it is evident that the portion of Maryland covered by the Cambro-Ordovician rocks is too small a part of the North American continent to reveal much of the paleogeography, still it may be noted from the accompanying maps that western Maryland has been much concerned in the continental oscillation and other earth movements which occasioned the repeated invasions and withdrawals of the sea. In order to plot these sea invasions not only must the distribution of the marine sediments of the time be determined and the ancient shore lines thus approximated, but also the particular oceanic basins from which the several fossil faunas have migrated must be ascertained. The waters which have repeatedly flooded the continent have come from the Arctic, Atlantic and Pacific oceans and the Gulf of Mexico, and each brought with it such samples of its own particular life as were available and suited to existence in shallow epicontinental seas.

Comparative studies of the fossil faunas have shown them to have had a considerable sameness in composition when derived from the same oceanic source, and to have had great unlikeness to contemporaneous faunas that originated in other oceanic basins. This appears to indicate not only that the life in the several oceanic basins evolved more or less independently, but also that each maintained in recognizable measure its individual characteristics. These distinctive facies were perhaps never less and may often have been greater than now. At any rate Ordovician faunas of Arctic origin are at least as distinct from approximately contemporaneous ones of Gulf origin as the life of the Arctic Ocean to-day is different from that of the Gulf of Mexico. Appreciating these distinctions paleontologists are succeeding very well in discriminating the faunas that came in from the east or south from those that invaded the continent from the north or west.

The underlying principles of the science of paleogeography and the methods employed in the preparation of paleogeographic maps have been discussed in detail by Ulrich.[1] In brief the study of first, fossil faunas and floras, and second, of the phenomena expressed under the general name of diastrophism, afford the data for such maps. In the study of the ancient life forms, conclusions of value are reached first, by determining the areal distribution of certain associations of species of land and water organisms, and second, by the discovery of their place of origin.

The second method of study, based on diastrophism depends upon the idea of essentially permanent depressions and elevations of the earth's surface. According to this view the surface of the continent can be divided into (1) positive areas that have been rarely if ever submerged, this being shown by the distribution of the sedimentary rocks around them; and (2) negative areas which often received deposits from waters of one or another of the oceanic basins whenever by subsidence they were brought below sea level. A paleogeographic map therefore is produced by plotting the isolated occurrences of a definitely identified fossil fauna and connecting them with the ocean of their origin by sea ways within the negative areas.

From the study of the criteria of paleogeography it becomes apparent that the Paleozoic epicontinental seas occupied mostly small, shallow, often disconnected, basins, communicating with the nearest oceanic basin. In general they must have been much like Hudson Bay, which may be regarded as a modern representative of an American interior continental sea. Many of these land basins were filled and emptied many times, occasionally receiving their water from the Atlantic and at other times from the Arctic, and ofttimes from the Gulf of Mexico. Naturally, with each change in the source of the waters, the geographic pattern differs considerably, and at times fundamentally, from the next preceding. In

[1] Bull. Geol. Soc. Amer., vol. xxii, 1911, No. 3, pp. 281-680, 5 pls. and Compte Rendu, XII session du Congrès géologique international, pp. 593-667.

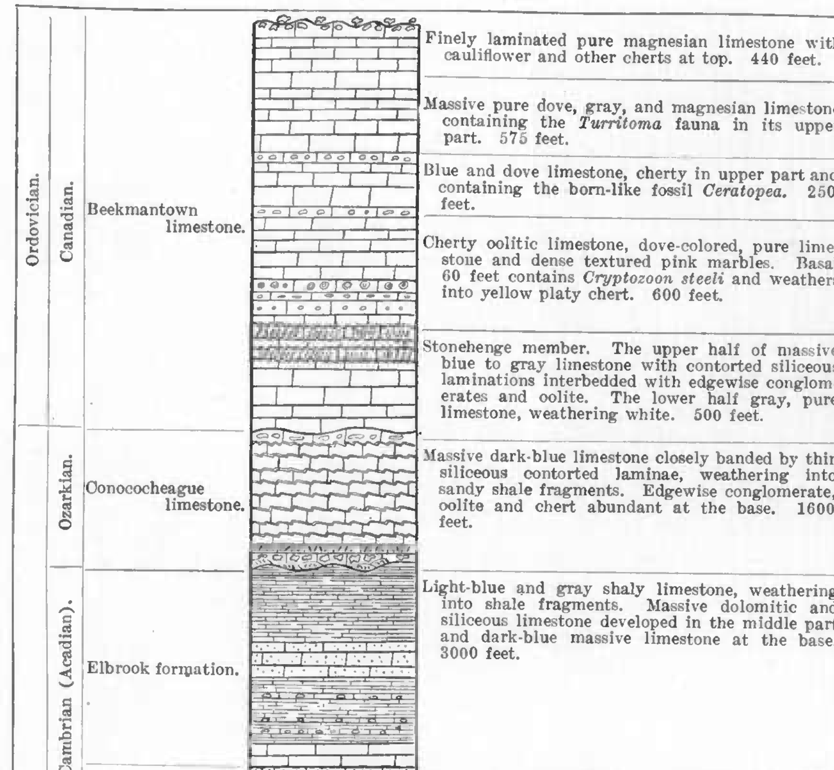

FIG. 1.—COLUMNAR SECTION OF THE CAMBRIAN, OZARKIAN AND CANADIAN STRATA OF MARYLAND AND NEIGHBORING STATES.

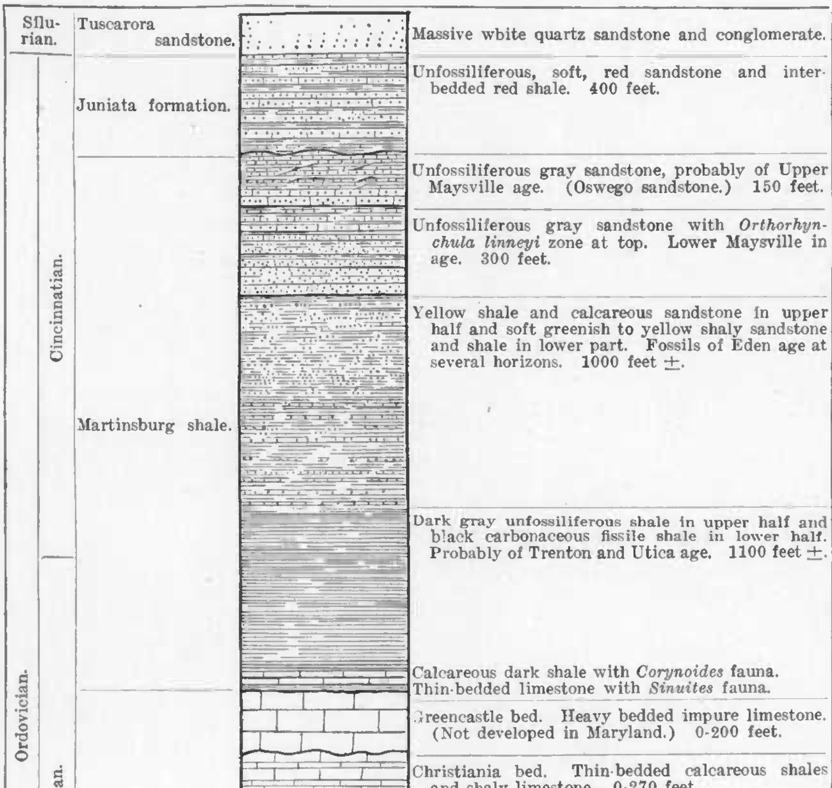

FIG. 2.—COLUMNAR SECTION OF THE ORDOVICIAN ROCKS OF MARYLAND AND NEIGHBORING STATES.

the Appalachian region the seas were often contained in narrow troughs which connected at some point with the Atlantic, although occasionally these troughs communicated at both ends with the ocean.

The complete changes in the source and direction of the faunal invasions are well shown in some of the maps of North America in Early Paleozoic time. For example the Gulf invasion of Lower Black River (Lowville) time is superseded by an incursion from the Arctic in the Middle Black River (Decorah) and this is followed by one which seems to have come in from the west.

STRATIGRAPHIC AND PALEONTOLOGIC CHARACTERISTICS

Throughout the Appalachian provinces the Early Paleozoic strata comprised in the Cambrian and Ordovician systems may be conveniently arranged into three great phases of sedimentation—the lowest of sandstone, quartzite, and sandy shales of Lower Cambrian age, next limestone deposits extending from uppermost Lower Cambrian to the lower part of Middle Ordovician times, and last a shale phase covering the remaining Middle and Upper Ordovician. In Appalachian Maryland each of these three phases is well developed, their combined thickness reaching 16,000 feet. Of this total, the lower division comprises over 3300 feet, the middle limestones over 10,000 feet, and the upper shales 2400 feet. These thicknesses vary in different parts of the Appalachians. As a rule they are greatly diminished to the north of Maryland and much increased in the states to the south. Columnar sections of the Cambrian and Ordovician rocks of Maryland and neighboring states are presented on pages 48 and 49, while a correlation table of these strata is given on page 51.

These three quite different lithologic divisions outcrop in equally distinct geographic areas. The siliceous rocks are confined to the Blue Ridge province, the limestones form the floor of the Appalachian Valley, and the shales, although sometimes occurring as a great infold or syncline in the limestone in the middle of the Valley, are best developed in the eastern ranges of the Allegheny ridges.

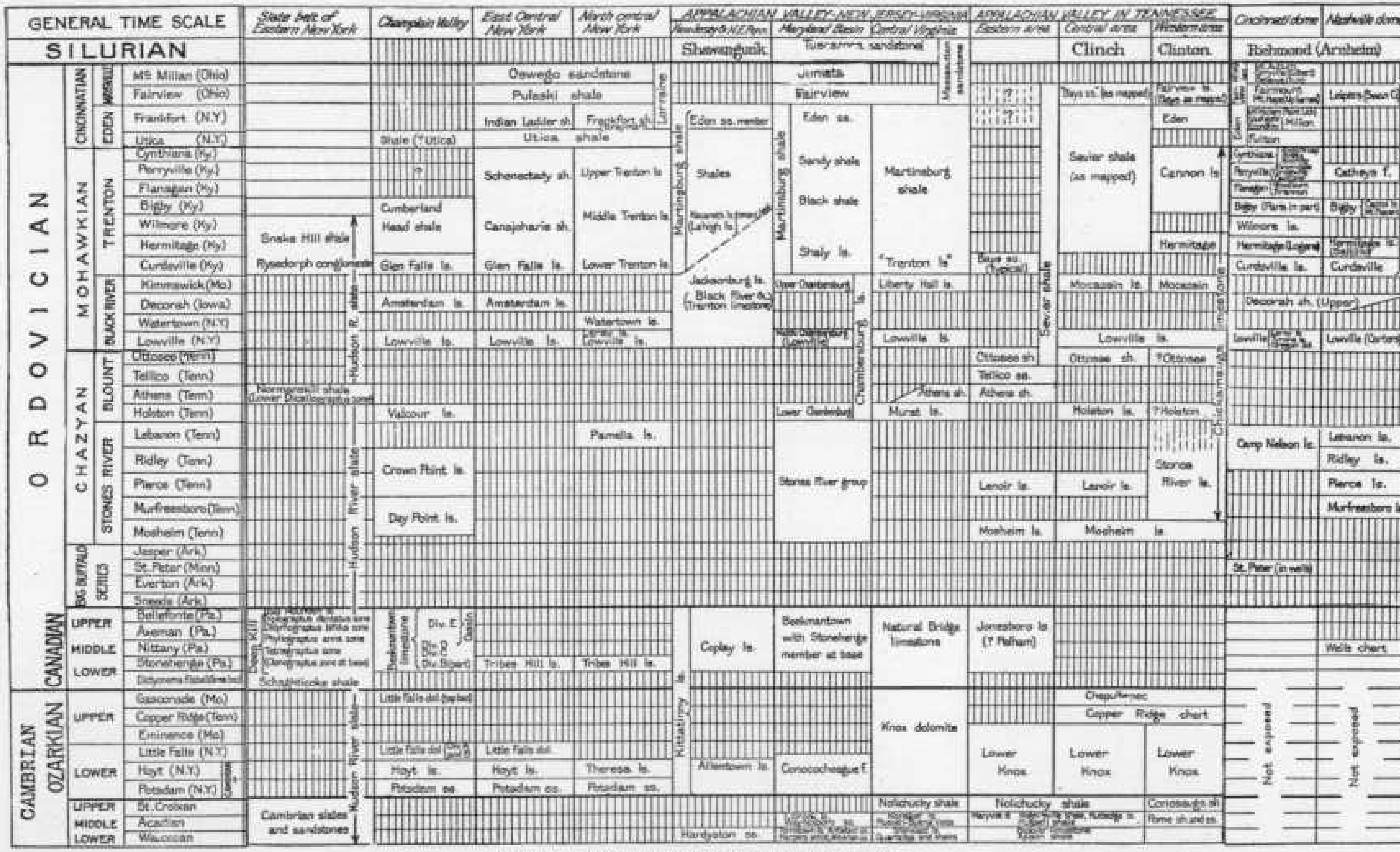

Fig. 3.—Cambrian-Ordovician Correlation Table.

East of the Blue Ridge province, sandstone metamorphosed into quartzites, limestone changed into marbles, and shales into slates or schists, outcrop in small patches at numerous points on the Piedmont Plateau. Although fossil evidence regarding the age of these latter strata is in most cases wanting, it is believed that they represent at least portions of the three phases of deposition farther west. Their correlation, however, cannot be confirmed until the geologic history of the Piedmont province has been studied in detail. The present volume is therefore devoted more to the discussion of the stratigraphy and paleontology of the Cambrian and Ordovician rocks of the Blue Ridge and more western provinces, although for the sake of completeness, brief notes on the Piedmont strata of apparently the same age are introduced in their appropriate places.

CAMBRIAN SILICEOUS FORMATIONS

Although the siliceous Lower Cambrian rocks outcrop in long but interrupted stretches from Vermont to Alabama, they differ so greatly in character and sequence from place to place that none of the formations, if any were ever so extended, are unquestionably recognizable throughout the whole Appalachian province. A few widely separated areas have been studied in detail, but, on account of difficulties in correlation, differing sets of local names had to be applied to the formations distinguished in each. The excellent exposure in the gorge of the Potomac River where it breaks through the Blue Ridge early attracted the attention of geologists to the Maryland-Virginia section. The sequence of formations here determined and named has been traced to the north across the state into Pennsylvania and proved satisfactory, and is generally accepted as the standard for the Lower Cambrian in the north middle Appalachian region. These formations and their thicknesses arranged in geologic order, are as follows:

Table of Maryland Lower Cambrian Siliceous Formations

	Feet
Antietam sandstone. Coarse grained white to bluish sandstone	800
Harpers shale. Bluish gray sandy slates and schist	1200
Weverton sandstone. Massive white and purple sandstone and quartzite	800
Loudon formation. Dark slates, sandstone, shales and marbles	500

VIEW OF THE POTOMAC WATER GAP AT HARPERS FERRY.

THE LOUDON FORMATION

The oldest sedimentary Paleozoic rocks in Maryland are argillaceous dark slates, sandy shales, blue limestones, white marble, gray sandstone, and quartz conglomerate, immediately overlying the crystalline rocks and known collectively as the Loudon formation, named from Loudon County, Virginia, where all the members are well displayed. Weathering of the unconformably underlying Catoctin schist gave rise to a great variety of sediments, which accounts for the diverse strata composing the succeeding formation. A fine grained, dark slate usually makes up the greater part of the Loudon formation, but almost all of the other varieties of sedimentary rocks, especially coarse and fine conglomerate, shale, and pure limestone are locally developed.

The formation outcrops in Maryland in depressions and valleys with lines of small hills and ridges. It gives rise to a thin, micaceous, sandy soil of little importance agriculturally. The rocks are exposed in long narrow belts along several lines of outcrop, namely, the east side of Elk Ridge, both sides of South Mountain and both sides of Catoctin Mountain. In the granite and schist area between Catoctin Mountain and South Mountain a few narrow synclines made up of the coarser deposits of the formation are also found. The finer and thinner strata of the formation occur only in the mountain areas mentioned above where the Weverton quartzite overlies the Loudon formation. The limestone occurs as lenses in the slate, and in Maryland has been found only along a line just west of Catoctin Mountain for a distance of a mile or two north of the Potomac River. This limestone is usually metamorphosed into marble, but the marbles are interbedded with slate and schist and are almost always too poorly developed to be worked for commercial purposes. However, almost every outcrop of this limestone has in the past afforded rock for lime.

The black slate makes up a large part of the Loudon formation in Maryland, especially along the Catoctin Mountain line of outcrop. Here the thickness is not over 200 feet, but along the Blue Ridge at Turner's Gap, 10 miles north of the Potomac River, a thickness of 500 feet has been measured. All trace of the original bedding in these slates has been lost by metamorphism during the folding of the rocks. The Loudon slate can be found at localities one mile east of Harper's Ferry and half a mile south of Rohrersville, Maryland, with coarse fragments of the Catoctin schist such as epidote and jasper imbedded in it.

The conglomerates of the Loudon formation, with few exceptions, are confined to the synclinal areas where the Weverton sandstone is not present. These conglomerates are limited in extent and are composed of quartz, granite, jasper, and epidote boulders imbedded in the usual black slate. Grains of magnetite and ilmenite washed from the Catoctin schist are present in many of the beds. Sandstones likewise occur, but these are thin and unimportant in Maryland, their greatest development being south of the Potomac River.

The Loudon formation as a whole has been subjected to much metamorphism and its various members exhibit the usual metamorphic products, namely, quartzite, slate, schist, and marble. The alteration is most marked in the argillaceous beds where all trace of their original stratification has been lost in the change to slate and schist. This slate and the few marble areas weather readily, forming low ground. The more siliceous rocks, metamorphosed into quartzite, resist weathering and as a result form the low hills or ridges of the Loudon areas.

No fossils have been discovered in the Loudon formation, the conditions of sedimentation being unfavorable for the preservation of organic remains. These rocks, however, apparently mark the beginning of the siliceous Lower Cambrian deposits, the age of which is determined by paleontological evidence in the overlying Harpers shale and Antietam sandstone.

THE WEVERTON SANDSTONE

The prominent outcrops in the gorge of the Potomac River at the south end of South Mountain near Weverton, Maryland, consist of massive beds of fine, pure, white and purple sandstone, quartzite, and conglomerate, overlying the basal Cambrian Loudon formation. These strata, termed the Weverton sandstone, are the most resistant of all the Cambrian and Ordovician deposits, and for that reason they are the main mountain-

Fig. 4.—Lower Cambrian (Waucoban).

Fig. 5.—Middle Cambrian (Acadian).

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making formation of the Blue Ridge province. Elk Ridge, South Mountain, and Catoctin Mountain are the principal elevations in Maryland due to the resistant Weverton sandstone and it is along their crests that the formation is exposed. Sugar Loaf Mountain is the easternmost elevation due to this formation.

This sandstone is composed almost entirely of siliceous fragments, mainly quartz and feldspar, firmly cemented together and often changed into quartzite. The color of the finer sandstone is white, and the coarser gray to purple. Streaks of bluish black and black sometimes occur in the white sandstone on South Mountain. Feldspathic material is present in greatest abundance at the northern end of Catoctin Mountain, but its occurrence does not change the general aspect of the formation. As a rule, however, the Weverton is usually composed of well-worn quartz grains washed clear of argillaceous material. Cross bedding is not an uncommon occurrence.

As the quartz particles forming the main mass of the Weverton sandstones do not admit of much alteration, this formation has been subjected to comparatively little metamorphism, even when it has been greatly folded. Slight schistosity has been noted in the southern part of Catoctin Mountain, but the development of quartzite is the usual occurrence.

The Weverton sandstone varies little in composition from place to place, but the thickness is subject to much variation. Along Elk Ridge its thickness is about 500 feet. At the type locality near Weverton, the thickness is also about 500 feet, but northward along South Mountain this increases to 800 feet. A similar increase in thickness is seen in the Catoctin Mountain area.

This formation is not only of no value agriculturally, but the debris from it lessens the value of neighboring areas. It decays very slowly into quartz sand and its heavy blocks cover the mountain sides and the contiguous lowlands. The mountain streams carry great quantities of boulders of Weverton sandstone out on the surrounding areas where they are deposited as a drift formation not unlike glacial deposits. South Mountain has furnished boulders of white quartzite and sandstone, which

FIG. 1.—VIEW OF THE GREAT VALLEY FROM SOUTH MOUNTAIN AT BLUE MOUNTAIN STATION.

FIG. 2.—VIEW ALONG ROAD BETWEEN PEN MAR AND HIGH ROCK, MARYLAND, SHOWING MOUNTAIN SIDE COVERED WITH BLOCKS OF WEVERTON QUARTZITE.

are now spread out in all the lowland areas of the Hagerstown Valley in a strip one to two miles wide paralleling the mountain.

Fossils have not been found in this sandstone, but as it is a part of the siliceous series terminated by the Antietam sandstone, which contains a Lower Cambrian fauna, the age of the Weverton sandstone also is very probably Lower Cambrian.

THE HARPERS SHALE

The bluish gray slate or schist exposed so prominently in the vicinity of Harper's Ferry, West Virginia, in the gorges of the Potomac and Shenandoah rivers and known as the Harpers shale, follows the Weverton sandstone in the geological column, although its outcrops are almost everywhere included between faults. In southern Maryland the Harpers shale is composed almost entirely of sandy slates with a few sandstone layers developed in its upper portion. These shales are of a dull bluish-gray color when freshly exposed, but they weather to a light greenish-gray. Northward in Maryland the sandstone layers increase in thickness until, in the region of Pen Mar, and especially at Montalto Mountain in southern Pennsylvania, a massive quartzite 750 feet in thickness is developed in the middle portion of the schist. This is the Montalto quartzite member mapped by Stose in the Chambersburg (Pennsylvania) quadrangle, but it is hardly of sufficient importance in Maryland to be distinguished as a separate unit. This Montalto member is only 20 feet thick just north of the Maryland line, but it thickens to 850 feet going northward a distance of 20 miles in Pennsylvania.

As no complete section of the Harpers shale is exposed in Maryland or even in its other areas of outcrop, its thickness is difficult to determine. Moreover one or often both sides of its areas of outcrop are cut off from adjoining formations by faults. At Harper's Ferry, the type area of outcrop, the thickness has been estimated by Keith as 1200 feet. In southern Pennsylvania northeast of Waynesboro the thickness is increased to 2750 feet, due in part to the development of the Montalto quartzite member.

The typical outcrop of the Harpers shale extends northward from Harper's Ferry into Maryland for several miles in a belt a mile or less in width, following the western slope of Elk Ridge until it is terminated by a fault against the Tomstown limestone, a mile south of Keedysville. A second belt of outcrop is one-half mile wide and follows the western slope of South Mountain across the state. The last and easternmost belt occurs on the eastern side of Catoctin Mountain.

The decay of the Harpers shale gives rise to soils of moderate value when its areas of outcrop are not too deeply covered with sandstone debris from the adjacent mountain sandstone ridges. As an example of the latter feature, the entire area of outcrop of this shale west of South Mountain in Maryland is covered with a thick deposit of such sandstone boulders. So far as known the only clean exposures of the shale itself are in cuts of the Western Maryland Railway in its ascent of South Mountain to Pen Mar, and in certain road and stream cuttings.

With the exception of casts of the worm burrow *Scolithus linearis* no fossils have been found in the Harpers shale. Its age, however, is undoubtedly Lower Cambrian because it forms a part of the same series of siliceous sediments as the overlying Antietam sandstone which contains typical Lower Cambrian fossils.

THE ANTIETAM SANDSTONE

The Harpers shale forming the western slope and foot hills of South Mountain is found to contain an infolded sandstone formation wherever a conspicuous elevation is developed in front of the main ridge. Such front ridges of South Mountain owe their origin to coarse grained white to bluish-gray quartzite and sandstone about 500 feet in thickness, which weathers readily to a white sand. This is the Antietam sandstone, so named from the good exposures on the tributaries of Antietam Creek east of Sharpsburg, Maryland. This sandstone is the uppermost of the mountain-making formations of the Blue Ridge province and is the last of the siliceous deposits of Lower Cambrian age. It is composed of small grains of white quartz, worn and assorted, cemented together by a small percentage of carbonate of lime. Its color is usually white, but some of the upper layers change to a dull brown. Actual outcrops of the rock are very rare, but its presence can be determined readily by the numerous lumps of white sandstone strewing the surface and by its topographic form. On account of their location and the abundance of rock fragments in the soil, its areas of outcrop are unsuitable for agriculture other than the growth of fruit trees.

The Antietam sandstone does not outcrop in a continuous belt like the associated formations, but is displayed in a number of small areas just west of the main elevation of South Mountain. Its occurrence coincides with that of the Harpers shale, and indeed Keith's detailed mapping has shown that this sandstone is found only as synclinal remnants lying upon the shale. The largest of these areas in Maryland are the ridge about four miles long just east of Pondsville and the V-shaped ridge east of Mapleville. The elevation just east of Boonsboro likewise is composed of Antietam sandstone, while a few small areas are infolded in the Harpers shale belt just north of Rohrersville. The western foot hills of Elk Ridge likewise contain a few small, scattered areas, while the larger elevation two miles east of Sharpsburg is composed almost entirely of this formation. The Harpers shale belt on the east side of Catoctin Mountain contains small, schistose, sandy beds lying above the Harpers shale which may be the metamorphosed equivalent of the Antietam sandstone.

Except a few worm burrows in the sandstone member of the Harpers shale, the Lower Cambrian deposits in Maryland are practically unfossiliferous beneath the upper part of the Antietam sandstone. Even here fossils are by no means common at any place. In Maryland the best locality for fossils is in the sandstones along the mountain front near Eakles Mills where fragments of *Olenellus thompsoni* Hall, *Hyolithes communis* Billings, and *Obolella minor* Walcott have been found by Walcott. These fossils are associated with the *Scolithus* tubes which are abundant in the upper part of the formation at practically all of its outcrops. This fauna, although small, is sufficient to determine the age of the Antietam sandstone as Lower Cambrian. The same association of species has been found on Observatory Hill, two miles south of Keedysville and at a locality about one mile southeast of Smithsburg.

CAMBRIAN-ORDOVICIAN LIMESTONES

The second great phase of deposition in the Appalachian region comprises a group of limestones which, from the fact that these strata form the floor of the great Valley, were first named the Valley limestone. In Virginia, the geographical term Shenandoah limestone was subsequently substituted for Valley limestone of the older geologists. In all the earlier maps of the central Appalachian Valley this limestone was regarded as a single formation and its thickness was supposed to approximate 5000 feet. This calcareous phase of deposition between the Cambrian siliceous rocks and the Ordovician shales is such a conspicuous feature throughout the Appalachian Valley that various local names have been applied to it. In Maryland the name Shenandoah formation was used for this limestone until comparatively recent years when geologic work in adjacent areas of Pennsylvania showed that these strata can be subdivided into seven distinct formations with an aggregate thickness of over 10,000 feet. The names, age, and thickness of these seven formations are as follows:

Table of Cambrian-Ordovician Limestones in Maryland

		Feet
Middle Ordovician, Chambersburg limestone		300
Lower Ordovician, Stones River limestone		1000
Lower Ordovician (Canadian)-Beekmantown limestone (Stonehenge member at base)		2500
Upper Cambrian (Ozarkian)-Conococheague limestone		1600
Middle Cambrian	Elbrook formation	3000
	Waynesboro formation	1000
Lower Cambrian-Tomstown limestone		1000

All of the above formations may be more or less readily recognized by lithologic peculiarities, by the contained fossils, by the topographic forms and residual debris which their weathering produces and by their known position in the stratigraphic sequence. Limestones of similar aspect may be found common to all the formations, but fortunately the boundary between adjoining divisions commonly is marked by one or more distinctive lithologic features which aid considerably in the delimitation of the formations.

THE TOMSTOWN LIMESTONE

The lowest division of the "Shenandoah" is a thick limestone formation which outcrops along the eastern edge of the Appalachian Valley just west of the Blue Ridge or the equivalent mountain range in a narrow strip often largely covered by sandstone debris from the adjacent mountain. These rocks are usually highly tilted and as a result the band of outcrop is often quite narrow. In Virginia this limestone received the designation, Sherwood limestone, and more recently the corresponding beds in southern Pennsylvania were termed the Tomstown limestone on account of their outcrop at Tomstown, Franklin County. In Maryland the area of outcrop of the Tomstown limestone is broader than usual because these strata are here not so sharply folded.

TOPOGRAPHY.—The Tomstown limestone is the most soluble of all the formations outcropping in the eastern part of the Appalachian Valley. Its outcrops therefore occur only in lowland areas. As the overlying formation, the Waynesboro, is composed in large part of sandstone and shale, it resists weathering and solution much more than the Tomstown limestone and forms hills in contrast to the limestone valley between them and South Mountain. Within this valley, however, there are long, narrow elevations trending northeast-southwest which owe their origin to synclinal infolding of remnants of Waynesboro sandstone. Some of the pronounced hills of this valley region, however, are underlain by limestone, but these elevations also have resulted from differential resistance to weathering, as they are formed in large part of black banded chert which is a characteristic component of the upper beds of the Tomstown. A good example of a Tomstown limestone valley is the lowland area in which Cavetown is located with a ridge of the Waynesboro formation to the west and the foothills of Harpers shale and South Mountain of Weverton sandstone on the east.

Exposures of this limestone are infrequent because its area of outcrop, lying as it does at the foot of South Mountain, commonly is covered by a thick deposit of mountain wash in addition to its own mantle of soil. This mountain wash is thickest and most widely spread where streams from the mountain enter the valley and form alluvial cones. In Maryland, however, as mentioned above, this Lower Cambrian limestone is often only moderately folded and this, in connection with other factors, causes its area of outcrop to be much wider than in neighboring states. Overturned folds and faults are not uncommon, but as a rule these are of relatively insignificant proportions so that the usual condition of gently dipping strata is soon resumed. Such a fold with slight faulting is well displayed along the Western Maryland Railway, one mile west of Cavetown.

LITHOLOGIC CHARACTERS.—In the type area, southern Pennsylvania, the Tomstown limestone is described as a formation composed largely of thin bedded and massive dolomite and limestone with considerable shale interbedded near the base. The rocks are not well exposed in Pennsylvania and it is possible that the marbles which are such a conspicuous feature of the formation in Maryland are present also in Pennsylvania. At any rate proceeding southward into Maryland the main mass of the formation consists of white to pinkish shaly marble which upon weathering gives rise to yellow and greenish shale-like fragments quite sericitic in nature. The Tomstown limestone is especially well exposed in a belt of outcrop three miles in width southeast of Hagerstown, where the usual drift deposits are not so thick and widely dispersed. In this area exposures, particularly of the middle and upper beds of the formation, are numerous.

The lowest beds of the Tomstown are not well exposed in Maryland, being nearly everywhere buried beneath the mountain wash. However, it is believed that the gray to dark blue massive, rather pure limestone exposed in the large quarry at Cavetown represents some portion of the lower Tomstown, since at this point the Tomstown is faulted against the Waynesboro and the characteristic marbles are not in evidence. The

FIG. 1.—EXPOSURE OF TOMSTOWN LIMESTONE ALONG TROLLEY LINE JUST SOUTHEAST OF WAGNERS CROSS ROAD, WASHINGTON COUNTY, MARYLAND, ILLUSTRATING WEATHERING OF MASSIVE SHEARED LIMESTONE INTO SHALE FRAGMENTS.

FIG. 2.—LIMESTONE QUARRY AT CAVETOWN, MARYLAND, SHOWING TOMSTOWN LIMESTONE FAULTED AGAINST WAYNESBORO SANDSTONE.

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uppermost beds of the formation, on the contrary, are very commonly exposed in Maryland because there are so many small areas of the overlying Waynesboro formation yet remaining in the valley to mark the top of the Tomstown. These upper strata, while still retaining pinkish to pearl-colored marble beds, also comprise massive dark blue magnesian limestones. Most of the limestones of the Tomstown, and especially the marbles, exhibit some lamination with the result that upon weathering the rock is easily split into thin slate-like fragments. This lamination is usually quite regular, but in southern Maryland there is a body of Tomstown limestone where the rock is so irregularly laminated that it weathers into a mottled effect. Shearing of this laminated limestone is frequent, especially in the marbles. Such strata give the characteristic fracture due to the combination of lamination and shearing.

The shape of the characteristic shale fragments resulting from the weathering of this limestone is due to this same combination of lamination and shearing, so that, while many of the pieces are broken, others are undulated or twisted. The shearing planes are marked on the residual shale-like fragments by thin films of silky, sericite-like material. Somewhat similar shale fragments result from the weathering of the Elbrook formation. When the Tomstown and Elbrook limestones are brought in contact by faulting-out of the intervening Waynesboro formation, careful discrimination is necessary to identify the formations correctly. In doubtful cases it is necessary to search for an outcrop of the rock furnishing the shale residue. When this has been found it should be easy to distinguish the sheared marbles of the Tomstown from the dull laminated clayey limestone of the Elbrook.

RESIDUAL PRODUCTS.—One of the characteristic residual products of the Tomstown is black banded chert in small blocky pieces left in the soil upon the weathering of the upper beds of the formation. This chert is almost chalcedonic in nature and the black bands passing through it give it somewhat the aspect of agate. Chert of this particular nature is not found again until the middle division of the Stones River limestone, and as there is little danger of confusing these two widely separated formations which are also quite distinct lithologically, the banded chalcedonic chert of the Tomstown can be relied upon as a distinguishing feature as much as a characteristic fossil. The usual fragment of this chert is a block four or five inches long, several inches wide and an inch or two thick. The upper and lower surfaces are uneven and coarsely pitted, but the interior is of dense black and lighter colored silica almost waxy enough to be called chalcedony. This chert in the soil is largely responsible for the maintenance of those hills in the Tomstown limestone valley which are not capped by the Waynesboro formation. The hills southwest of Pondsville are due to the chert of the upper Tomstown.

A second residual product of the Tomstown limestone is the yellow to greenish shale fragments resulting from the weathering of the marbles of the formation. As the black chert occurs only in the upper part of the Tomstown and the shaly marbles occur throughout its thickness, these shale fragments are more widely dispersed than the chert and therefore may be said to be more characteristic of the formation as a whole. The decay of the shaly marbles into yellow and greenish shales is well displayed in the cut of the Hagerstown-Frederick trolley road just east of Wagner's Cross Roads. At the bottom of the cut the rocks are massive limestones, although much sheared. Near the top, solution has removed much of the lime and the strata are easily broken into shaly blocks. At the surface itself the separation into shale fragments is complete, each fragment being covered with a soapstone-like film, in many cases not unlike sericite.

ECONOMIC FEATURES.—The decomposition of the Tomstown limestone results in a firm, compact soil, but over most of the area this soil has been lightened and made more porous by admixture with the sand and gravel from the nearby mountains. This is particularly true on the lower slopes of South Mountain where the orchards of the famous South Mountain peach belt are to a great extent located on such well-drained soil.

In the past, kilns for the burning of agricultural lime were numerous in the Tomstown area, but this practice has now been discontinued. At present the only quarry of consequence where the Tomstown limestone is

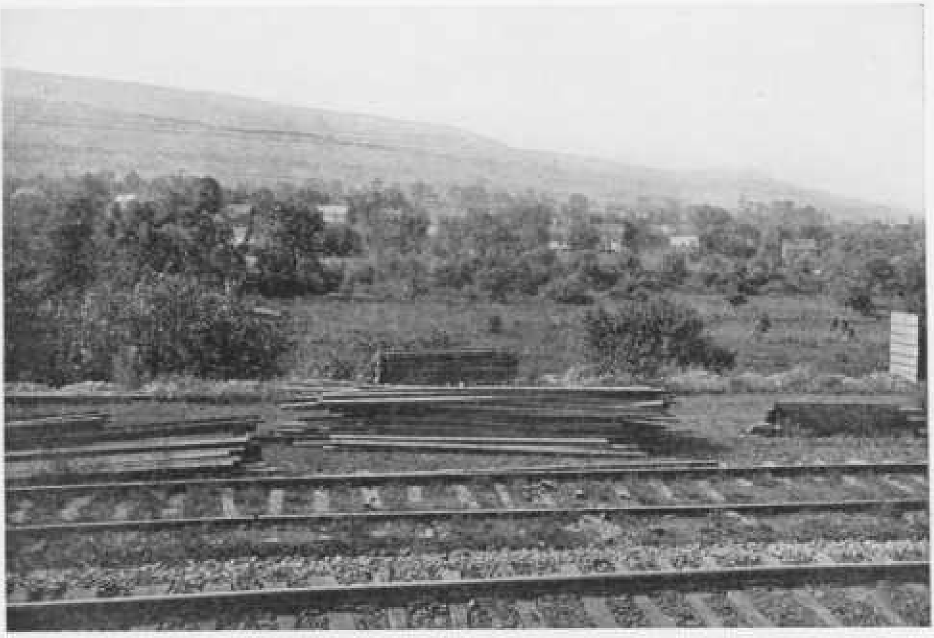

FIG. 1.—VALLEY OF TOMSTOWN LIMESTONE LOOKING EAST FROM CAVETOWN, MARYLAND, SHOWING FOOTHILLS OF HARPERS SHALE, AND SOUTH MOUNTAIN OF WEVERTON SANDSTONE IN THE DISTANCE.

FIG. 2.—VALLEY OF TOMSTOWN LIMESTONE WITH SOUTH MOUNTAIN IN THE DISTANCE SHOWING PENEPLAINED SURFACE. THE HILL JUST BEYOND THE HOUSE IS CAPPED BY TOMSTOWN CHERT. PHOTOGRAPH TAKEN ONE MILE SOUTH OF CAVETOWN, MARYLAND.

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utilized for lime and ballast is at Cavetown, where good location and transportation facilities are at hand.

The marbles of the Tomstown were formerly quarried to a considerable extent, especially in the southern part of the area, but at present the only development is near Eakles Mills. White marbles which occur at several horizons in the formation, have been most frequently quarried. With these is a bed of a cream-white color with a very fine texture, but the associated beds are impure and have the more usual grayish banded appearance. The pinkish shaly marbles likewise include some pure white beds which might be profitably quarried if transportation facilities were available. An abandoned quarry, situated on the bank of Beaver Creek, one mile northeast of Harmony Hill school, gives a good exposure of these light colored marbles.

AREAL DISTRIBUTION.—The outcrops of the Tomstown limestone are confined to the eastern part of the Hagerstown Valley just west of the Blue Ridge in a belt of low land at the foot of South Mountain about two miles wide in the northernmost portion, increasing to a width of three miles or more southward. Along the entire eastern border of the formation the Harpers shale is faulted against this limestone with the intervening formation, the Antietam sandstone, either wanting or outcropping some little distance east of the Tomstown as an infold in the shale. The western border of the Tomstown limestone in northern Maryland as far south as the Western Maryland Railway is the normally overlying Waynesboro formation. South of this, the Tomstown is faulted first against the Elbrook formation, then against the Conococheague limestone as at Chewsville, then against the Elbrook again for some miles, and finally at Benevola on the National pike, the succession becomes normal again. A fault passing north and south just east of Boonsboro parallels South Mountain and along its western side several small areas of Waynesboro are exposed. West of this fault in the middle of the Tomstown valley the line of hills starting a mile north of Smithsburg and ending near Beaver Creek are formed by an infolded area of the Waynesboro formation. With these exceptions and several small areas where the

Waynesboro formation is nothing but a surface remnant, all the valley east of the line first mentioned is composed of the Tomstown limestone.

THICKNESS.—In spite of numerous good exposures, no continuous sections of any thickness of the Tomstown limestone are exposed in Maryland, and indeed no place has been found where the normal sequence can be determined. In southern Pennsylvania an approximate thickness of 1000 feet has been measured. This has been accepted as the thickness in Maryland, although in the southern half of the state where the marbles are well developed a greater thickness is possible.

AGE AND CORRELATION.—No fossils have so far been noted in the Tomstown limestone in Maryland and indeed the sheared marbles and dolomitic strata of the formation are not favorable for the occurrence of organic remains. In southern Pennsylvania near Roadside and near Waynesboro, fragments of the mollusk shell *Salterella* have been collected. A few miles north of this at the foot of the mountain east of Little Antietam Creek fragments of the characteristic Lower Cambrian trilobite *Olenellus* were discovered by Walcott. A Lower Cambrian age for the formation is therefore accepted, although the paleontological evidence is still quite meager. Fossil evidence in the rocks holding the same stratigraphic position in states to the south is also very slight, but favors the same age. The most interesting of these fossils is a large species of *Archeocyathus* recently found in the Sherwood limestone and a similar large species of the same genus in the Shady limestone.

In contrast with the few fossils of the areas just mentioned is the abundant, well-preserved Lower Cambrian fauna found in limestones and shales in the vicinity of York and Fruitville, Pennsylvania. It seems probable that these fossiliferous strata form a part of the Tomstown limestone, but the lithology is so different that a close study of the intervening area is necessary before this correlation can be made with certainty.

THE WAYNESBORO FORMATION

Viewed as a lithologic unit the most obvious and easily recognized formation in the Shenandoah limestone series is the mass of reddish to purple calcareous sandstone and shale here known as the Waynesboro

FIG. 1.—OVERTURNED FOLD WITH SLIGHT FAULTING IN TOMSTOWN LIMESTONE ALONG WESTERN MARYLAND RAILWAY, ONE MILE WEST OF CAVETOWN, MARYLAND.

FIG. 2.—RIDGE OF THE WAYNESBORO FORMATION JUST EAST OF MIDDLE BRIDGE, ANTIETAM BATTLEFIELD, WASHINGTON COUNTY, MARYLAND.

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formation. These striking beds form more or less conspicuous ranges of hills in the lowland area just west of the Blue Ridge and corresponding mountain ranges to the north and south of Maryland. Weathering of these red to purple strata results in similarly colored soils which therefore contrast strongly with the grayish-brown and black soils of adjacent limestone areas.

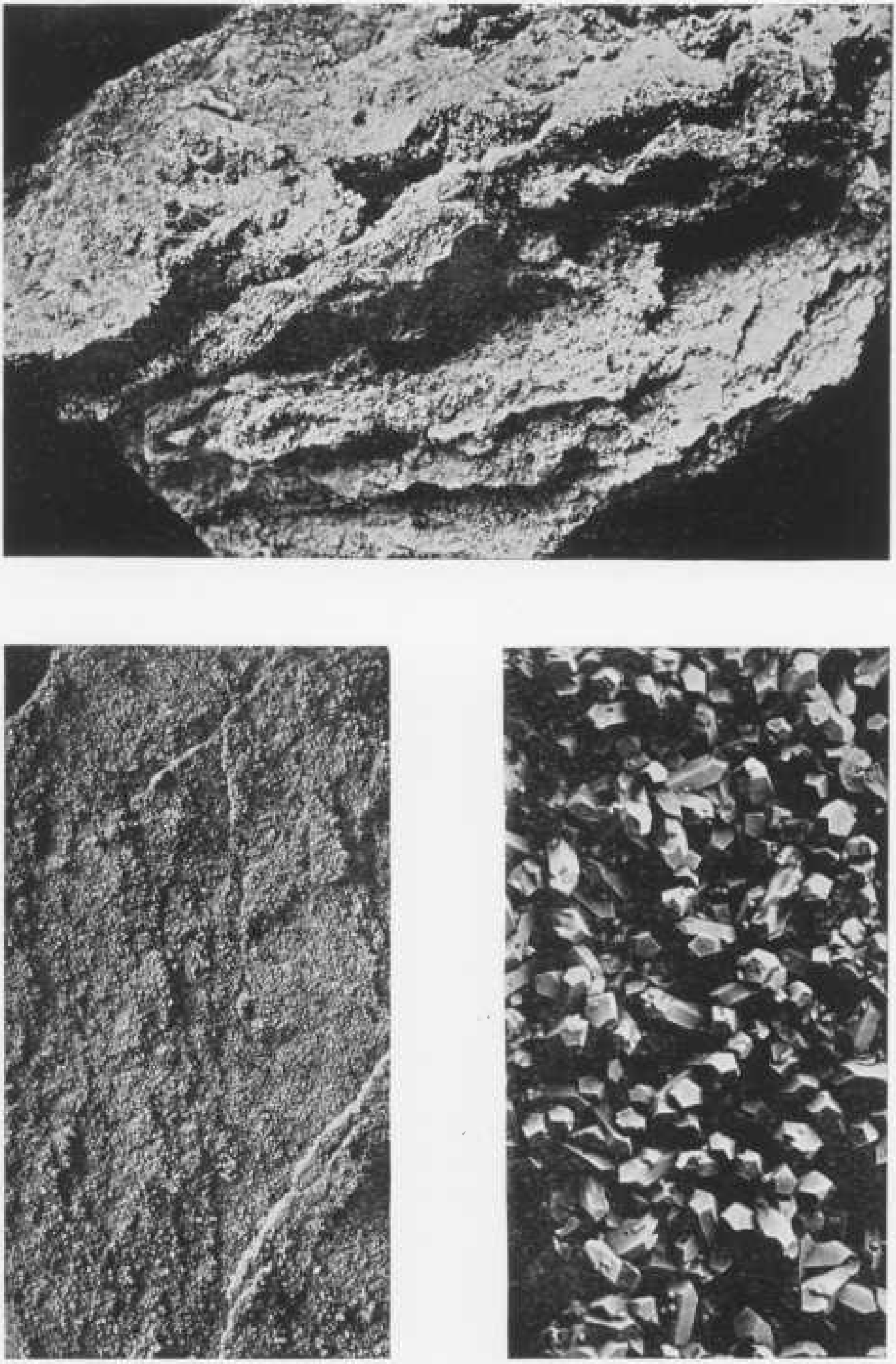
NAME AND SYNONYMY.—In publications upon the central and northern part of the Appalachian Valley the red zone mentioned above was frequently noted, especially in folios of the United States Geological Survey, but it was not separated as a distinct formation until 1905[1] when H. D. Campbell proposed the name Buena Vista shale for corresponding red beds in central western Virginia. Later Stose[2] discriminated similar sandstones and shales in southern Pennsylvania as the Waynesboro formation, the typical development of which extends southwestward from Waynesboro, Pennsylvania, into Maryland, where its outcrops form the "peach lands" in the valley west of the Blue Ridge slope. The formation here being the same in general character and sequence of beds as in Pennsylvania it is manifestly desirable to use the same name for it in both states. It is not yet finally decided whether this name should be the one proposed by Stose or some other. Regarding the term, Buena Vista, it cannot be used in this connection because the same name had been given many years before to rocks in Ohio. Among several probably synonymous terms that have been considered, the name Wautaga shale, proposed in 1903 by Keith,[3] for series of red and green shales in east Tennessee, occupying apparently the same stratigraphic position as the Maryland formation under consideration, is perhaps the most appropriate designation. According to Keith the Wautaga shale has been traced far enough northward to warrant the application of this name in west central Virginia in place of the preoccupied term Buena Vista; and there may be sufficient reason for its extension to Maryland and southern Pennsylvania. However, the lithologic development of this northern facies of the Appalachian

[1] Amer. Jour. Sci., vol. xx, 1905, pp. 445-447.
[2] Folio 170, U. S. Geol. Surv., 1910.
[3] Cranberry folio, No. 90, U. S. Geological Survey, 1903.

Middle Cambrian red beds for which the term Waynesboro was proposed, is different from the Wautaga facies to the south in that considerable thicknesses of sandstone and limestone are intercalated with the characteristic red and purple shales. Moreover, there are two other names whose claims must be considered before this nomenclatural question can be finally settled. These names are the Rome sandstone and shale and Russell shale, both in good standing and of prior dates than Wautaga shale. Provisionally, therefore, it is thought advisable to retain the name Waynesboro formation for these strata in Maryland and Pennsylvania.

LITHOLOGIC CHARACTER AND THICKNESS.—In Maryland as well as in the type area of outcrop, the Waynesboro formation consists of a lower member of very siliceous gray limestone and calcareous sandstone, a middle member of limestone, and an upper one of red and purple siliceous shale, aggregating 1000 feet in thickness. Of the three members, the upper is the best developed and most frequently exposed, since faulting often cuts out the middle limestone and lower sandstone divisions. The weathering of this upper part is mainly responsible for the characteristic red color of the soils derived from the formation. The basal siliceous limestones weather into shaly, porous sandstone with which are associated numerous blocks of secondary white vein quartz and rounded corrugated sandy fragments full of crevices lined with small quartz crystals. The limestones of the middle division range from dark blue massive limestone to fine grained white marble which, on account of their soluble nature, are generally not exposed. In Pennsylvania this middle portion is several hundred feet thick, but in Maryland the thickness is probably not as great. These limestones become siliceous toward the top of the member and finally seem to grade into the dark red to purple sandy shale which makes the upper part of the formation. Certain parts of the upper member contain argillaceous flaggy sandstone which has been locally quarried for paving stones. On weathered surfaces the flags break up into fragments of sandy shale.

Such slabs frequently exhibit ripple marks and mud cracks, the latter being well displayed in some of the paving stones of Smithsburg. One



IRON-STAINED CONTORTED SANDSTONE OF WAYNESBORO FORMATION. THE UPPER FIGURE REPRESENTS THE USUAL ASPECT OF THE ROCK. THE CAVITIES IN THE SANDSTONE ARE COVERED BY DRUSY QUARTZ AS SHOWN IN THE FIGURE TO THE LEFT ($\times$ 2) OR BY BEAUTIFUL MINUTE CRYSTALS OF QUARTZ ILLUSTRATED IN FIGURE TO RIGHT ($\times$ 6).

of these showed the interesting occurrence of two sets of intersecting mud cracks, one set about a foot apart and the other about four inches.

Topographic Form.—Faulting is so frequent along the eastern edge of the Waynesboro outcrops in Maryland that the normal sequence of strata is seldom apparent. Siliceous strata always form a part of the Waynesboro wherever developed, so that its topographic form is always an elevated area. If the strata have been strongly folded this highland area assumes the form of elongated hills paralleling South Mountain. Should the normal sequence of the three divisions of the Waynesboro occur, the basal siliceous strata will give rise to a range of low hills nearest the mountain and the upper sandy shales will occasion another range to the west, the narrow depression between them being underlain by the less resistant limestones of the middle portion.

Tomstown-Waynesboro Boundary.—The base of the Waynesboro formation is formed of a very siliceous gray limestone which weathers to slabby, porous sandstone. Except in very fresh exposures the limestone nature of this part of the formation is not apparent and it seems to be made up of sandstone entirely. Sandstone slabs are very abundant on the weathered slopes and associated with them are large masses of contorted, minutely laminated, iron stained, sandy rocks, with numerous cavities filled with beautiful drusy quartz. These masses are sometimes several feet in diameter and their presence in the fields and especially in the fences identifies this basal portion of the Waynesboro. Wherever in Maryland the Waynesboro sequence is normal such iron stained, drusy quartz masses are found in abundance. Associated with this sandy rock and also in the higher strata of the lower portion of the Waynesboro are numerous fragments of secondary white vein quartz which in connection with the other siliceous rock helps in identifying the basal beds. Plate VII represents a small fragment of the contorted sandy masses in which all the crevices are filled with minute quartz crystals. An enlarged view of a drusy quartz portion of one of these masses is shown on the same plate. The crystals, though perfectly formed, are so small as to be indistinguishable without a magnifying lens. To the unaided eye the surface of this drusy quartz has a beautiful velvety appearance, the beauty of which is enhanced by the lemon-yellow to brownish-olive color with just enough reflection from the minute crystals to add a silvery sheen to the surface. Other specimens of the same rock show these crystals increased to a length of about 2 mm. and a magnified view exhibits their perfection of form. These crystals are interesting in that practically all of those observed are terminated by a single rhombohedron instead of the two usually found in quartz.

AREAL DISTRIBUTION.—The geologic structure of the various occurrences of the Waynesboro formation in Maryland varies considerably. The normal section from upper Tomstown through the Waynesboro into the overlying Elbrook is present only in the strip of outcrops extending from Benevola southwest to Burnside Bridge east of Sharpsburg, and even here both ends of the strip are faulted. The ridge east of the Upper Bridge and Middle Bridge of the Antietam battle-field exposes the different divisions of the formation to best advantage for study. Here only does the limestone middle portion form its characteristic topographic feature of a valley between the two ridges left by the lower and upper siliceous parts. Northeast of Benevola is a number of small outcrops which in most cases are little more than surface remnants. The same holds true of several lines of outcrop east of Chewsville where the rocks are of such little depth that the underlying limestone is occasionally plowed up in the fields. A shallow syncline commences one and a half miles north of Smithsburg and terminates seven miles to the southwest near Beaver Creek, one mile northeast of Wagner's Cross Roads, in another normal syncline. These two syncline terminal areas are connected by a narrow strip of the formation in which the greater part of its thickness is covered by overthrust faulting. Thus in the limestone quarry at Cavetown the lower part of the Tomstown limestone is faulted against the purple shales of the Waynesboro. An interesting anticline of Waynesboro sandstone exposing the upper Tomstown with its characteristic black banded chalcedonic chert in its axial part, enters the state from Pennsylvania and is terminated by faulting at Ringgold.

On the western edge of the Valley the Waynesboro outcrops in a narrow strip along the eastern base of Fairview and Powell mountains, where it is brought to the surface by faulting. Few outcrops can be found in this area, however, since the country is so thoroughly covered with drift material from the nearby mountains.

ECONOMIC FEATURES.—Compared with the neighboring limestone areas the soils derived from the weathering of the Waynesboro formation are comparatively poor and the fields are frequently covered with small sandstone or sandy purple shale slabs and milky quartz fragments. Freshly plowed fields, especially when wet, have a distinct purple to red color. As the formation always outcrops topographically above the adjoining areas, and as the soil is quite porous, Waynesboro areas have both good water and air drainage. This causes such areas to be of especial value for fruit culture, and as a result most of the Waynesboro hills have been cleared and planted in orchards, peaches being the fruit most commonly raised.

From a commercial standpoint the Waynesboro formation is of little importance. When there was a strong local demand for iron years ago, it afforded small quantities of residual iron ore. The limestones in the middle portion have in the past been employed very locally for lime burning. The thin-bedded sandstones make excellent flagging stones which are used in the villages close to the areas of outcrop. Mention of the suncracked flagstones in the pavements of Smithsburg has been made in a preceding paragraph.

AGE AND CORRELATION.—No fossils have been observed in the Waynesboro formation in Maryland, but at the type locality just north of the Maryland line a few poorly preserved phosphatic brachiopods of the genus *Lingulella* have been noted. These suggest a Middle Cambrian age. The Buena Vista shale of Virginia has yielded an *Olenellus*-like trilobite which would suggest a Lower Cambrian age for this shale, although in recent years the range of *Olenellus* has been extended into the Middle Cambrian. The age of the Waynesboro is therefore not clearly indicated by paleontologic evidence, but stratigraphic and diastrophic data place it as Middle Cambrian.

THE ELBROOK FORMATION

Overlying the purple shales of the Waynesboro formation in the normal section is a thick series of light-blue and gray shaly limestone and calcareous shales which, in Maryland, are seldom exposed in natural outcrops. These strata were not recognized as a distinct formation until 1910, when Stose[1] named them the Elbrook formation from the village on the Western Maryland Railway in southern Pennsylvania.

LITHOLOGIC CHARACTER AND THICKNESS.—The shaly limestone and calcareous shale making up the major portion of the Elbrook formation weathers very rapidly into shale fragments, so that usually there are few natural outcrops. In stream valleys and artificial exposures the following general succession has been determined. At the very base of the formation are beds of rather pure dark blue massive limestones not over 100 feet thick which have afforded the only fossils found. Succeeding this and constituting approximately the lower third of the formation is 1000 or more feet of minutely laminated shaly limestone and calcareous yellow to green and some reddish shale which weathers into calcareous shaly plates. The middle of the formation is marked by siliceous limestones and massive beds of dolomite which form a slight elevation in the generally low area of outcrop of the formation. The upper half of the formation is composed of light colored calcareous shale and impure laminated limestones which, like the lower part, weather shaly. However, it is slightly more siliceous than the lower third and weathers into more irregular often cubical sandy red to brownish fragments. It is followed by the limestone conglomerates and sandy oölite marking the base of the succeeding Conococheague limestone. The total thickness of the Elbrook as determined in both northern and southern Maryland is about 3000 feet.

AREAL DISTRIBUTION.—Notwithstanding its great thickness the Elbrook formation occupies less area in Maryland than almost any other of the Cambrian or Ordovician formations. It appears at the surface in a narrow northeast-southwest band crossing the state in the eastern part

[1] Folio 170, U. S. Geol. Surv.

FIG. 1.—EXPOSURE OF ELBROOK LIMESTONE ALONG BALTIMORE AND OHIO RAILROAD JUST SOUTH OF SHARMAN, MARYLAND. THESE MASSIVE BEDS WEATHER INTO THIN SHALY LAYERS.

FIG. 2.—VIEW LOOKING NORTH OVER ANTIETAM BATTLEFIELD SHOWING EXPOSURE OF ELBROOK LIMESTONE. PHOTOGRAPH TAKEN ONE-HALF MILE EAST OF SHARPSBURG, ALONG ROAD TO BURNSIDE BRIDGE, MARYLAND.

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of the Hagerstown Valley and in a still narrower band along the extreme western edge of the Great Valley. The eastern area of outcrop enters the state from Pennsylvania just north of Ringgold and proceeding southward in a strip less than a mile in width is terminated by a fault near Chewsville. South of Chewsville the throw of this fault becomes less, so that the Elbrook formation reappears at the surface and continues southward in a band averaging a mile in width paralleling the hills of the Waynesboro formation on the east. At Sharpsburg beyond the extremity of an infolded mass of the overlying limestone, the Elbrook is partly repeated in the two limbs of the syncline and the outcrop correspondingly widened.

The western band of outcrop doubtless parallels North Mountain, but is known only from a few exposures, as almost its entire area is covered by mountain wash. The beds dip steeply in these exposures, so that the outcrop of the formation must be confined to a strip scarcely exceeding a half mile in width.

Topographic Form and Residual Products.—Where the geologic section is normally developed, two ranges of pronounced hills—those of the siliceous Waynesboro on the east, those of the siliceous limestones of the Conococheague on the west—flank a lowland in which the less resistant limestones and shales of the Elbrook are at the surface. However, this lowland band is not a simple valley, but is divided longitudinally into two narrow valleys by a series of low hills due to the relatively resistant beds of siliceous limestone and dolomite that occur in the middle part of the Elbrook.

The topographic form of the Elbrook is not unlike that of the Tomstown and the shale fragments left in the soil from both formations are quite similar. In areas where the intervening Waynesboro formation is cut out by faulting, such as the area about five miles southeast of Hagerstown, great care must be exercised in discriminating the two formations. Determined search in areas of Tomstown limestone will sooner or later reveal outcrops of the characteristic sheared marble which on weathering leave the shale-like residual fragments. On the other hand, in an Elbrook area the simulating residual shale will be traced to merely dull laminated limestone or calcareous shale.

A characteristic weathering product of the lower half of the Elbrook is light colored, sometimes almost white, waxy translucent chert approaching chalcedony in appearance and structure. This appears in the soil in small fragments, usually only a few inches thick with more or less rounded edges. The color of this chert is sometimes a light yellow or even light red, but it is never black nor banded like the Tomstown chalcedonic chert.

AGE AND CORRELATION.—Fossils have been found only in the basal limestones of the formation in the vicinity of Waynesboro, Pennsylvania. These consist mainly of well-preserved heads and tails of two species of trilobites, one of which, a species of *Dolichometopus,* is not uncommon. These trilobites belong to new species whose age relations have not been definitely determined. However, as they are closely allied to species known to be characteristic Middle Cambrian fossils it seems highly probable that the Elbrook is of similar age.

THE CONOCOCHEAGUE LIMESTONE

On the northwest, north and east flanks of the Adirondack uplift the Potsdam sandstone grades upward through passage beds into a limestone to which Ulrich and Cushing have applied the name Hoyt limestone. This is succeeded by a massive dolomite known as the Little Falls dolomite. Fossils have been found in all three of these formations, but are reasonably plentiful only in the Hoyt limestone. The fauna of this limestone was first procured and in part briefly described by Walcott many years ago. Recently the same authority revised and completed his studies of the Hoyt and Potsdam faunas, the results being published in a small monograph. As now known these early New York "Saratogan" faunules comprise, besides a number of trilobites and shells of various kinds, large concentrically laminated masses in reef-like aggregations. These masses are thought to be calcareous algae. Two species are distinguished, one having been described by Hall under the name *Cryptozoon proliferum;* the other is a related new species. These two species have

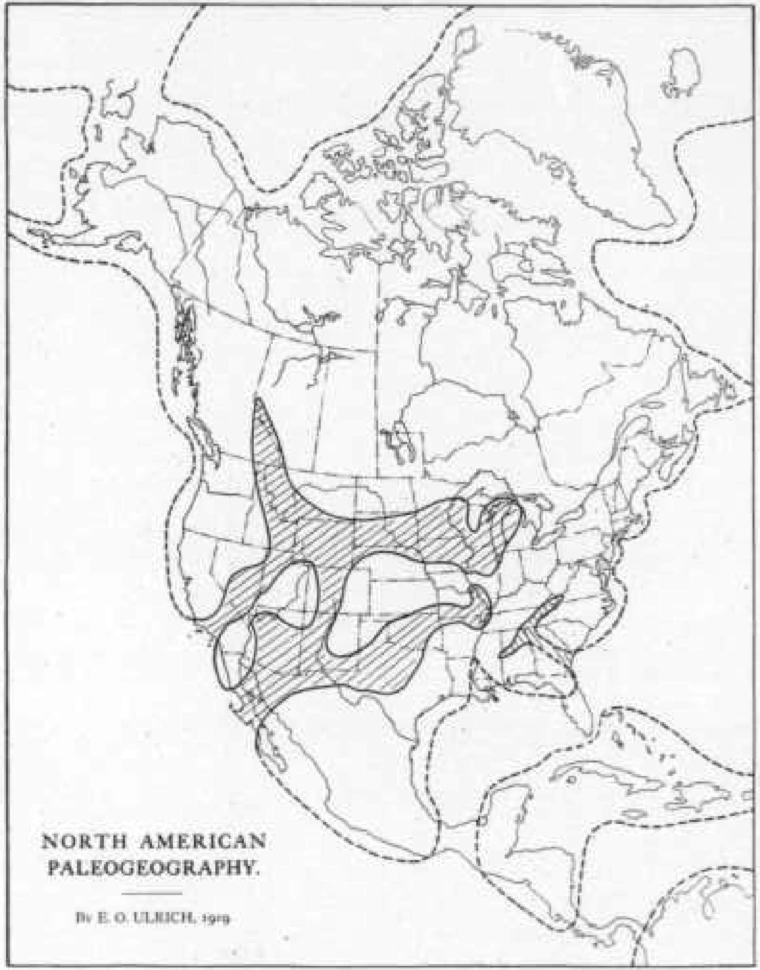

FIG. 6.—UPPER CAMBRIAN (ST. CROIXAN).

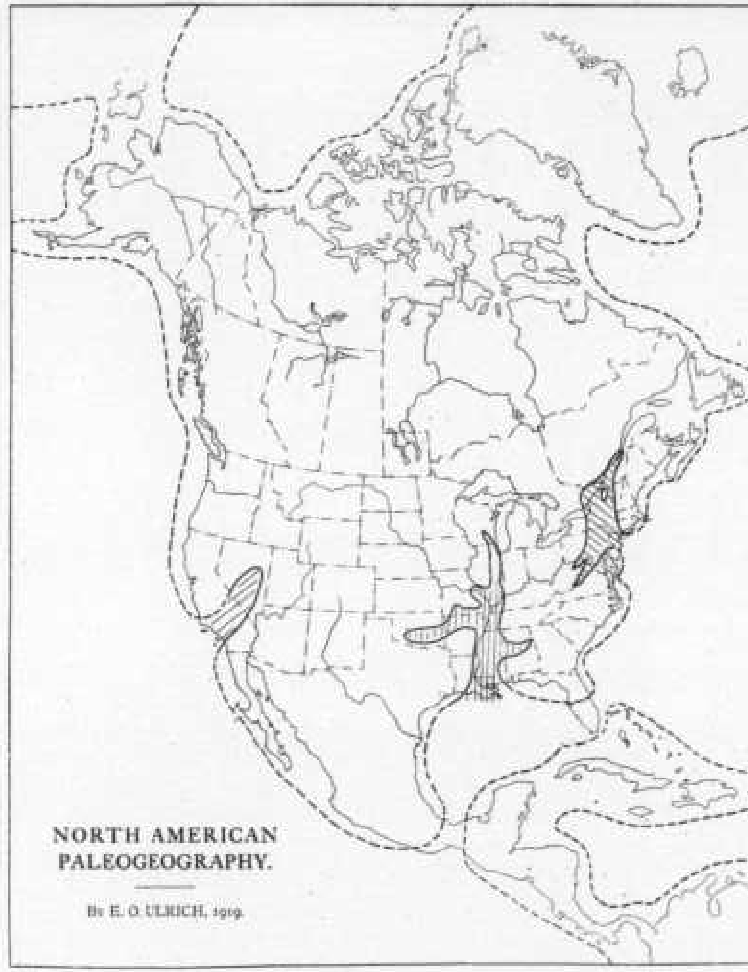

FIG. 7.—EARLY OZARKIAN (CONOCOCHEAGUE)

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an important bearing on the age determination of certain formations in the Appalachian Valley. Apparently the same species occur abundantly in the basal part of the Kittatinny limestone in the Lehigh Valley of Pennsylvania and nearby areas in New Jersey where they are associated with trilobites of the same general types as those found near Saratoga, New York.

In the Cumberland Valley of southern Pennsylvania these same species of *Cryptozoon* are found in the basal part of a thick series of siliceous banded limestone that lies between the Middle Cambrian Elbrook limestone and another great mass of relatively pure limestone that corresponds to the well-known Beekmantown limestone of the New York section. This intervening formation which is about to be described was distinguished and mapped by Stose in the Mercersburg-Chambersburg (Pennsylvania) folio of the U. S. Geological Survey as the Conococheague limestone, so called from the good exposures along the banks of Conococheague Creek near Scotland, Pennsylvania. From this place the formation extends in typical development to the Great Valley of Western Maryland, where its outcrops cover a considerable area.

LITHOLOGIC CHARACTERS.—The main body of the Conococheague limestone is composed essentially of massive dark-blue, closely banded limestones. The banding is usually one-half to one inch in width and is caused by the alternation of thin, wavy, sandy laminae with thin layers of purer rock. The sandy laminae are inconspicuous in the freshly fractured rock, although close examination reveals the alternation of the dark blue purer and gray siliceous limestone bands quite clearly. Upon weathering, the siliceous laminae appear as yellowish sandy streaks separating light-blue or gray bands of limestone. Further weathering causes the siliceous laminae to stand out in relief as more or less parallel ribs. Finally, where the rock has suffered complete disintegration, these laminae are left in the soil as hard, siliceous thin plates. Strata of this nature can be found in almost any outcrop of the formation, but interbedded with them are various other types of limestone. Of these, the most striking are the beds of "edgewise" conglomerate which alternate frequently with the usual banded limestone. This conglomerate is

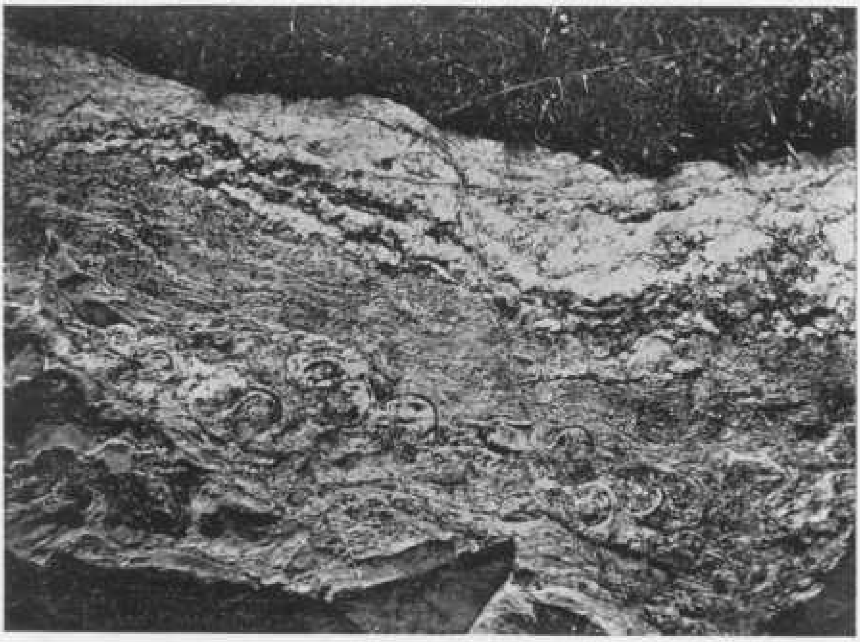

FIG. 1.—CRYPTOZOON REEF AT BASE OF CONOCOCHEAGUE FORMATION, EXPOSED ALONG NORFOLK AND WESTERN RAILROAD ABOUT ONE MILE SOUTHWEST OF ANTIETAM STATION, MARYLAND. PHOTOGRAPH ABOUT ONE-FIFTEENTH NATURAL SIZE.

FIG. 2.—CRYPTOZOON STRUCTURE IN UPPER PART OF CONOCOCHEAGUE LIMESTONE EXPOSED ALONG WESTERN MARYLAND RAILWAY, ONE-FOURTH MILE WEST OF CHARLTON, MARYLAND. PHOTOGRAPH ONE-SIXTH NATURAL SIZE. THE OÖLITES HAVE BEEN OUTLINED IN INK.

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composed of slender fragments of limestone tilted at all angles in a matrix of limestone distinctly different in composition.

The general nature of the strata composing the Conococheague limestone is shown in the type section near Scotland, Pennsylvania, published by Stose. The continuity of this section is known to be interrupted by small faults and folds. Although allowances were made for these, the section, as finally compiled, is scarcely to be considered as entirely satisfactory. The total thickness may be greater than given.

Section of Conococheague Limestone West of Scotland, Pennsylvania

	Feet
Rather pure light-colored limestone, much sheared, followed above by siliceous banded dark limestone and "edgewise" conglomerate (Stonehenge member of Beekmantown).	
Granular limestone with coarse "edgewise" conglomerate, oölite, and fine-grained pink marble, with numerous slaty partings	90
Covered	300
Pure dove-colored even-grained limestone interbedded with light siliceous-grained cross-bedded limestone, coarse "edgewise" conglomerate, and chert	15
Largly covered: dark impure limestone with large banded chert at the base	390
Dark and light limestone, in part banded with impurities	10
Dark, rather impure limestone with argillaceous partings weathering to slaty fragments and soft yellow shale; contains trilobites and beds of oölite	180
Dark limestone with shaly partings on weathering	90
Massive beds of light, dense, even-grained limestone with few wavy siliceous partings weathering in relief	40
Covered	70
Wavy impure siliceous banded limestone, weathering hackly and shaly.	180
Dense black impure limestone, weathering with thick gray coating	30
Thick massive beds of crumpled siliceous banded limestone	40
Section folded and discontinuous. Dense siliceous banded limestone, with sandy beds, oölite, "edgewise" conglomerate, and layers of *Cryptozoon* at the base	200±
	1635±

The exposures of the Conococheague limestone in Maryland are too discontinuous to allow a complete section to be taken at any particular locality. The following general section gives the sequence of these rocks east of the Martinsburg shale belt of the Valley.

General Section of the Conococheague Limestone in the Hagerstown Valley, Maryland

	Feet
Massive, rather pure, light colored limestone with cephalopods and gastropods of the Stonehenge limestone.	
Pink marbles, oölite, granular limestone with edgewise conglomerate and massive fine grained light colored limestone separated by beds of banded dark blue siliceous limestone. Vein quartz with crystals and yellow chert are left in soil upon weathering	400
Dark impure banded limestone weathering to slaty fragments and banded chert. Occasional beds of edgewise conglomerate	600
Wavy, blue to black siliceous banded impure limestone with layers of edgewise conglomerate	400
Siliceous banded dark blue limestone with intercalcated sandy beds, oölite and edgewise conglomerate. On weathering some of the strata give rise to large chunks of scoriaceous chert	200
Massive dark blue to light colored rather pure limestone with reefs of *Cryptozoon proliferum* Hall and *C. undulatum* new species	50
Light colored calcareous shale and laminated impure limestone of the Elbrook formation, weathering shaly.	
Total	1650

Because of the discontinuous exposure of the formation and the folding to which it has been subjected the thickness is a difficult matter to determine. The above total of 1650 feet is apparently a fair average for Maryland.

Although five divisions are shown above in the general section of the Conococheague limestone, the rocks may be conveniently grouped for purposes of study into three divisions. First, a basal division of 250 feet of oölite, edgewise conglomerate and Cryptozoon reefs; second, the main mass of the formation about 1000 feet or more in thickness made up of the usual banded limestone; and third, an upper part of 400 feet which contains pink marbles in addition to the usual rocks of the formation. All three divisions are indicative of shallow water conditions during their deposition, but the basal beds are particularly so. The edgewise conglomerate and the oölites are shallow water deposits and the rounded grains of quartz occurring with them indicate nearby land. In these beds are also inclusions of red clay which closely resemble clays resulting from the surface weathering of limestone. The most interesting residual

FIG. 8.—UPPER OZARKIAN (COPPER RIDGE).

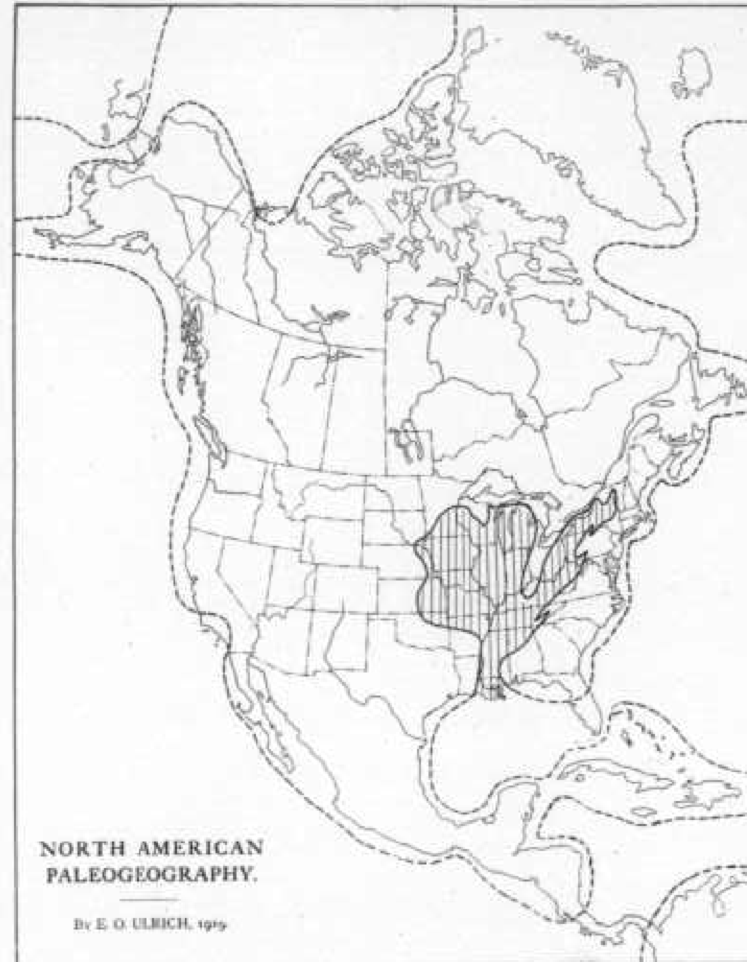

FIG. 9.—LATE OZARKIAN (CHEPULTEPEC).

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product of these basal beds is a scoriaceous chert which occurs in great quantity in the soils derived from their weathering. These chert masses are sometimes several feet in diameter, and while they are composed of crystalline milky quartz, they are so iron stained and cavernous that they have the appearance of slag or volcanic material. Fences composed of this chert are not uncommon in both the northern and southern areas of outcrops and they are good evidence that the dividing line between the Elbrook and Conococheague formations is close at hand. Good examples of such fences may be seen on the Antietam battle-field just north of Sharpsburg along the Hagerstown turnpike.

The main mass of the formation is described in preceding paragraphs. The upper beds of pink marble are very much like similar strata in the overlying Beekmantown limestone. However, there is no occasion to confuse the two since the usual siliceous banded rocks of the Conococheague are intercalated with these purer strata. Besides, the soils derived from these upper beds contain abundant fragments of black to yellow chert and milky vein quartz. Such siliceous residuals are characteristic of the Conococheague, but not of any part of the Beekmantown.

The above remarks apply particularly to the formation as developed east of the Massanutten syncline. West of the great shale belt in Maryland the general features of this limestone remain about the same, with the exception that 600 or more feet of massive sandy dolomite are intercalated between the usual sandy laminated limestones and the overlying Beekmantown limestone. These sandy dolomites weather into sandstones which strew the ground with large and small blocks. These sandstones are coherent enough at times to have been used in the past as a local source of grindstones. More extended study in neighboring states will probably show that these upper sandy dolomites represent the eastward extension of strata which do not really belong with the typical Conococheague limestone. However, until such studies have been made it is thought advisable to classify these upper sandy beds provisionally with the Conococheague limestone. A good section of this upper member may be seen in the Western Maryland Railway cut just west of Charlton,

FIG. 1.—EXPOSURE OF CONOCOCHEAGUE LIMESTONE ON EDGE, ALONG ROAD NEAR BAKERSVILLE, MARYLAND. THE CHARACTERISTIC STRONGLY CRINKLED, SANDY LAMINAE ARE WELL DEVELOPED.

FIG. 2.—LOWER CONOCOCHEAGUE SCORIACEOUS CHERT EXPOSED IN FENCE ALONG HAGERSTOWN TURNPIKE JUST NORTH OF SHARPSBURG, MARYLAND.

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Maryland. East of the Massanutten syncline these sandy strata are known only in the western part of the broad expanse of Conococheague limestone south of Hagerstown.

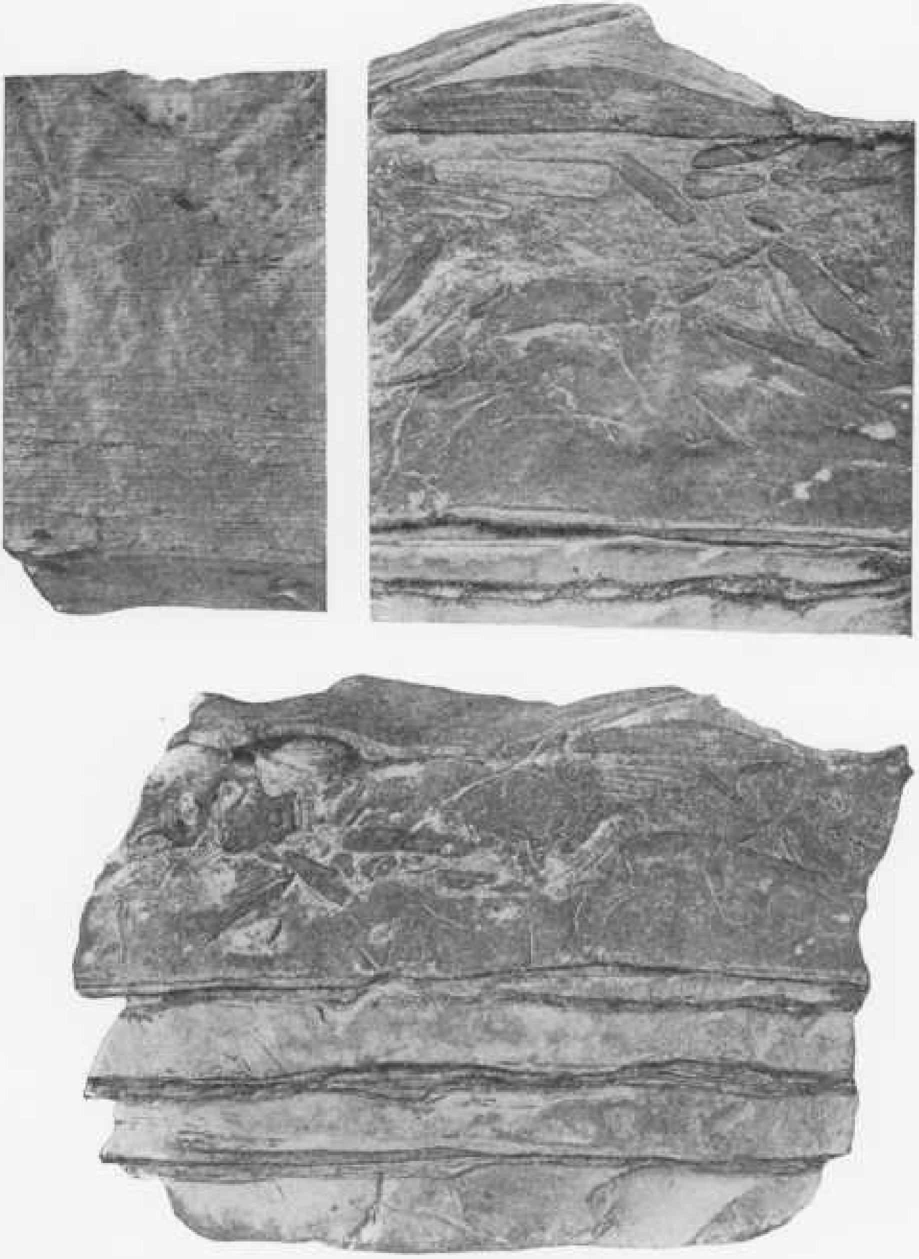
TOPOGRAPHY.—The topographic features of the Conococheague limestone are not as distinctive as those of the adjacent formations, still its presence is indicated by relatively minor topographic pecularities that after all are decidedly characteristic. The siliceous beds at the base of the formation are most resistant to weathering and as a result give rise to a line of low hills trending in the direction of the outcrops. The considerable amount of scoriaceous chert arising from the weathering of these lower beds also tends to form highlands. The hills formed by the siliceous basal beds are most conspicuous in the northeastern part of the valley in Maryland from the state line southeast through Bowman's Mill to Chewsville. The siliceous character of the upper portion of this formation likewise resists weathering, but not in as great a degree as the lower division. In general the areas of Conococheague limestone are somewhat elevated and exhibit rugged topography in comparison with the adjoining formations. Outcrops of the limestone are numerous, in fact rolling country with low hills and numerous rocky exposures is its characteristic feature in northern Maryland, but in the broad area in the southern part of the state the rocks themselves are seldom seen. Here the land is well cultivated and all evidence of the outcrop has usually been removed. The stone fences, however, are indicative of the underlying formation, as the rock employed in them has usually been taken from neighboring fields. Stone fences built of the characteristically banded Conococheague limestone are a sure indication of the presence of the formation.

AREAL DISTRIBUTION.—The Conococheague limestone forms the surface rock of a comparatively broad area in the eastern half of the Great Valley in Maryland, little interrupted by infolds of other formations. This is bordered on the east by the older Elbrook formation, the line of contact being quite regular except in the northern part of the state where faulting brings two narrow tongues of the Elbrook to the surface. The western boundary of this area is less regular due to several infolds of the

Stonehenge member of the overlying Beekmantown limestone. This area of outcrop therefore has a general monoclinal structure since younger beds border it on the west and older beds pass beneath it on the east. East of Hagerstown, Security on the west and Chewsville on the east mark the boundaries of the outcrop which averages three miles in width. Numerous exposures of the typical limestone may be seen along the Western Maryland Railway between Chewsville and Security and at the latter place the large quarry of the Security Cement and Lime Company exhibits a considerable section of the upper beds (see pl. XII, fig. 1). Leitersburg, five miles northeast, stands on a rocky ridge of Conococheague limestone, the rock here belonging to the lowest beds as evidenced by the scoriaceous chert found in abundance in the vicinity. South of Hagerstown the width of the belt of outcrop increases to over five miles, and a wide, unbroken expanse of this limestone occurs along the Potomac and for some miles northward. In many places here the beds are either very gently folded or almost horizontal.

In the western half of the Valley the outcrops of the Conococheague consist of several narrow belts of strata brought to the surface in the lowland area between the shale highland on the east and the front range of the Alleghenies on the west. Here the areas of outcrop are marked by many chert fragments and sandstone debris left in the soil.

AGE AND CORRELATION.—Only a small number of species of fossils has so far been discovered in the Conococheague limestone, these consisting of calcareous algae occurring in the basal beds, several brachiopods and trilobites found in the upper strata, and a large species of alga near the top of the formation. The two calcareous algae (*Cryptozoon proliferum* Hall and *C. undulatum* new species) at the base of the formation are found in abundance wherever these beds are exposed. The large *Cryptozoon* near the top is a not uncommon fossil, but the trilobite, *Saukia stosei* Walcott, and the brachiopod, *Eoorthis* cf. *desmopleura* (Meek), are of very rare occurrence in the higher beds. The trilobite has been found only in the Cumberland Valley, so it is of little value for exact correlation. Still it belongs to a genus that is elsewhere represented only in late Upper



"EDGEWISE BEDS" CHARACTERISTIC OF BEEKMANTOWN (UPPER RIGHT HAND FIGURE) AND CONOCOCHEAGUE FORMATIONS (LOWER FIGURE), HAGERSTOWN VALLEY, WASHINGTON COUNTY. THE UPPER LEFT HAND FIGURE REPRESENTS THE CHARACTERISTIC FINELY LAMINATED FEATURE OF THE BEEKMANTOWN LIMESTONE.

Cambrian and Middle Ozarkian formations. Moreover, its affinities lie nearer the Ozarkian species than the Cambrian, so that its evidence, so far as it goes, favors assignment of the Conococheague to the Lower Ozarkian. The brachiopod, also, as now understood, has too wide a range for detailed stratigraphic work. The two species of *Cryptozoon* at the base occupy this position throughout a large part of the Appalachian Valley and serve as excellent guide fossils.

The Maryland early Paleozoic section is far from complete and the age of the Conococheague limestone must be determined from more fully developed sections in other areas. The *Cryptozoon* fauna occurs in central Pennsylvania in the Gatesburg dolomite which, roughly speaking, is the equivalent of the Conococheague limestone. Beneath the Gatesburg dolomite, and separating it from the Middle Cambrian, Elbrook, is an Upper Cambrian formation, the Warrior limestone. To the south in Virginia, Tennessee, and Alabama, the same *Cryptozoon* fauna is also known and in each case it is separated from the Middle Cambrian equivalents of the Elbrook limestone by Upper Cambrian formations of great thickness and containing well-developed faunas. Evidently then we must conclude that the contact between the Elbrook and Conococheague in Maryland is unconformable and represents a stratigraphic break of considerable magnitude.

Cryptozoon Reefs.

The basal 15 or 20 feet of the Conococheague limestone usually exhibit layers so uniformly and curiously laminated over considerable areas that this phenomenon cannot be attributed to ordinary plications in the strata. All of the sandy laminated and banded portions of the formation show a wavy or crinkled structure, especially where strong folding has occurred, but the laminations of the basal beds are of a quite different nature. The limestones in which the latter laminated structures occur are not of the usual banded type, but are composed of a massive, rather homogeneous and somewhat purer rock. In an edge view of a stratum the rock is seen to be made up of thin, parallel films of material piled one upon the other.

At first these films are practically horizontal to the bedding planes, but soon undulation commences and narrow or broad folds with narrower or sharper bending down of the films occurs. After an interval of several inches exhibiting such undulation, the horizontal lamination is resumed and this in turn is followed by a repetition of the undulations. These wavy outlines as seen in cross-sections of the strata appear as concentrically lined areas of varying diameter on the bedding planes themselves. The greater the width of the fold seen in transverse section, the greater the diameter of the corresponding concentric area.

These laminated strata at the base of the Conococheague follow two distinct patterns. In each the basal laminae are horizontal to the bedding plane, but the succeeding undulations are quite different. In one kind the undulations are an inch or less across and retain this diameter uniformly. In the other, the width of the undulations varies from a central one, several inches across to lateral ones an inch or less wide. Upon the weathering of the surrounding strata, masses of this laminated rock are left in the soil, still retaining their calcareous composition or, as is more frequently the case, changed to silica. In either case the uniformity in shape of these residual masses would seem to indicate that they are definite organic structures.

Walcott has described a number of quite similar laminated structures from the Proterozoic rocks of the West and has shown that they represent the secretions of calcareous algae. Certain of the Proterozoic limestones contain beds crowded with these algal structures which are repeated again and again through thousands of feet of strata. These remains are not those of the fossil plant itself, but are simply the secretions of calcium carbonate upon the tissue of the plant. As is well known, calcium carbonate held in solution by an excess of carbon dioxide in the water is deposited when the carbon dioxide is abstracted. In securing carbon from the carbon dioxide for the building of their tissues the lime is deposited upon the films of the plant which abstracts the carbon dioxide. The form of the plant, however, is well preserved in these limestone secretions.

FIG. 1.—QUARRY IN UPPER PART OF CONOCOCHEAGUE LIMESTONE WITH SECURITY CEMENT WORKS, SECURITY, MARYLAND, IN DISTANCE.

FIG. 2.—TYPICAL EXPOSURE OF THE LOWER PURE FINELY CONGLOMERATIC BEDS OF THE STONEHENGE LIMESTONE ALONG NATIONAL HIGHWAY, JUST SOUTH OF FUNKSTOWN, MARYLAND.

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The Proterozoic forms of calcareous algae have been described under six genera, but all of the Cambrian and Early Ordovician forms have been referred to the single genus *Cryptozoon*. The basal Conococheague species, consisting of a wide, flat basal portion of laminae growing into numerous head-like masses large at the center and small along the edges, was described long ago by Hall as *Cryptozoon proliferum*. The second species, with laminae of equal undulations, is described in this volume as new.

These two types of structure are often associated together in such numbers that they form a true reef. Sometimes only one of the species will be represented in the reef, though occurring in such great numbers as to completely fill the rock. A reef composed entirely of *Cryptozoon proliferum* is well exposed in a cut along the Norfolk and Western Railroad about one mile southwest of Antietam Station, Maryland (see pl. IX, fig. 1), where the highly tilted limestones expose the individual colonies of the alga to good advantage. Similar reefs of *C. proliferum* were observed along the northern line of outcrop from the state line southeast to Chewsville. The base of the line of low hills about a mile west of Ringgold gives numerous specimens of this species. The outcrops of the basal beds along the line five miles southeast of Hagerstown show reefs of the new species *Cryptozoon undulatum* most commonly.

These reefs of calcareous algae are of interest and practical value from the standpoint of structural geology because they afford an exact criterion for determining the top or bottom of a stratum. In areas of highly folded strata such as the Appalachian Valley, this determination is frequently highly important and sure methods are few. The broad upfolds of the laminations and the narrow sharp down folds register the upper and lower sides respectively of the stratum without a doubt.

Still a third type of strongly laminated *Cryptozoon* structure occurs near the top of the Conococheague limestone in both the eastern and western areas of outcrop in Maryland. No specimens have been obtained free from the matrix, but natural sections in the rock show that the undulations are 18 or more inches in width and that the zone of strong undulations rises in the stratum to a height of two feet or more. This *Cryptozoon* sometimes consists of a single mass of strongly marked undulating layers one-half inch apart rising in the rock like a column. Specimens may be seen to advantage two miles northwest of Leitersburg along the road south of Millers Chapel, and along the Western Maryland Railroad just west of Charlton, Maryland. This particular *Cryptozoon* is of special interest in having oölites one-eighth of an inch in diameter abundantly developed in the areas between the downfolds of the laminations (see pl. IX, fig. 2). The formation of these oölites appears to have been connected with the life activities of the plant.

Edgewise Conglomerate.

These peculiar conglomerates are such a marked feature of the Conococheague limestone that they are described at this point, although they occur equally well developed in subsequent formations. The typical dark-blue, banded and frequently crinkled limestones of the Conococheague formation, are often separated by layers varying from a few inches to a foot or more in thickness, composed of a rather homogeneous or slightly granular rock filled with long, slender fragments of a distinctly different limestone tilted at various angles to the bedding plane. The actuality of the difference in composition of the two rock types making up such layers is not conspicuously evidenced on a freshly fractured surface, but weathering causes the slender fragments to stand out quite prominently upon exposed surfaces. The position of the fragments frequently on end or on edge in the matrix has given the common name of edgewise beds to such strata. Some of these fragments are sharp-edged and show no evidence of wave action; others are rounded at one or both ends and have apparently been worn. Often the matrix of these conglomerates contain small, rounded quartz grains, evidently derived from some nearby land area.

These edgewise beds have long been considered as intraformational conglomerates and under a broad definition of that term they could still be considered so. However, the original intraformational conglomerate described by Walcott did not include this type. All of his examples are more of the nature of real conglomerates even though the fragments of which they consist are of the same age as the surrounding matrix and are not, as an ordinary conglomerate, composed of foreign rocks.

Although these curious edgewise structures have been known to geologists for many years, little mention of them has been made in the literature until comparatively recently. The term "edgewise" was coined by Nason in 1901[1] and the occurrence of such structures was mentioned by Bain and Ulrich in 1905.[2] In 1906 Seely described the edgewise conglomerate in division D of the Beekmantown limestone in the Champlain Valley as the "Wing Conglomerate," naming it after Mr. Wing who made the original observations upon it.

Seely believed that these flat pebbles could not be laid down in either swift or slow water in the position they are now found and came to the conclusion that they were organic. He described them as three species of the genus *Wingia,* a new genus of Beekmantown sponges.

Stose, in 1910, in the Chambersburg-Mercersburg folio of the U. S. Geological Survey, mentioned these conglomerates and ascribed their origin to the breaking up of freshly deposited thin-bedded lime sediment by shallow-water wave action into shingle or flat fragments that were shuffled about on the beach. T. C. Brown,[3] in an article on the origin of certain Paleozoic sediments, reverted to the organic origin of the pebbles, but concluded they resulted from the activities of calcareous algae. He admitted that no specimens preserving any organic structure sufficiently well to prove their origin had been found. Another interesting origin for these conglomerates is that discussed by Grabau in his Principles of Stratigraphy where he explains that they are due to deformation through gliding which has resulted in the complete brecciation of the layers. He distinguishes the intraformational conglomerates in which the fragments lie in all positions, and the edgewise conglomerate where the gliding process has caused the thin cakes to assume a vertical position in the rock

[1] Amer. Jour. Sci., 4th ser., vol. 12, p. 360.
[2] Copper deposits of Missouri, Bull. 267, U. S. Geological Survey, p. 23.
[3] Journal of Geology, vol. xxiii, No. 3, 1913.

mass. No such distinction as this can be drawn in nature because there are all gradations of arrangement.

The observations of Ulrich, Stose, Butts and other geologists who have had numerous opportunities to study the edgewise beds, all tend to the conclusion that these conglomerates are not organic, but are composed of fragments formed on tidal flats by mud cracks. The Appalachian early Paleozoic formations are practically all shallow-water deposits in which the area was often subject to uplift above the sea level. Mud flats which by uplift are exposed to evaporation soon develop the usual shrinkage figures known as sun cracks and the edges of these to-day curl up and are broken off and tossed about by the wind. This same condition has occurred time and again in the past, and indeed limestones still preserving well-defined sun cracks with the edges curled up and ready to be formed into edgewise conglomerates have been observed.

FOSSILS OF CAMBRIAN AGE

In spite of the considerable thickness of Cambrian rocks developed in the Appalachian region of Maryland, and the careful search that has been made, fossils of this age are exceedingly rare. Usually no trace of organisms can be detected in the rocks, and the few specimens noted have always been fragmentary and poorly preserved. These few remains occur in the Harpers schist, Antietam sandstone, and Tomstown limestone of Lower Cambrian age, in the two Middle Cambrian formations, the Waynesboro formation and Elbrook limestone and in the Upper Cambrian (Ozarkian), Conococheague limestone. The basal Cambrian Loudon formation and the succeeding Weverton quartzite are lithologically of such a nature that fossils would not be expected in them, but the overlying formations are more promising in this respect and may possibly yield to some fortunate collector more representative faunas than known at present. Fairly well-developed Lower and Middle Cambrian faunas are known in the Appalachians both north and south of Maryland, but it appears that the strata bearing them are usually not represented in the Maryland section. For example, the Lower Cambrian strata at York, Pennsylvania, containing well-preserved trilobites, do not appear to be present in Maryland.

The few species thus far discovered in the Conococheague limestone of southern Pennsylvania and Maryland give no idea of the characteristics of the Upper Cambrian (Ozarkian) faunas. It is true that the two species of *Cryptozoon* are characteristic Ozarkian fossils over a wide area, but very similar species are found in the succeeding Ordovician strata. The single species of trilobite is very limited in its distribution and the brachiopod is too little restricted to be of any stratigraphic value.

The few Cambrian species identified in Maryland strata are described in the following pages. These species are listed below under their appropriate formations:

Lower Cambrian (Waucoban) Fossils of Maryland

Harpers shale. *Scolithus linearis* Haldemann.
Antietam sandstone. *Scolithus linearis* Haldemann, *Obolella minor* (Walcott), *Hyolithes communis* Billings, and *Olenellus thompsoni* (Hall).
Tomstown limestone. *Olenellus thompsoni* (Hall) and *Salterella* sp.

Middle Cambrian (Acadian) Fossils

Waynesboro formation. *Lingulella* sp.
Elbrook formation. *Dolichometopus* sp.

Upper Cambrian (Ozarkian) Fossils

Conococheague Limestone

Cryptozoon proliferum Hall (common at base)
Cryptozoon undulatum n. sp. (common at base)
Saukia stosei Walcott (rare in upper part)
Eoorthis desmopleura (Meek) (rare in upper part)

THE BEEKMANTOWN LIMESTONE

The middle part of the Appalachian Valley in Maryland, with the exception of the Martinsburg shale belt which is three miles in width, and small areas or other formations, is directly underlain by a thick mass of rather pure limestone. Nearly all of this rock is fine grained and most of it is minutely laminated. Interbedded with these are pure minutely laminated limestones with some layers containing occasional, more or less massive, ledges in which the lamination is obscure. Some of these contain numerous poorly preserved fossils. Study of these fossils shows that a large part of the local fauna consists of species previously found in the Beekmantown limestone of the Champlain Valley in New York, Vermont, and southeastern Ontario. In 1910[1] the northern extension of these strata was distinguished and separately mapped under the same name by which the formation is known in New York.

The Frederick Valley in Maryland, east of the Blue Ridge, also contains a considerable development of rather pure massive limestone holding Beekmantown fossils. This development of the Beekmantown is discussed in a separate chapter, so that the following description of the stratigraphy applies only to the Appalachian Valley. As a whole, the Beekmantown limestone of Maryland is quite distinct lithologically from the other divisions of the Shenandoah group, although the occurrence of similar beds in most of the formations often causes difficulty in the recognition of isolated outcrops. Its strata are most likely to be confused with the underlying Conococheague limestone, because edgewise conglomerates are not uncommon in the Beekmantown, in fact in the upper half of the lowest division they are as well developed as in the Conococheague limestone. The characteristic sandy laminated banded, dark blue rock of the latter, excepting one bed, is not developed in the Beekmantown. The main mass of the Beekmantown formation is of finely laminated, lighter colored and purer rock than occurs in the Conococheague. The successive beds also are more uniform in texture, color and composition. On this account, it is difficult to distinguish the different portions above the basal division, which contains the exception mentioned above in which siliceous banded limestones occur.

Fortunately there are four fossiliferous zones in the formation with characteristic species in each, which appear frequently enough in the outcrops to obviate some of the difficulties of determination. Several distinct zones in this formation may also be recognized by residual

[1] Chambersburg-Mercersburg folio, U. S. Geological Survey.

FIG. 10.—LOWER CANADIAN (BRETONIAN).

FIG. 11.—MIDDLE AND LATE CANADIAN (BEEKMANTOWN).

products left in the soil by the weathering of the limestone. The top, middle and lower portions are especially well characterized by siliceous products, such as chert, flint and sandy shale fragments, which are discussed in detail in succeeding paragraphs.

LITHOLOGIC CHARACTER.—Although the Beekmantown limestone differs considerably in its lithological development in the eastern and western parts of the valley, the formation as a whole is composed of much purer limestones than the underlying Conococheague. On the other hand its purest beds are inferior in calcium carbonate content to the high average of the overlying Stones River limestone. The purer limestones of the Beekmantown are interbedded with greater thickness of relatively impure finely laminated beds which occur, or at least outcrops, so frequently that the presence of these laminated limestones is a good criterion for the formation. This characteristic minute lamination of the average rock of the formation is due to impurities in the rock and most apparent on weathered surfaces. Pink and white fine grained marbles in ledges of considerable thickness also are of common occurrence in the Beekmantown, especially in the lower half of the formation. Marbles occur in the underlying Conococheague limestone, but as they are always associated with the characteristic siliceous banded limestone of that formation they are readily distinguished from the marble beds of the Beekmantown. But it should not be forgotten that siliceous banded limestones quite similar to those of the underlying Conococheague beds occur also in the lower fifth of the Beekmantown. These are so constantly developed in the eastern half of the valley that the part containing them has been mapped as a distinct basal division under the name of the Stonehenge limestone member. This basal member can be recognized locally also in the western part of the valley, but here its lithologic characters are hardly distinct enough to warrant its separation in the mapping.

As practically all of the Beekmantown areas of Maryland are covered by gently rolling cultivated farm lands it is almost impossible to make out the complete section of the formation in any particular place. However, by assembling incomplete sections in various parts of the valley the following generalized section for Maryland and southern Pennsylvania has been described by Ulrich in his Revision of the Paleozoic Systems:[1]

Generalized Section of Beekmantown Limestone in Southern Pennsylvania and Maryland

	Feet
Base of Stones River limestone with quartz pebble conglomerate and cauliflower chert	...
Hard dense white chert and granular quartzose chert forming by secondary silicification, cauliflower chert	40
Fine grained gray, finely laminated, interbedded pure and magnesian unfossiliferous limestone with sandy chert and limestone and dolomite conglomerates at the top	400
Turritoma zone. Thin bedded argillaceous and massive purer limestone containing the *Turritoma* fauna. Many of the beds weather so as to appear riddled with worm borings	200
Alternating beds of pure dove, pure gray and magnesian gray unfossiliferous limestone often laminated, with occasional beds of fine limestone conglomerate	300
Massive pure dove gray and magnesian limestone terminated above by sandy fossiliferous chert containing *Syntrophia lateralis, Maclurites sordida* and species of *Liospira*	75
Ceratopea zone. Blue and dove fossiliferous limestone *cherty* in the upper half, containing *Ceratopea* and associated fossils. At the base is a blue limestone filled with rounded quartz grains	250
Cryptozoon steeli zone. Fine grained nearly pure limestone with some magnesian beds and several layers of porous chert	275
Dove, pink and bluish fine grained pure limestone and marble	300
Oölitic, cherty blue and gray limestone holding the *Cryptozoon steeli* fauna and weathering into platy yellow chert	60
Stonehenge limestone member. Massive dark blue to gray limestone with contorted argillaceous and siliceous laminations weathering to sandy shale, interbedded with edgewise beds and oölites	250
Massive blue to gray pure limestone weathering white, with cephalopods and gastropods occurring in reef structures	250
Top of Conococheague limestone with sandy laminae and beds of edgewise conglomerate	...
	2400

From the stratigraphic standpoint the important divisions of the above section are the Stonehenge member and the three zones marked respectively the *Cryptozoon steeli, Ceratopea,* and *Turritoma* zones. The faunal and other characteristics of these zones are discussed in succeeding paragraphs.

[1] Bull. Geol. Soc. America, vol. xxii, No. 3, 1911, pp. 652-655.

While the general section given above holds fairly well for all parts of the Valley, the detailed stratigraphy of the formation in the eastern and western parts is, as mentioned above, somewhat different. The best exposure of the Beekmantown limestone east of the Martinsburg shale belt is adjoining the Chambersburg-Gettysburg Pike one mile east of Chambersburg, Pennsylvania. This section, measured by Ulrich and Stose, is given below with slight emendations to show the position of the fossil zones.

Section of Beekmantown Limestone One Mile East of Chambersburg, Pennsylvania

	Feet
Base of Stones River, containing fine limestone conglomerate and laminar and oölitic chert	...
Interbedded fine-grained pure and magnesian limestones, finely laminated in part and containing small quartz geodes; porous sandy chert near top; dark-blue layers near base containing numerous gastropods (*Turritoma* fauna) and ostracods and mottled by magnesian material that weathers out, leaving pits and holes	600
Alternating pure dove-colored and gray limestone and magnesian limestone, with layer of sandy chert	375
Bluish to dove-colored fine-grained fossiliferous limestone, at the base containing rounded quartz grains. *Ceratopea* fauna at top	100
Pink fine-grained marble, containing layers of milky quartz chert; gastropods of the genera *Ophileta*, *Maclurites* and *Eccyliopterus* rather abundant	275
Pure dove-colored and blue fine-grained limestone, with some pink limestones; contains fragments of trilobites	285
Fine-grained dove-colored to dark gray limestone with fine conglomerate and oölite beds; abundant chert in upper portion, in part oölitic and conglomeratic. *Cryptozoon steeli* in middle part	145
Stonehenge limestone member:	
Fine-grained light to dark gray limestone containing wavy laminae of sandy matter that stand in relief or fall to sandy shale on weathering and thick beds of "edgewise" conglomerate; gastropods in upper and fine fragments of trilobites in lower portion	225
Dark to very light gray massive limestone, containing *Dalmanella*, *Ophileta* and trilobite fragments	260
Top of Conococheague, containing wavy and sandy laminae and beds of coarse limestone conglomerate	...
	2265

West of the shale belt, the details of the Beekmantown section are somewhat different, although the several fossil zones can be readily recognized. No continuous well-exposed section of these strata was noted in Maryland, and the section repeated below is one, published by Ulrich and Stose,[1] of the northern continuation of the formation in southern Pennsylvania. This section is broken and probably incomplete 480 feet beneath the base of the overlying Stones River limestone. If the Turritoma zone which was not observed is present in this basin, it may have been faulted out or is concealed by covering soil and debris. However, it has been recognized in the southern continuation of the belt in Maryland.

Section of Beekmantown Limestone near Mouth of Licking Creek, Franklin County, Pennsylvania

	Feet
Interbedded pure and magnesian limestone of Stones River type	...
Light-gray, finely laminated magnesian limestone and white dolomite with cherts of rosette type at the top	340
Dark and light coarse dolomite	140
Rocks folded and largely covered; white dolomite, dark-blue oölitic limestone, and dark coarse dolomite with yellow blocky sandstone fragments and rosette cherts; exact continuity indeterminable, but the previous beds are apparently repeated by folding	...
Interbedded pure and magnesian limestone, with beds of coarse dark dolomite, and in the lower part beds of "edgewise" conglomerate; at base contains *Ceratopea* gastropods, cephalopods, and trilobites	350
In large part finely banded magnesian limestone with few pure limestones; contains fine conglomerate beds and gastropods	170
Largely dolomite, some coarse and dark; large scoriaceous black chert and coarse sandstone at the base	130
Chiefly dolomite, coarse and dark in upper part, with some pure fossiliferous limestone; bed of granular limestone with numerous *Ophileta* and pinkish fine-grained limestone near middle; cross-bedded banded limestone at base, locally unconformable on underlying beds	290
Fine-grained limestone seamed with calcite and dolomite beds with flinty chert containing *Cryptozoon steeli* at the base	65
Partly covered; lower part pure dark limestone with a few beds of finely laminated magnesian limestone and fine white oölite near base; small rough chert with casts of crystals at the base	130
Light-blue limestone with fine contorted sandy laminae that weather in relief; contains fine dark conglomerate with red limestone pebbles and fragments of trilobites	165
Purer fine even-grained limestone with few sandy partings	530
Sandy laminated limestone, much contorted (Conococheague)	...
	2310

[1] Chambersburg-Mercersburg folio U. S. Geological Survey.

Comparison of these sections brings out several salient differences in the lithology of the two areas. East of the shale belt, the Stonehenge member with its characteristic siliceous banded limestone, is distinct enough to be mapped as a separate unit, but west of that belt the siliceous banding of the lower Beekmantown is not so well developed. However, the same faunas are present in these strata in both areas so that there is no doubt as to the presence of beds corresponding to the Stonehenge member in both. The higher beds in each area also contain similar faunas, but the lithology is somewhat different, limestone predominating in the east and dolomite in the west. Chert in large quantities weathers from certain portions of the dolomite in the western area, but it is not so conspicuously developed in the east.

The two sections illustrate the lithologic changes occurring in the formation going from the east, where over three-fourths of the formation consists of pure limestone, across the strike to the western side of the Valley where more than half of the strata is more or less highly magnesian. In Appalachian areas still further west, as in central Pennsylvania, the change to magnesian limestone becomes yet more pronounced.

FAUNAL ZONES.—Although the lithologic features of the various portions of the Beekmantown limestone vary considerably, the basal member is the only division which can be definitely recognized from the character of its strata. Above this lower division—the Stonehenge member—three distinct faunal zones aid in the recognition of their respective horizons. These are in ascending order above the Stonehenge member, the *Cryptozoon steeli* zone, the *Ceratopea* zone and the *Turritoma* zone. The value of these zones is not local for they have a wide distribution.

Stonehenge Member.—The village of Stonehenge, just east of Chambersburg, Pennsylvania, is located on the lower beds of the Beekmantown, which are sufficiently distinct lithologically and faunally from the remaining strata of the formation to warrant their separation as a distinct member. This Stonehenge member is composed of massive finely conglomeratic pure limestone in the lower half and siliceous banded limestone alternating with layers of large edgewise conglomerate in the upper half.

FIG. 1.—EXPOSURE OF STEEPLY INCLINED STONEHENGE LIMESTONE (UPPER DIVISION) AT CHARLTON, MARYLAND, SHOWING THE DISINTEGRATION INTO SILICEOUS SHALE, UPON PROLONGED WEATHERING.

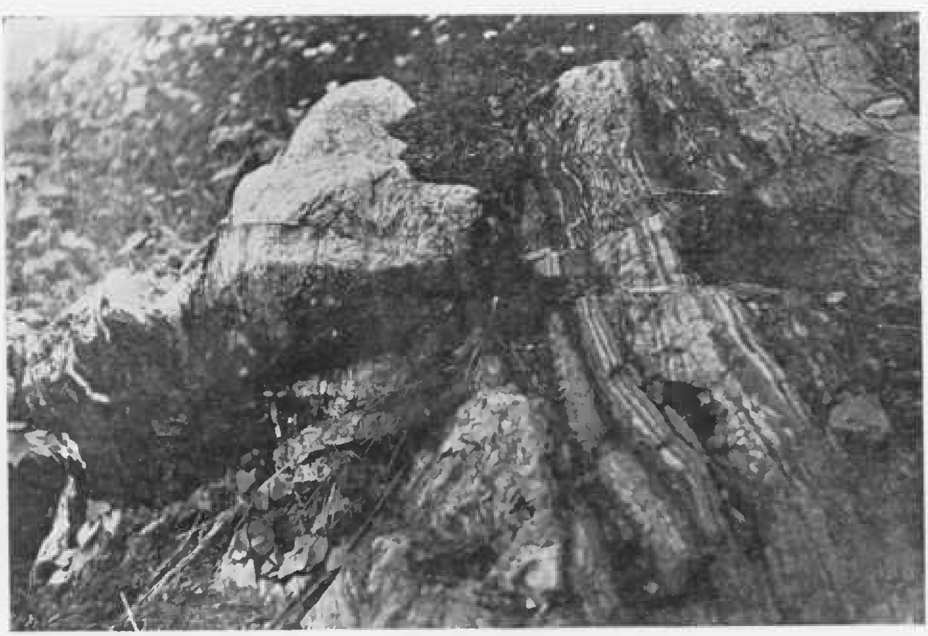

FIG. 2.—TYPICAL EXPOSURE OF EDGEWISE CONGLOMERATE FROM THE UPPER PART OF THE STONEHENGE LIMESTONE, BALTIMORE AND OHIO RAILROAD, ONE MILE NORTH OF BALLS, MARYLAND.

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The lower Stonehenge limestone is made up in large part of very massive blue to dove-colored limestone weathering bluish-white or white. The outcrops are always of a distinctly lighter color than the associated formations. This feature is one of several that serve unmistakenly in identifying this basal zone of the formation. On close inspection a large part of these massive limestone ledges appears to the unassisted eye as granular in texture, but under a lens the granules prove to be very small brecciated pieces of limestone usually less than a sixteenth of an inch in diameter. These small fragments are of a more distinctly white color than the surrounding matrix and the combination of a light blue rock crowded with lighter colored minute angular fragments is very distinctive. The lower division is further distinguished by absence of chert. In all of the numerous outcrops that have been studied no chert of any kind has been observed either in the weathered limestone or in the soil derived from it. At intervals varying from an inch to two inches the limestone develops very thin layers of carbonaceous or argillaceous material which gives it a banded aspect. These layers or laminae are usually about one-eighth of an inch in thickness, flat and parallel with the bedding planes. They are quite unlike the sandy intertwining laminae so characteristic of the upper division of the Stonehenge member.

Along the National Highway just south of Funkstown there are splendid outcrops of typical lower Stonehenge limestone where fossils may be found and its lithologic character can be studied to advantage. Hagerstown and vicinity also affords numerous, excellent and instructive exposures of those beds.

Excepting the shells of a few brachiopods the fossils in this zone cannot be cleanly extracted from the rock because they are so firmly cemented to the fine-grained matrix that in breaking the limestone with a hammer the fracture passes through the fossils and not along their surfaces. It is only upon the weathered surfaces of the ledges that the fossils can be discerned, and at that merely as cross-sections. The exposures near Funkstown have shown clearly that the fossils of the lower Stonehenge fauna, especially the cephalopods and gastropods which constitute much the greater part, occur mainly in reef-like masses. These reefs are of slightly different material than the enclosing rock, lenticular in form, and seldom exceed two feet in maximum thickness. Straight and coiled cephalopods are the most abundant fossils seen in cross-sections of these reefs, but *Maclurites* and *Ophileta*-like gastropods are not uncommon.

Most of the beds of the upper Stonehenge resemble the Conococheague limestone so closely in their development of sandy laminated strata with numerous beds of edgewise conglomerate that in areas of faulted or intricately folded strata the distinction between the two formations is made with difficulty. The absence of chert in the weathered Stonehenge limestone contrasting with its frequent occurrence in the Conococheague is perhaps the best of the physical means of separation. It will be observed also that in the upper Stonehenge the sandy laminae are more undulating and interwoven than in the laminated beds of the Conococheague in which commonly they form relatively parallel bands. The presence of shells of cephalopods and gastropods in the Stonehenge also serves to distinguish this member from the Conococheague which has never yielded any molluscan fossils. In areas where the sequence is normal the boundary between the two formations is readily determinable by the criteria given. Desirable and conclusive corroboration may be secured by establishing the lower Beekmantown sequence of (1) the lower Stonehenge composed of pure dove-colored to gray strata containing beds of a minute limestone conglomerate; (2) dark impure limestone with undulating siliceous laminae followed by (3) relatively pure limestone consisting largely of pinkish marbles.

All the hills within the city of Hagerstown and its vicinity are formed of the upper Stonehenge limestone, and as the quarries for building stone in the early days were located on these hills, it follows that many of the older buildings in Hagerstown are of this limestone. The stone is not only easily quarried and dressed, but as it whitens in weathering and the edgewise conglomerate and wavy laminae become distinctly visible, it has also a handsome and unique appearance. Several of the churches are constructed of Stonehenge limestone and its value and beauty as building rock may be seen particularly in St. John's Episcopal Church on West Antietam Street, and the Presbyterian Church at the corner of Washington and Prospect streets. The conglomeratic nature of the rock is especially well brought out in the many stone embankments about Hagerstown in which long exposure to the weather has emphasized this and the laminated character. At the present time brick and concrete construction have largely displaced this limestone as building material.

Although the upper division of the upper Stonehenge is well exposed at many localities in Maryland, perhaps the best places to study it in detail are in the various railroad cuts around Hagerstown. The cut on the Western Maryland Railway one-half mile west of Bissel exposes the characteristic edgewise conglomerate and the heavy, wavy laminae especially well. At this place, as well as at other localities around Hagerstown, a few granular layers are found crowded with brachiopods and poorly preserved gastropods.

Seventeen species of fossils have been noted in the Stonehenge limestone of Maryland and Pennsylvania. Following Ulrich[1] these have been correlated with the Tribes Hill limestone fauna of New York. The same fauna is found also in the upper part of the Kittatinny limestone in New Jersey and in the basal or Stonehenge limestone division of the Canadian in central Pennsylvania. The brachipod *Dalmanella wemplei* Cleland is found in abundance in certain granular layers, but other fossils are not so common. The cephalopods are almost confined to reef-like structures in the purer limestones of the lower half. The gastropod *Ophileta complanata* Vanuxem is found in both the lower and upper parts of the member and it may be considered the characteristic fossil.

Representatives of one species of fucoid and 16 species of invertebrates, including one brachiopod, six gastropods, five cephalopods, three trilobites, and one branchiopod crustacean, have been found in the Stonehenge member in Maryland sufficiently well preserved for specific identification. Fragments of a few more species too imperfect for accurate determination have also been noted. The gastropod *Ophileta complanata* is highly characteristic of this part of the Beekmantown and the fauna may be known as the *Ophileta complanata* fauna. The Stonehenge limestone

[1] Ulrich, Revision Paleozoic Systems. Bull. Geol. Soc. America, vol. xxii, 1911, No. 3, pl. xxvii; Ulrich and Cushing, Age and Relations of the Little Falls dolomite—N. Y. State Museum, Bulletin 140, 1910, p. 137.

does not leave any residual chert upon weathering and its contained fossils unfortunately do not become silicified. As a result, their preservation is not of the best and natural sections in the rock or poor casts are the rule. The granular beds associated with the edgewise conglomerate of the upper part of the Stonehenge limestone is the most favorable place for collecting the brachiopod and gastropod shells, some of these beds being fairly crowded with specimens of *Dalmanella wemplei.* The cephalopods and trilobites have in the main been found in reef-like structures in the lower Stonehenge and their occurrence is therefore quite sporadic. At one point a stratum will exhibit numerous cross-sections of fossils, but a foot or two away where the reef material composed of a very fine edgewise conglomerate has disappeared, no trace of a fossil can be found.

The following table gives a list of the Stonehenge fauna and shows the distribution of the species in the Kittatinny limestone (upper part called the Coplay limestone) of New Jersey and the Tribes Hill limestone of New York, formations with which on stratigraphic and paleontologic grounds, the Stonehenge is correlated.

LIST OF STONEHENGE LIMESTONE FOSSILS SHOWING DISTRIBUTION

	Kittatinny limestone (upper beds) of New Jersey	Tribes Hill limestone of New York	Other horizons of Beekmantown	Stonehenge limestone of Pennsylvania and Maryland
Palæophycus tubulare Hall	..	*	..	*
Dalmanella wemplei Cleland	*	*	..	*
Ophileta complanata Vanuxem	..	*	..	*
Ophileta levata Vanuxem	..	*	..	*
Eccyliomphalus multiseptarius Cleland	..	*	..	*
Pleurotomaria ?? floridensis Cleland	..	*	..	*
Raphistoma ? obtusum Cleland	..	*	..	*
Raphistoma ? columbianum Weller	*	..	..	*
Orthoceras primigenium Hall	..	*	*	*
Ooceras kirbyi Whitfield	..	*	*	*
Cyrtoceras gracile Cleland	*	*	..	*
Cyrtoceras beekmanense Whitfield	..	..	*	*
Cyclostomiceras cassinense? (Whitfield)	..	..	*	*
Asaphellus gyracanthus Raymond	*	*	..	*
Hemigyraspis collicana Raymond	..	..	..	*
Symphysurus convexus (Cleland)	*	*	..	*
Ribeiria nuculitiformis Cleland	..	*	..	*

FIG. 1.—VIEW OF A WEATHERED OUTCROP OF THE UPPER STONEHENGE LIMESTONE, EASTERN EDGE OF HAGERSTOWN, MARYLAND.

FIG. 2.—VIEW TAKEN FROM HILL OF UPPER STONEHENGE LIMESTONE, EASTERN EDGE OF HAGERSTOWN, MARYLAND, LOOKING EAST, SHOWING EFFECT OF WEATHERING OF THE VARIOUS FORMATIONS UPON TOPOGRAPHY. THE VALLEY IN THE FOREGROUND IS IN THE LOWER STONEHENGE PURE LIMESTONE WHILE THE RIDGE IS FORMED OF THE SILICEOUS, MORE RESISTANT UPPER STONEHENGE. SOUTH MOUNTAIN IS SEEN IN THE DISTANCE.

In Maryland and southern Pennsylvania, the Beekmantown strata following the Stonehenge member are so uniform in lithologic character that their separation into distinct formations is impracticable. In the Nittanny and other valleys in central Pennsylvania the corresponding strata not only attain a much greater thickness, but also are so developed that four formations are readily distinguishable. These are, in ascending order, (1) the Stonehenge limestone at the base with a thickness of 662 feet; (2) the Nittanny dolomite, 1267 feet thick, cherty and holding the *Cryptozoon steeli* fauna in its lower part; (3) the Axeman limestone 158 feet, and (4) the Bellefonte dolomite 2145 feet thick. The entire series, with both overlying and underlying formations, is to be seen in excellent and practically continuous exposures at Bellefonte, Pennsylvania. As this section gives the maximum known development of the Canadian system in the Appalachians, the four formations into which it has been divided as above by Ulrich have been adopted in the general time scale.

Cryptozoon steeli Zone.—Following the Stonehenge member, which has just been described, are 600 or more feet of cherty oölitic limestones, dove-colored, fine-grained pure limestone and usually dense textured pink marble. The basal 60 feet consisting mainly of oölitic cherty limestone contains the characteristic fossil of this division—a globular mass, commonly four to eight inches in diameter composed of concentric layers and supposed to represent the secretion of calcareous algae to which the name *Cryptozoon steeli* has been applied. Though doubtless calcareous originally, these rounded masses are now almost without exception more or less completely replaced by silica in the form of chert. This fossil occupies a similar position in the Beekmantown throughout the Appalachian Valley and it is so abundant and characteristic that this division is termed the *Cryptozoon steeli* zone. Subaerial decomposition of these particular strata leaves a light reddish residual clay and soil containing an abundance of ordinary yellow platy chert besides the numerous rounded silicified masses of *Cryptozoon*. These cherty residual masses unfailingly identify the outcrop of this zone. It is particularly well exposed in the railroad cut about three-fourths of a mile east of Charlton, Md. Here deep weathering and decomposition of the steeply dipping limestone strata has removed their calcareous matter and left only residual clays with the chert clearly marking its position. The abundance of chert and silicified *Cryptozoon* heads formed in the weathering of this zone is well attested by the frequent piles of chert collected along the roadways.

Immediately following this cherty zone with *Cryptozoon* are 300 feet of dove and pink fine-grained pure limestone, of which a considerable portion can be called marble. These marble beds are well shown in several railroad cuts around Hagerstown. Fossils are rare in these strata, but an occasional layer shows traces of species found also in the underlying beds holding *Cryptozoon steeli.* This zone ends with 275 feet of fine-grained, nearly pure limestone with occasional beds of magnesian limestone and several layers of porous chert.

The platy chert, weathering out of the limestone of the *Cryptozoon steeli* zone is common at all outcrops of the zone, but is so abundant in the western half of the valley that it occasions a distinct row of hills marking the line of outcrop. This topographic feature and the numerous masses of *Cryptozoon* associated with the chert cause this portion of the Beekmantown to be easily recognized. The following species have been found either associated with *Cryptozoon steeli* or in strata underlying it, but still included in this division:

Fossils of Cryptozoon steeli Zone

Cryptozoon steeli Seely
Rhabdaria fragilis (Billings)
Tetradium simplex new species
Syntrophia lateralis (Whitfield)
Maclurites affinis (Billings)
Eccyliopterus triangulus (Whitfield)
Ophileta compacta Salter
Hystricurus conicus (Billings)

At the very base of this zone two interesting fossils have been found associated with the usual gastropods. These are the sponge-like organism *Rhabdaria fragilis* Billings and *Tetradium simplex,* a new species of coral of particular interest in being the oldest known undoubted coral.

The Maryland outcrops of the Cryptozoon steeli zone are so numerous and easily located both on the map and in the field that only a few localities need be mentioned. In the western half of the valley, outcrops along the Western Maryland Railway, especially three-quarters of a mile east of Charlton, show these rocks and their contained fossils. East of the Martinsburg shale belt, exposures in the vicinity of Williamsport and also north and west of Hagerstown have afforded fossils. In the western part of the valley the line of hills in the Beekmantown area next to the Beekmantown-Conococheague boundary represents this zone, but in the eastern part the exposures parallel a line of hills caused by the more resistant Stonehenge beds.

Ceratopea Zone.—Succeeding the dove and pink pure limestones and marbles of the Cryptozoon steeli zone are 250 feet of blue and dove limestone cherty in the upper half, containing horn-like fossils known by the generic name *Ceratopea.* The exact nature of these fossils is unknown, but they are believed to be the opercula of large gastropods like *Maclurites.* From a stratigraphic standpoint they are of considerable interest because this particular species and the fauna associated with it has a wide geographic distribution, but restricted geologic range throughout the Appalachian and Mississippi valleys. Free silicified specimens of this organism occur in the soil where this zone outcrops, or they may be found attached to the limestone. Associated with the *Ceratopea* are a few species of gastropods and fragments of trilobites, but the *Ceratopea* itself is the most characteristic fossil of the division. In Maryland numerous outcrops of this zone can be found in the vicinity of Halfway, particularly in cuts along the Cumberland Valley Railroad. Localities near Hagerstown have also afforded this fossil, although in no place has it been found in the abundance that prevails in Virginia and the states to the south.

The fauna of the Ceratopea zone so far identified consists of nine species. Fragments of a few other species have been noted, but they are too imperfect for description and can only be identified with certainty when a monographic study of the entire Beekmantown formation has been made.

Fossils of the Ceratopea Zone

Dalmanella electra (Billings)
Pleurotomaria ?? canadensis Billings
Hormotoma artemesia (Billings)
Maclurites sordidus (Hall)
Ceratopea keithi Ulrich
Raphistomina laurentina (Billings)
Goniurus caudatus (Billings)
Pliomerops salteri (Billings)
Isochilina gregaria (Whitfield)

Turritoma Zone.—The next division of the Beekmantown consists of about 575 feet of pure dove and gray laminated magnesian limestone, which contains in its upper part high-spired gastropods with a species of *Turritoma* apparently confined to these beds. The lower 375 feet of the Turritoma zone is composed of alternating highly magnesian, finely laminated gray limestones and pure gray and pure dove limestone with occasional beds or streaks of fine limestone conglomerate. The basal 75 feet of this portion occasionally exhibits a few fossils of which *Syntrophia lateralis* and species of *Maclurites* and *Liospira* are most often found.

The association of species called the Turritoma fauna is found only in the upper 200 feet of this division where the fossils usually occur in beds that weather so as to appear riddled with worm borings. Here the fossils are not silicified, but they occur as dolomitic casts, often, however, in good preservation. They are extremely fragile and much care is required to preserve them. Gastropods, particularly the species *Turritoma acrea* (Billings), are most conspicuous. A number of species of fossils, too imperfectly preserved for recognition, occur in this zone in Maryland; eight species have been identified specifically. The strata with *Turritoma* are the uppermost fossiliferous rocks of the Beekmantown, but they are followed by 400 feet of finely laminated, gray, interbedded pure and magnesian limestone of the type considered characteristic of the formation as a whole. At the top of these finely laminated beds are sandy cherts and hard, dense white chert marking the top of the Beekmantown. Associated with these cherts and continuing upward for about 40 feet are great numbers of the secondarily silicified cherts which have assumed

FIG. 1.—EXPOSURE OF LOWER BEEKMANTOWN LIMESTONE JUST ABOVE THE STONEHENGE MEMBER IN BRICKYARD, EASTERN EDGE OF HAGERSTOWN, MARYLAND. CLAY FOR BRICK MANUFACTURE RESULTS FROM THE WEATHERING OF THE PURER BEDS.

FIG. 2.—BEEKMANTOWN LIMESTONE AT LEGORE QUARRY, LEGORE, MARYLAND. THE WEATHERED OUTCROPS OF THESE STRATA HAVE YIELDED NUMEROUS CEPHALOPODS.

the form of a cauliflower. These mark the boundary between the Beekmantown and Stones River limestones. As explained on another page, the secondary silicification necessary to form the cauliflower variety is supposed to have occurred in the time interval between the two formations when the Beekmantown rocks formed a land area.

Sometimes the upper Beekmantown strata holding the Turritoma fauna do not weather as described above, but show the usual occurrence of smooth, rounded outcrops in which the fossils, although numerous, appear only as natural sections in the rock. Such exposures along the National Highway in the vicinity of Huyett, Maryland, have yielded the following species:

Fossils of the Turritoma Zone in Maryland

Dalmanella electra (Billings)
Pleurotomaria ?? gregaria Billings
Hormotoma gracilens (Whitfield)
Turritoma acrea (Billings)
Maclurites oceanus (Billings)
Eccyliopterus disjunctus (Billings)
Cyrtocerina mercurius Billings
Trocholites internistriatus (Whitfield)
Isochilina scelyi (Whitfield)

Traces of this fauna, although always in poor preservation, have been noted at numerous places in Maryland, in fact Beekmantown strata exposed near the boundary line of the Stones River areas usually reveal one or more layers showing natural sections of these fossils.

Topography and Residual Products.—The Beekmantown as a whole produces gently rolling country, but the lower Stonehenge member and a zone about 800 feet above the base of the formation give rise to very characteristic topographic features, which are of extreme importance in the mapping of areas in which rock outcrops are infrequent.

These topographic features are the result of the various siliceous products left in the soil by weathering of the limestone. They are so distinctive that they become as important factors in the identification of the strata as the characters of the rock itself or of its contained fossils. In the absence of fossil remains or indeed of satisfactory rock outcrops it is often possible to determine the underground stratigraphy by the character of these surface residual products alone. In fact such criteria were alone available over considerable stretches of the rolling agricultural country with few rock exposures, that in this region at least, is characteristic of Beckmantown limestone areas. On this account, although they have been mentioned incidentally and repeatedly in foregoing pages, it seems desirable to give here a connected discussion of the three most important residual products, namely, the siliceous shale fragments near the base of the formation, *Cryptozoon* and platy yellow chert near the middle, and the cauliflower chert at the top.

The relatively pure limestone of the lower half of the Stonehenge member weathers rapidly and as its surface is not held up by some resistant residual a slight depression in the land surface results. On the other hand, the upper half of the Stonehenge member, with its sandy laminated strata weathering into a protective covering of thin siliceous shale fragments, forms hills corresponding in width to the outcrops and trending in the direction of the strike of its beds. As the Beekmantown everywhere in the Appalachian Valley of Maryland is highly folded, these hills assume the usual northeast-southwest direction of the folds and their development is so marked a feature that by plotting these elongated narrow hills, the upper Stonehenge member can be mapped in areas of few outcrops of the rock itself. When the succession is normal the lower Stonehenge limestone therefore occurs in a slight valley between the low hills of the upper Stonehenge on one side and the higher land on the other side formed by the chert weathered out of the upper part of the Conococheague limestone. This topographic feature, however, is well developed only to the east of the Martinsburg shale belt. West of this belt the siliceous content of the laminated division of the Stonehenge is so much less that it has little effect on the topography. This topographic feature of the Stonehenge in connection with the line of hills next described makes it possible to map the complicated folds involving the Beekman town limestone without much doubt and has greatly aided in deciphering the geologic structure in areas of few outcrops. The Beekmantown rocks next or immediately succeeding following the Stonehenge divisions are of a more soluble nature and therefore weather into lowland areas again. Therefore the broad area of folded Beekmantown limestones in which Hagerstown is located presents a succession of elongated highland areas alternating with usually broader lowland areas. This alternation in the topography is well shown in Hagerstown itself, where the hills passing through the town are composed of upper Stonehenge limestone and the low areas between them are underlaid by lower Stonehenge or by the overlying Beekmantown limestone.

The line of low hills formed by the upper member of the Stonehenge limestone is a characteristic feature of the Beekmantown topography only, as noted before, in the eastern half of the Appalachian Valley of Maryland, because west of the Martinsburg shale belt the siliceous nature of this member is not so well developed and consequently weathers much like the remaining portions of the Beekmantown. The marked topographic feature of the western belt of outcrops is a line of hills composed of the chert derived from the Cryptozoon steeli zone of the formation which is unusually well developed in this part of the Valley. Here specimens of the *Cryptozoon* are very abundant, and as they silicify upon weathering, their remains leave considerable masses of chert in the soil However, the greater part of this residual material consists of yellow, platy, flinty chert formed by replacement of certain layers of the limestone. The Beekmantown limestone weathers so readily that the determination of the geologic structure of the formation in many cases would be almost impossible were it not for this extensive development of *Cryptozoon* and its accompanying chert. This chert zone is plotted on the map of the western part of the Valley where it gives a clue to the lower boundary of the formation and also aids in determining the structure. For example, the small synclinal area on the west flank of the larger synclinal area three miles northeast of Clear Spring is an interesting case of this zone's value in determining structural relations.

The cauliflower chert developed at the top of the Beekmantown does not occur abundantly enough or through a sufficient thickness of strata to form a topographic feature, but the unusual shape of these flinty objects is so characteristic that their presence in the soil is the surest criterion in determining the dividing line between the Beekmantown and the overlying Stones River limestone. These cherts are believed by some students to represent in reality the physical evidence of the unconformity between these two great limestone formations. Unlike many other cherts they are not the result of present-day surface weathering, but appear to have been formed in the land interval between the two formations. These cherts occur as a regular bedded deposit and their origin seems to be as follows:

With the uplift at the end of Beekmantown time, weathering of the exposed limestones took place, resulting, as it does to-day, under favorable conditions, in a soil with more or less numerous chert fragments. Continual exposure to waters bearing silica in solution caused a secondary silicification of these cherts by the formation of rosettes of silica over their surface. The rosette areas continued to grow larger and larger until the characteristic cauliflower shape resulted. The reason for the formation of such rosettes is obscure, but it is a fact that fractured fossils or pieces of chert will develop areas of rosette quartz along the fractured zones if subjected to the influence of silica-bearing waters. All of the chert at the top of the Beekmantown has not undergone secondary silicification into the cauliflower form. Fragments of platy chert representing the primary silicification stage may occasionally be noted with fracture zones penetrating into or entirely through them. The water with silica in solution will seep into these fractures and deposit the silica there first, thus starting a growth area which develops into the characteristic rosettes of the cauliflower variety. By this process a small fragment of platy or irregular chert by continual growth of the rosette areas will develop into specimens of the cauliflower variety a foot or more in diameter.

Apparently the same process occurs in fractured fossils found in certain siliceous shale formations, particularly of Silurian and Mississippian ages. For example, a crinoid column of say one-half inch in diameter, exposed to silica-bearing waters, will first receive a deposit of silica in its central canal and rosettes of silica will project from each end. The column is fractured by this process and each fracture line then

FIG. 1.—NEAR VIEW OF BEEKMANTOWN LIMESTONE AT LEGORE QUARRY, LEGORE, MARYLAND. STRATA PENETRATED BY A SIX-INCH DIABASE DYKE (MARKED BY HAMMER).

FIG. 2.—VIEW OF CONTACT BETWEEN THE BEEKMANTOWN (B) AND STONES RIVER (S) LIMESTONES ALONG THE SOUTH SIDE OF THE NATIONAL HIGHWAY AT WILSON, MARYLAND. THE ZONE OF CAULIFLOWER CHERT (C) IS WELL DISPLAYED AT THIS PLACE.

becomes filled with silica which, with continual deposition, enlarges the original small column into a mass several inches in diameter. Usually in such cases the resulting mass is hollow and lined internally with crystals, thus forming a geode. Sometimes, however, it is solid, in which event a structure not unlike the cauliflower chert results.

The general problem of silicification is most complicated and little is known yet of either its chemical or physical aspects. Why a certain limestone should, under past or present-day weathering, develop chert products which are so alike over large areas that they can be used in the determination of the bed, is not only an interesting question scientifically, but it is also of such geological importance as to merit the most detailed study.

Another interesting feature in connection with the cauliflower chert is its occurrence, noted at several places, in a black shale, sometimes regularly bedded but again irregularly deposited, much resembling an ancient soil. Such a shale bed at the top of the Beekmantown may be seen in the cut along the National Highway just west of Wilson, Md. Cauliflower cherts are very abundant in this shale bed and its surface outcrop strews the ground with the irregular masses. However, they are not limited to this shale, for here, as well as at other places, the typical chert occurs in regularly bedded dolomite.

Although discussed here in connection with the Beekmantown, the zone of cauliflower chert, if the above explanation is correct, should be regarded as basal Stones River. It might in reality be regarded as a basal conglomerate formed, however, in a totally different manner from other conglomerates.

Areal Distribution.—The Beekmantown limestone with its basal Stonehenge member is the most widely distributed early Paleozoic formation in Maryland, as its outcrop covers large areas in both the Appalachian and Frederick valleys where its strata weather rapidly into good soil and produce a gently rolling country with excellent farm land.

In the eastern belt of outcrop in the Appalachian Valley the formation is closely folded, occupying an area equal to half that of the Valley and extending from a line passing through Security, three miles east of Hagerstown, to a northeast-southwest line west of Williamsport where a fault brings the limestone in contact with the Martinsburg shale. The broad expanse of Conococheague limestone in southern Maryland reduces the width of the Beekmantown here from a belt almost seven miles wide at the Pennsylvania state line to less than three at the Potomac. South of Hagerstown the Conococheague and Beekmantown limestones are intimately folded together, exhibiting characteristic Appalachian pitching anticlines and synclines. The western edge of this belt is a fault line except at the extreme northern and southern ends where the normal sequence is resumed. This fault is clearly shown at Williamsport where the middle limestone of the Beekmantown may be seen in contact with the lower Martinsburg shale. North of Williamsport the displacement of this fault is greater and brings the Beekmantown in contact with the upper sandy portion of the Martinsburg. Infolded in this large area of Beekmantown are elongated, narrow bands of the purer limestones of the succeeding Stones River formation.

In the area west of the Martinsburg shale plateau the Beekmantown limestone likewise occupies about one-half of this part of the Appalachian Valley, but here closely folding with the Conococheague limestone causes each formation to appear at the surface in elongated, more or less parallel bands. The continuity of these bands is broken in the northern part of the state by a transverse fault. West of the eastern base of North Mountain no rocks of Beekmantown age are exposed.

The surface rock of a considerable portion of the Frederick Valley belongs to the red beds of Triassic age, but of the limestone portion of the valley about one-half is occupied by strata referred to the Beekmantown. These Beekmantown areas occupy in general the eastern half of this portion, although folding brings small areas to the surface in the western half. Two small areas just east of Catoctin Mountain are of interest because erosion of the red beds has proceeded far enough to expose the underlying Beekmantown strata.

East of the Frederick Valley on the Piedmont Plateau, narrow, elongated, infolded areas of limestone occur, only one of which is shown on the map because of its evident relationship to the limestone of the valley proper. Metamorphism has destroyed the evidence as to the age relations of these limestones, although it is possible that they represent an eastern extension of the fossiliferous Beekmantown strata of the Frederick Valley.

FREDERICK VALLEY LIMESTONES

The considerable development of Early Paleozoic limestones east of Catoctin Mountain in the Frederick Valley and their economic value has long been known to geologists. As these deposits occur east of the Blue Ridge and are the easternmost unmetamorphosed Paleozoic strata known, the determination of their exact age relations is a matter of importance and interest. The Frederick Valley is bounded on the west by Catoctin Mountain, composed of Lower Cambrian sandstone and shale, and on the east by a range of low hills formed by pre-Cambrian schist. The length of the limestone area is about 30 miles and its maximum breadth about six miles. North of LeGore, Maryland, the limestones pass under cover of the Newark red beds, while at the Potomac they cross into Virginia where they again soon disappear under the red beds.

This area has been studied by several geologists, but the most important work upon it was that of Keyes, who published his results in 1890 in the Johns Hopkins University Circular. His description of these rocks is as follows: "The beds have a mean dip of about 25 degrees to the eastward. Along their western border they are covered by Triassic red sandstones (Newark formation). To the east the limestones pass gradually into shales and slates, the whole forming apparently a conformable series. The limestones in great part are bluish in color, compact and heavily bedded; but on approaching the shales they become more and more thinly bedded and very dark blue or nearly black, owing to the bituminous matter present. The latter, however, is driven off by burning, leaving a pure white lime. In places this lime rock is highly siliceous on account of the presence of a considerable amount of rather coarse quartz sand.

This large amount of silica renders the rock unfit for the manufacture of lime, which at present is the chief use to which the Frederick Valley limestones are put. From the thin-bedded belt the limestone passes into a more earthy facies and grades into dark colored calcareous shales and these again into slates or into sandy shales."

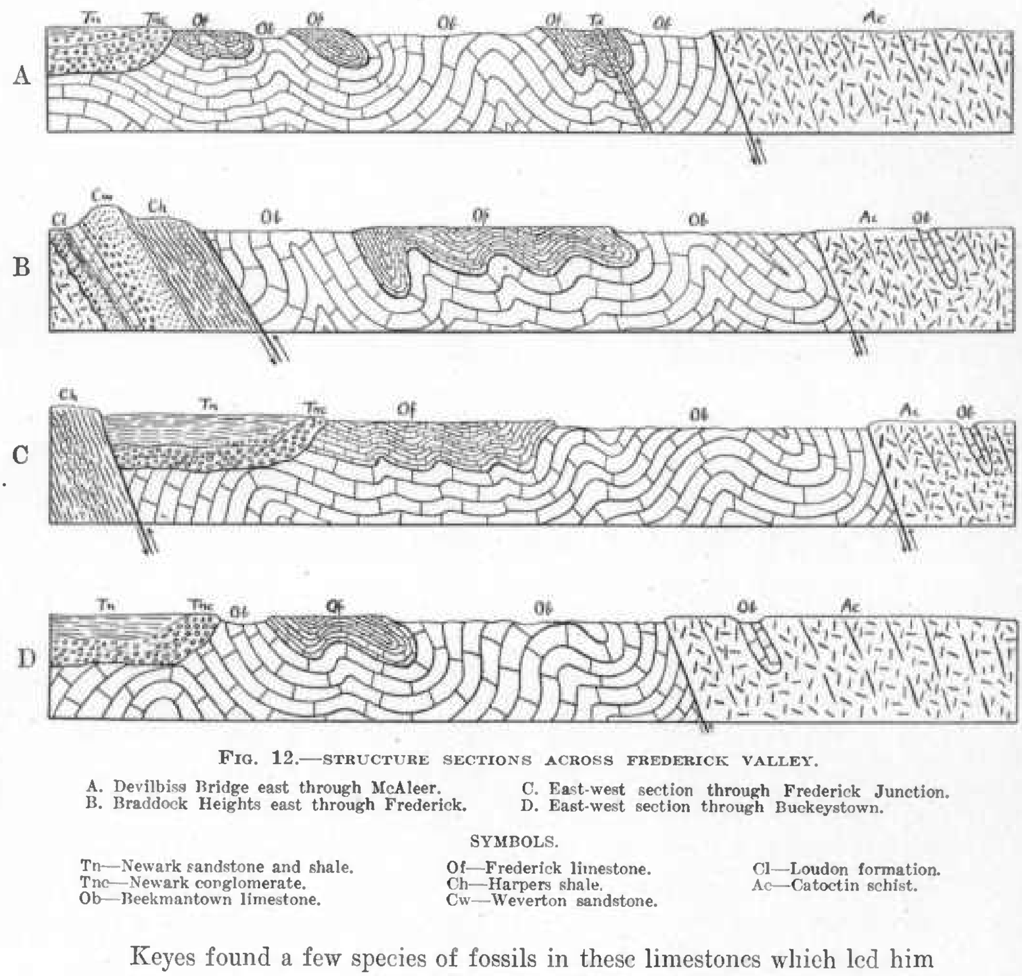

FIG. 12.—STRUCTURE SECTIONS ACROSS FREDERICK VALLEY.

A. Devilbiss Bridge east through McAleer.
B. Braddock Heights east through Frederick.
C. East-west section through Frederick Junction.
D. East-west section through Buckeystown.

SYMBOLS.

Tn—Newark sandstone and shale.
Tnc—Newark conglomerate.
Ob—Beekmantown limestone.
Of—Frederick limestone.
Ch—Harpers shale.
Cw—Weverton sandstone.
Cl—Loudon formation.
Ac—Catoctin schist.

Keyes found a few species of fossils in these limestones which led him to suggest that the whole series was equivalent to the Chazy, Trenton, and Hudson River formations. The determination of the age and structure relations of the Frederick Valley limestones was a matter of some difficulty, and the present author was fortunate in having this earlier work upon the subject even though he is unable to agree with some of the conclusions. Comparison of the four structure sections across the Frederick Valley, here presented as fig. 12 with that published by Keyes, will show that the present conception of the structure and stratigraphy differs radically.

The lowest sedimentary rocks of this particular region are comprised in the Lower Cambrian quartzites, the Weverton sandstone and the succeeding Lower Cambrian Harpers shale exposed in Catoctin Mountain. Sugar Loaf Mountain, on the east, likewise is composed of Lower Cambrian quartzite. In the opinion of the writer the limestone series does not pass upward on the eastern side of the valley into Hudson River shales, but it is faulted against shales and schists which are of pre-Cambrian age. Along the western side of the Frederick Valley the limestones are covered by the conglomerate, red sandstone and shale of the Newark series except in two areas where stream erosion has cut deeply into and in places almost to the base of the underlying limestones.

The structural relations of the Frederick Valley are so complicated that it would be difficult to unravel the stratigraphy were it not for the occasional presence of fossils. Determinable, though but rarely preserved, fossil remains have been noted at numerous places in the valley in two distinct kinds of rocks, namely, in dark blue thin-bedded strata, known locally as the building rock, and in massive, rather pure, blue to white limestone that is quarried for lime. The fossils in the quarry rock have been found distributed through several hundred feet of strata. They consist mainly of cephalopod shells which are closely related to lower Beekmantown species. The fauna found in the building rock consists of a brachiopod and a trilobite of types which are unquestionably of post Beekmantown age. By fossil evidence, therefore, the age of the quarry rock is established as older than the building rock. This conclusion is borne out also by the structural relations of the beds, the building rock being invariably infolded in the quarry rock. In all probability, the line of contact between the limestone which forms the floor of the valley and the siliceous formations which form its elevated east and west boundaries, is in both cases a fault plane. There is little doubt as to the faulting on the east side, but the evidence is not so convincing on the west side. The succession there may be normal, that is, undisturbed with the Beekmantown limestone lying unconformably on the Lower Cambrian Harpers shale.

The Beekmantown Limestone

All of the numerous quarries in the Frederick Valley operated for the burning of lime expose massive, rather pure, bluish limestones which hold fossils of Beekmantown age. The rock itself is not unlike that of the lower Beekmantown above the Stonehenge member in the Appalachian Valley, so that the use of the name Beekmantown for the quarry rock seems appropriate. It is even possible that the Stonehenge member is represented here, for in the outcrops of Paleozoic limestone in the western part of the valley, namely, along the trolley car track two and one-half miles northwest of Frederick, strata with edgewise conglomerates are well developed. Usually, in this part of the valley, these massive limestones are covered by Mesozoic red beds. However, in two places, erosion has removed the red beds so as to expose not only the quarry rock, but also the underlying Harpers shale. One of these is in a small area two miles south of Catoctin, the other a larger exposure just east of Braddock. Fossils were not observed in either of these areas, but the lithology of the limestone is precisely like that of the fossiliferous strata a short distance to the east. Moreover, as shown on the map (pl. I), an area of quarry rock just east of Braddock contains an infolded band of fossiliferous building rock. Throughout the central and eastern parts of the valley where the quarry rock frequently outcrops there can be no question regarding the Beekmantown age, for here fossils are not uncommon. Along the eastern edge of the valley just west of the pre-Cambrian schists there are outcrops of a massive light gray laminated limestone in which the laminae are much contorted and weather into a sandy shale somewhat resembling the shale fragments resulting from the disintegration of the upper Stonehenge member of the Beekmantown. Fossils have not been discovered in these particular beds, but these laminated strata undoubtedly represent a part of the Beekmantown as developed in the Frederick Valley.

The northernmost exposures of the Frederick Valley limestones occur at LeGore, Maryland, just before these strata disappear under the red beds. Extensive quarrying operations here have exposed a considerable section of closely folded and evidently repeated beds. The clue to the proper sequence is given by several bands of the normally overlying thin-bedded fossiliferous building rock that are infolded with the more massive Beekmantown limestones.

At LeGore the building rock is immediately underlaid by about 100 feet of massive dark blue rather pure limestone in beds two to three feet thick, alternating with similar beds of lighter colored strata. Cephalopods of Beekmantown affinities are not uncommon on the weathered edges of these strata. These upper fossiliferous beds are separated by about 50 feet of massive light blue limestone with quartz grains, from a lower fossiliferous zone. This comprises several hundred feet of strata similar in lithology and fossils to the upper beds. The section then continues for several hundred feet which appear to be a repetition by folding of the strata just described. Many of these massive beds are very homogeneous and marble-like in character. The quarries at Frederick and to the south also afford excellent exposures of the upper beds of the massive limestone, but as the strata are little folded here, the exposed thickness is consequently slight. On account of their ready solubility, outcrops of these pure massive limestones appear only in lowland areas. They also leave no surface residual products such as the quartz or shale fragments of the building rock.

The Frederick Limestone

This new name is proposed for the strata in the Frederick Valley overlying the Beekmantown limestone and containing a fauna probably of Chazyan age. The rocks are shown to advantage in numerous quarries and natural outcrops around Frederick. Fossils are of rare occurrence in these outcrops, but they may be found occasionally in the broad, thin slabs of which the stone fences of the valley are built.

The Frederick limestone consists of thin-bedded dark blue argillaceous strata separating into layers usually less than two inches in thickness. On further weathering, these leave as a residual product in the soil, brownish-yellow shale-like fragments quite similar to the weathered Martinsburg shale of the Appalachian Valley. This limestone is often much crumpled and so seamed with quartz veins that the disintegration of its strata leaves numerous fragments of white crystalline quartz in the soil. In freshly quarried exposures the Frederick limestone appears massive and dark blue, but slight exposure to the weather causes its separation into the thin flagstones so much used in this area for building fences and embankments that the local name of building rock is applied to it. It is less soluble than the associated purer Beekmantown limestone, so that in weathering it gives rise to hill topography which is in marked contrast to the lowland areas characteristic of the Beekmantown strata. The dark-blue color, thin platy layers of argillaceous composition, upland topography and residual quartz fragments distinguish it readily from the lighter colored, massive, purer rock referred to the Beekmantown.

Although numerous exposures of the Frederick limestone may be seen in the vicinity of Frederick, perhaps the best place to view its contact with the underlying Beekmantown limestone is at the Tabler quarry where a distinct line of unconformity may be noted between the two formations.

The thickness of the Frederick limestone is difficult to determine because it has no recognizable upper boundary such as the succeeding formation. However, in areas where it is infolded into the Beekmantown limestone, its thickness seems to be not less than 200 feet. Such infolded areas are well shown in the quarries at LeGore, Maryland.

Although of rare occurrence fossils can be found in this limestone more frequently than in the subjacent strata because the opportunities for collecting are more numerous. The natural outcrops of the rock seldom show organic remains, but it is only a matter of search along the stone fences of the Frederick Valley to discover fossils in the thin limestone layers of which most of them have been built. Five species have been noted, only two of which are sufficiently preserved for specific description. These are *Acidaspis ulrichi* and *Strophomena stosei,* two new species and an undetermined species each of the genera *Reteocrinus ?, Cameroceras* and *Isotelus.* The prime interest of this fauna, like that of the underlying Beekmantown, is in its occurrence east of the Blue Ridge. This particular association of species is also noteworthy because neither the fauna itself nor the beds containing it can be correlated directly with any Appalachian Valley formation. However, the fauna suggests a Chazyan or early Mohawkian age with the possibility more in favor of the former.

THE STONES RIVER LIMESTONE

The purest limestones of the Shenandoah series are contained in the strata occurring between the underlying finely laminated pure and magnesian Beekmantown formation and the overlying argillaceous nodular Chambersburg limestone of Black River age. These pure limestones are correlated on lithologic, stratigraphic, and paleontologic grounds with the Stones River group or formation of the Central Basin of Tennessee. In Maryland the Stones River limestone rests unconformably upon the Beekmantown, the uneven contact being well marked by an extensive development of secondarily silicified chert known as "cauliflower" chert.

The Stones River was named and defined as a distinct group in 1855 by Safford, who based it on the limestones outcropping along the Stones River in the vicinity of Murfreesboro, Tennessee. The group includes the lowest rocks appearing at the surface in the Nashville dome of the Cincinnati axis. Safford, in his "Geology of Tennessee" (1869), abandoned the term under the misapprehension that the Stones River rocks were equivalent to the Trenton of New York. Winchell and Ulrich, in 1897, revived the name, and later Ulrich and Hayes, in the description of the Columbia quadrangle of the U. S. Geological Survey, more completely defined the group.

GENERAL SECTIONS.—As recognized to-day the Stones River group in its type area in Central Tennessee includes the following formations:

Formations of Stones River Group in the Type Area, Central Tennessee

	Fee
Lebanon limestone, flaggy, dove and shaly limestone	120
Ridley limestone, massive subgranular, often cherty limestone	80
Pierce limestone, shaly limestone crowded with bryozoans	27
Murfreesboro limestone, heavy bedded cherty limestone (base not exposed)	125

In the gorge of Kentucky River at and above Highbridge, Kentucky, which cuts through the oldest rocks to be seen in the state, the lower 200 feet of the bluffs are made by massive limestone strata representing Lebanon and Ridley members of the Stones River. In the Appalachian Valley, rocks corresponding in age, and also very closely in lithologic character with the typical Stones River, outcrop in periodically interrupted bands from Alabama to New York. In the valley of East Tennessee, where they attain a maximum thickness of more than 1200 feet, the lithologic facies and sequence that agrees best with the typical expression of the formation is confined almost entirely to the western side of the valley. Here a twofold division may be recognized—a lower division of massive, mainly pure, dove limestone and an upper division of more argillaceous strata. The limestones in northern Virginia, Maryland, and Pennsylvania referred to the Stones River agree in all essential respects with these representatives of the group in the south. Here, however, the formation is divisible into three parts, of which the lower and upper thirds are of solid, massive, dove limestone and the middle third of more granular often cherty blue rock holding the fauna of which the large gastropod *Maclurites magnus* is the most characteristic member. The lower part is essentially equivalent to the Murfreesboro limestone, the middle division to the Pierce and Ridley beds, and the upper third to the Lebanon limestone of the type section. In the eastern half of the Appalachian Valley in Virginia and Tennessee the *Maclurites magnus* fauna occurs and attains its best development in a formation of argillaceous limestone—the Lenoir limestone. In this part of the valley the upper member is not present, so that here the Lenoir lies at the top of the beds that are strictly of the age of the Stones River. Beneath the Lenoir is a massive dove limestone formation, the Mosheim limestone, which is either

FIG. 13.—EARLY ORDOVICIAN (ST. PETER).

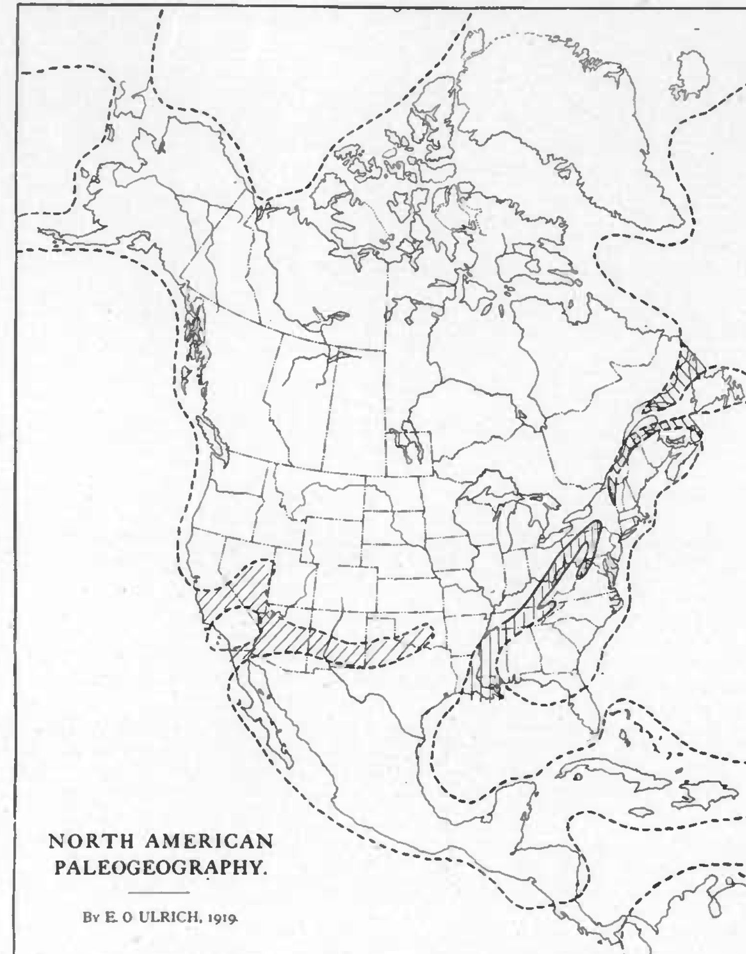

FIG. 14.—EARLY ORDOVICIAN (MOSHEIM).

distinctly older than the Murfreesboro limestone of the type area or it represents the basal part of that formation which does not reach the surface in central Tennessee. A weak, though typical representative of the Lenoir limestone fauna, is found in Maryland in the middle third of the Stones River and it is probable that the upper and lower thirds of the formations here developed represent all the remaining sedimentation of Stones River time.

Although there is no continuous section in Maryland where the complete sequence may be observed, a generalized section in areas where the three divisions are well developed is as follows:

Generalized Section of Stones River Limestone in Maryland

	Feet
Nodular, argillaceous strata of the Chambersburg limestone........	...
3. Massive and thin bedded fine grained, pure, dove-colored limestone..	300±
2. Massive pure limestone, blue to dark gray in color, compact, granular and oölitic, on weathering leaving black, blocky chert; contains the *Maclurites magnus* fauna..............................	200±
1. Massive and thin bedded, pure, dove limestone in the lower part interbedded with magnesian layers..............................	600±
Light gray, finely laminated magnesian limestone of Beekmantown age, with cauliflower chert at top..............................	...

This generalized section holds, also, for southern Pennsylvania, but from here northward the Stones River limestone diminishes in thickness due to progressive loss of the lowest beds by overlap. Between Greencastle and Chambersburg, Pennsylvania, the three divisions of the formation have a combined thickness of about 1000 feet. At Carlisle the lowest division and a part of the middle are missing, leaving the formation only about 450 feet thick. Farther north at Harrisburg the middle member has been diminished by another hundred feet. Throughout the Lehigh Valley in Pennsylvania and its continuation in New Jersey, the Stones River is absent altogether. In eastern New York this formation is still absent until the upper Champlain region is reached where the Stones River interval is occupied by Chazyan limestones. The Middle Chazyan Crown Point limestone contains the *Maclurites magnus* fauna and thus offers a means of correlation with the more southern Stones River limestone.

FIG. 1.—AN AVERAGE EXAMPLE OF THE CAULIFLOWER CHERT FROM THE BASE OF THE STONES RIVER LIMESTONE. VICINITY OF BOSTETTER, MARYLAND.

FIG. 2.—TYPICAL NATURAL OUTCROP OF UPPER STONES RIVER LIMESTONE IN CLEARED FIELDS, ONE-HALF MILE WEST OF PINESBURG, MARYLAND. THE GROWTH OF CEDAR TREES ON THIS PURE LIMESTONE IS ILLUSTRATED.

LITHOLOGIC CHARACTER.—The Stones River rocks in Maryland are in general heavily bedded dolomitic layers alternating with greater thicknesses of relatively pure dove-colored limestones. In color and texture the purer rock varies from fine-grained dove to a dense black with the dove-colored rock predominating. Many of the layers run as high in magnesia as the underlying Beekmantown limestone, but the Stones River formation differs in that at least a few pure dove limestone layers are found in almost every exposure. The pure limestone is most abundant at the top of the formation, which portion therefore is most extensively quarried. Many of the layers throughout the formation and especially the purer strata are penetrated by the thin calcite strings belonging to the single-tubed species of the coral *Tetradium,* which, in connection with the smooth, homogeneous ground mass and color of the main rock, gives it a very characteristic aspect. Another method of distinguishing the Stones River from the Beekmantown lithologically lies in the character of the soil to which each gives rise on weathering. The soil resulting from the decomposition of the Beekmantown limestone is of a deep red color, and generally contains a considerable quantity of broken chert. Stones River rocks, on the other hand, are practically free of chert except the middle division; and one soon learns to discriminate this chert from all the varieties formed in the decomposition of the Beekmantown limestone.

Soil formed by decay of Stones River rocks seems to be particularly suited for the growth of cedar trees. Indeed, the presence of a considerable number of cedar trees in an area of Ordovician strata is quite a reliable sign that the underlying rocks are of this age. Of course, this preference of cedars for Stones River areas is due primarily to the nature of the rock itself, in this case, the pure dove strata being cedar-bearing. The extensive well-known cedar glades of central Tennessee are located upon the pure, dove-colored Stones River limestone.

PALEONTOLOGY.—Dove limestones which make up the greater part of the formation do not as a rule afford well-preserved fossils, although traces of organic remains in the rock may be very numerous. In fact some of these pure limestone layers are crowded with gastropods, but specimens cannot be broken out of the rock in recognizable condition. Their cross-sections indicate a general type of structure quite unlike and more advanced than the gastropods found in the underlying Beckmantown limestone. Two fossils, however, both easily recognized, may be found at almost any outcrop of this limestone. One is a coral formed of single tubes, quadrangular in cross-section, but commonly appearing more like calcite stringers in the rock than organic remains. This is the *Tetradium syringoporoides* described on a later page. The second fossil is a bean-shaped bivalved crustacean allied to *Leperditia fabulites* which occurs throughout the limestone. Other recognizable fossils occur, but as they are more limited in their stratigraphic distribution, details regarding them are reserved for the special discussions of the several divisions.

Lower Stones River.—Although present in several bands of outcrop across Maryland, this portion of the Stones River is usually covered and the character of the rocks can be made out only from a few scattered outcrops. The best development is in the band of outcrop exposed just west of Pinesburg Station and running north almost to the state line. This same band of outcrop is exposed at Martinsburg, West Virginia. Here many of the layers, especially in the upper two-thirds of the member, show sections of undetermined gastropods and pelecypods and of the large ostracod *Leperditia fabulites.* In the quarries on the west side of the town which expose the lower 200 feet of the formation Ulrich reported certain weathered layers about 125 feet above the base of the formation, from which he collected the following fauna:

Fauna of Lower Stones River Limestone, Martinsburg, West Virginia

Girvanella sp.
Solenopora compacta var.
Small, undetermined monticuliporoid bryozoan
Cyrtodonta n. sp.
Matheria n. sp.
Liospira cf. *obtusa*
Lophospira cf. *perangulata*
Lophospira n. sp. of the *L. trochonemoides* section
Helicotoma ? n. sp.
Orthoceras sp. undet. Small, with narrow septa
Oncoceras ? sp. undet.
Leperditia fabulites Conrad var.

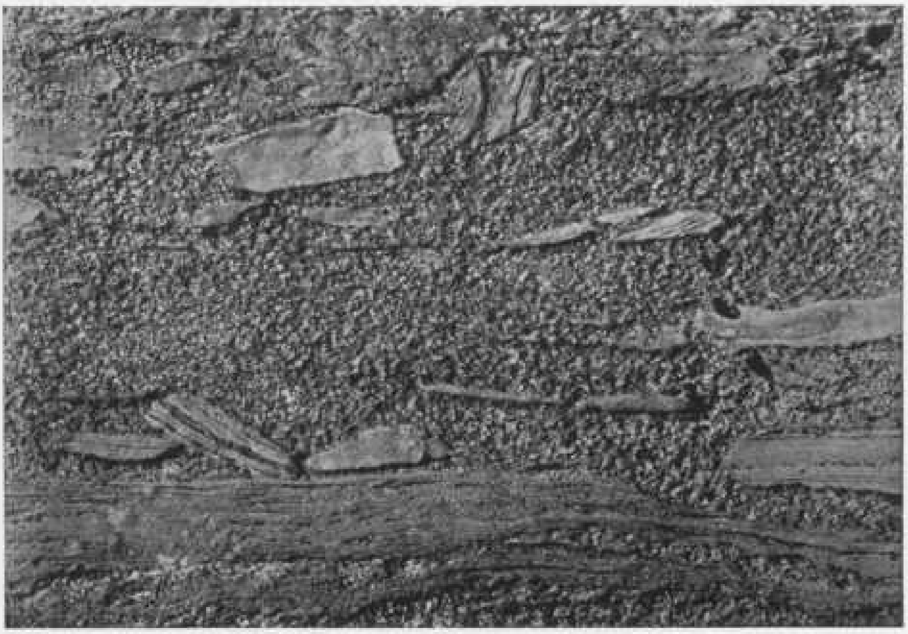

FIG. 1.—VIEW OF EDGEWISE CONGLOMERATE IN STONES RIVER FORMATION 2½ MILES SOUTHEAST OF WILLIAMSPORT, MARYLAND.

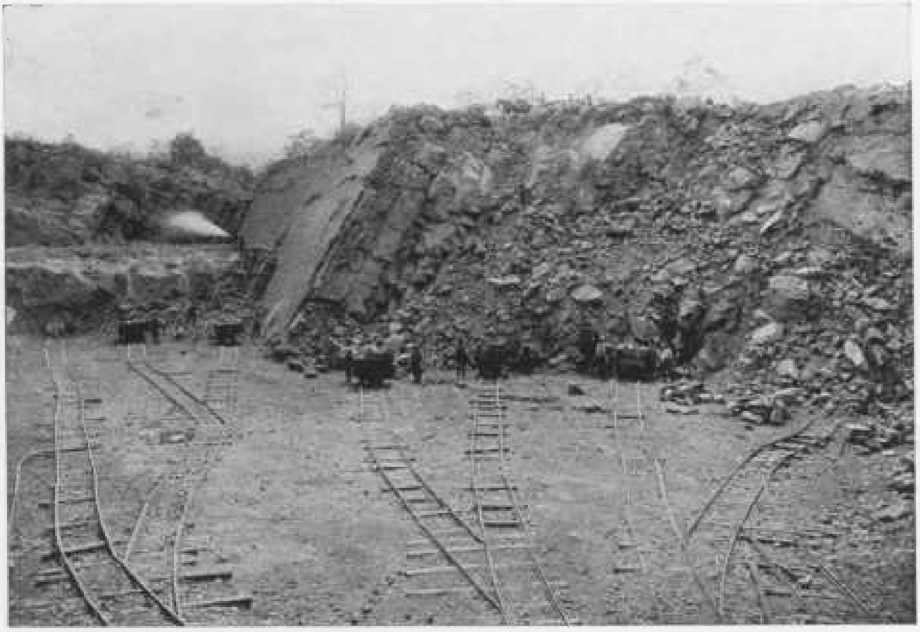

FIG. 2.—VIEW OF QUARRY IN CHAMBERSBURG LIMESTONE AT PINESBURG STATION, MARYLAND.

Traces of this fauna have been found in Maryland, but neither these nor the specimens from West Virginia are thought well-enough preserved to warrant illustration and description.

This lower division is about 600 feet thick and consists of massive and thin-bedded pure dove limestone interbedded, especially toward the base, with magnesian layers. Certain parts of the underlying Beekmantown limestone are much like these in lithic character, but the presence of bivalved pelecypod shells in the Stones River and their complete absence in the Beekmantown serves to distinguish the two formations. No well-exposed section of the Lower Stones River was found in Maryland, but at Martinsburg, West Virginia, the following section is more or less clearly exposed in quarries and nearby natural outcrops.

Section of Basal Beds of Stones River Limestone at Martinsburg, West Virginia

	Feet
Strata of Middle Stones River	...
Light to dark drab limestone banded with thin earthy or magnesian seams	275
Strata like the above but less well exposed	200
Dark-gray to dove-colored, fine, even-grained pure limestone (quarried)	100
Similar fine-grained, dove-colored limestone, increasing downward in magnesium (quarried)	100
Section extends to the cherty top of the Beekmantown.	
	675

Railroad cuts along the Cumberland Valley Railroad north of Kauffman, Pennsylvania, eight miles north of the Maryland line, show the general character of the division. This same band of outcrop continues southward into Maryland and a number of localities show small outcrops of the basal rocks. At Bostetter the very base of the formation is exposed at a low angle of dip, with the result that a considerable area here is covered with the cauliflower chert described under the discussion of the Beekmantown limestone. This cauliflower chert marks the base of the formation in the northern half of Maryland east of the Martinsburg shale belt, and it is present in all the bands of outcrop west of this belt. In the southern part of the area east of the shale belt, the Stones River rocks are poorly exposed and their basal beds are marked by edgewise conglomerates quite similar to those of underlying formations. These conglomerates occur in place of the cauliflower chert which is so conspicuously developed elsewhere in the valley. Occasionally these basal edgewise conglomerates become silicified, leaving very interesting chert blocks in the soil exhibiting the conglomeratic fragments as pure chalcedonic silica, or in some cases showing them leached out of the rock entirely.

Middle Stones River.—The middle part of this limestone is so readily distinguished from the upper and lower divisions by its fossils and lithology that it might well be ranked as a distinct formation. The Middle Stones River differs conspicuously from the other divisions in the presence of massive beds of dark, subgranular limestone interbedded with the more typical dove-colored, fine-grained, pure limestone. Fine-grained, pure, fossiliferous limestone weathering so as to show numerous bands of black chert form a characteristic part of this division. In the absence of outcrops an easily recognized criterion for the determination of the middle division is the presence of small blocks of chert in the soil. This chert is usually black, at least the inside of the blocks when broken show up as black. Furthermore, the Middle Stones River is generally more fossiliferous than the other divisions and the typical fossil, the large coiled gastropod shell *Maclurites magnus,* can usually be found in it after a little search.

The best outcrops for fossils of the Middle Stones River are in the quarries around Chambersburg, Pennsylvania, where the fauna listed below was collected and determined by Ulrich (Chambersburg-Mercersburg Folio). All of these species, however, have been noted in the corresponding band of outcrop in Maryland, although all have not occurred at a single place.

Fauna of the Middle Stones River Limestone in Southern Pennsylvania and in Maryland

Tetradium syringoporoides (Ulrich)
Hebertella borealis (Billings)
Hebertella vulgaris (Raymond)
Dinorthis platys (Billings)
Bucania sulcatina (Emmons)
Maclurites magnus (Lesueur)
Lophospira bicincta (Hall)
Ampyx halli (Billings)
Leperditia fabulites (Conrad) var.

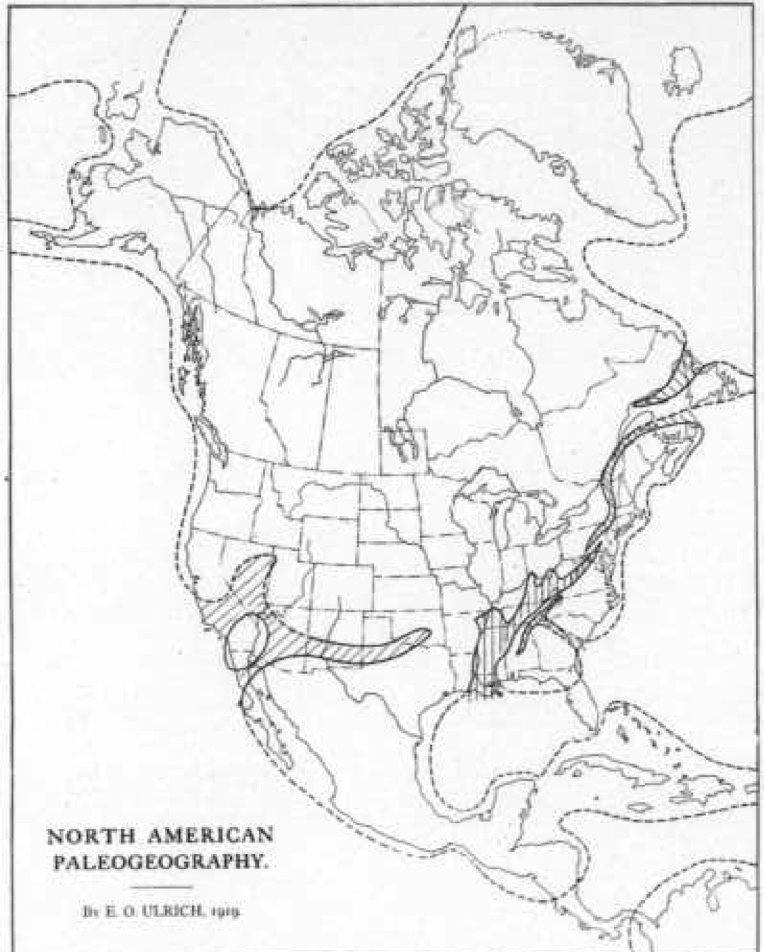

FIG. 15.—MIDDLE STONES RIVER ("MACLURITES MAGNUS" FAUNA).

FIG. 16.—UPPER STONES RIVER.

P. 124B

This fauna is correlated with the Middle Chazy or Crown Point limestone of New York and the Lenoir limestone of southern Virginia and Tennessee, in each of which most of these species occur.

Upper Stones River.—The upper division consists of very pure, thin-bedded, dove-colored or pearl gray homogeneous limestone which is quite frequently exposed because most of the quarries are in this rock. The large quarry at Pinesburg Station exposes a considerable thickness of these pure upper beds. Here also sections of numerous fossils may be noted, but the rock is so homogeneous that the specimens cannot be broken out, and it weathers in such a manner that the fossils are not left in relief on the surface. The only species which can be obtained in any fair state of preservation is the characteristic Stones River single tube coral *Tetradium syringoporoides.*

A conspicuous topographical feature of this portion of the Stones River particularly is the occurrence of numerous sinks along its line of outcrop. However, conditions favoring the formations of such sinks occur also in the lower portion of the Stones River.

AREAL DISTRIBUTION AND TOPOGRAPHIC FORM.—The outcrops of the Stones River limestone in Maryland are confined to the Appalachian Valley and cross the state in five distinct bands, three of which occur east of the shale belt of the middle portion of the Valley, and two to the west. The strata of the three eastern belts are not as highly folded as those to the west and the areas of outcrop are therefore wider. Each of these belts occupies a nearly level lowland broken only by low hills formed by the cherty middle division. In the northern half of these three belts the chert and resulting low hills of the Middle Stones River are especially well developed. In Maryland this middle portion has been noted in outcrops at many points. The residual black chert is frequently so abundant in the soil that it leaves its impress upon the topography in the form of low hills arranged according to the geological structure. This is illustrated in an area just south of the Pennsylvania state line and directly north of Hagerstown where the outcrop of the Middle Stones River cherty limestone is plainly indicated by the low hills elongated in a

FIG. 1.—PHOTOGRAPH SHOWING SUCCESSION OF SINKS ALONG THE BAND OF OUTCROP OF THE STONES RIVER LIMESTONE, ONE-HALF MILE SOUTH OF WILSON, MARYLAND. THE ROAD TO THE EAST FOLLOWS THE CHAMBERSBURG LIMESTONE.

FIG. 2.—NEAR VIEW OF A SINK FILLED WITH WATER.

general northeast-southwest direction, but aligned to coincide with the general structure of the region. In this same area the zone of cauliflower chert at the base of the Stones River is also well developed, but forms no special topographic features. With weathering, however, the chert breaks up into smaller and smaller fragments so that its presence is not a detriment to the soil. One of the two western belts lies just west of the Martinsburg shale area and the second is a short belt cut off by faulting in the middle of the state and occupies the center of the western half of the Great Valley.

Each of these more western belts is quite narrow, because the rocks are steeply inclined. Here too the Middle Stones River cherty limestone is not as clearly developed as in the more eastern areas. Rocks outcrops usually are few, and the formation everywhere gives rise to excellent farm land soil.

FAUNA OF THE STONES RIVER IN MARYLAND.—The fossils of the Stones River limestone in its typical development in the Central Basin of Tennessee have not received as much attention as those of the younger Ordovician formations, but a considerable fauna from each of its divisions has been collected and awaits description. The faunas of the corresponding rocks in the Champlain Valley have been quite fully described by Raymond in recent years and Middle Chazyan faunas have been recognized farther south in the Appalachians. In Maryland the middle division of the Stones River limestone contains enough Middle Chazy species to make it reasonably certain that these strata represent the same time interval. The massive, purer dove and magnesian limestone of the upper and lower divisions of the Stones River in Pennsylvania and Maryland are not favorable for the occurrence of well-preserved fossils. These two divisions do not weather into chert, and the best specimens from massive limestone are always to be found in the residual cherts. The single-tubed coral, *Tetradium syringoporoides,* and the bean-shaped ostracod, *Leperditia fabulites,* are abundant throughout the Stones River and may be found at almost all exposures. The other seven species here described are all species occurring in the Middle Chazy of the Champlain Valley. The Maryland Stones River fauna and its occurrence elsewhere is listed below.

FAUNA OF THE STONES RIVER LIMESTONE IN MARYLAND

	Stones River of Maryland			Lenoir lime-stone of Tenn.	Middle Chazy of Champlain Valley
	Lower	Middle	Upper		
Tetradium syringoporoides Ulrich	*	*	*	..	..
Dinorthis (*Plaesiomys*) *platys* (Billings)	..	*	..	*	*
Hebertella borealis (Billings)	..	*	..	*	*
Hebertella vulgaris Raymond	..	*	..	*	*
Bucania sulcatina (Emmons)	..	*	..	*	*
Lophospira bicincta (Hall)	..	*	..	*	*
Maclurites magnus Lesueur	..	*	..	*	*
Ampyx (*Lonchodomas*) *halli* Billings	..	*	..	..	*
Leperditia fabulites (Conrad) var	*	*	*	..	..

The lower and upper division of the Stones River in Maryland, particularly the latter, frequently exhibit layers crowded with gastropods and pelecypods. These show at the surface as natural sections and weather away as fast as the rock. Without a knowledge of the fauna of the similar dove limestone of the Stones River elsewhere, it is impossible to identify such natural sections with certainty.

The areas of the Stones River limestone east of the Martinsburg shale belt have yielded few fossils because the rocks weather into a deep soil and outcrops are consequently infrequent. The boundaries of these areas have in most cases been determined by the occurrence of the basal Stones River cauliflower chert zone. In northern Maryland, the broad folded area of this formation just northeast of Maugansville and another a mile northwest of the same place show the best development of the Middle Stones River limestone with the characteristic chert hills left by its weathering. In this chert all of the fossils in the above list have been noted. West of the shale belt the band of outcrop starting at Pinesburg Station and going east of north through Wilson to the state line affords numerous outcrops of the dove limestone of the lower and upper divisions. Some of the layers in the Upper Stones River at Pinesburg Station are crowded with *Tetradium syringoporoides,* while *Leperditia fabulites* and several species of undetermined shells occur in great number in other beds.

THE CHAMBERSBURG LIMESTONE

Most students of Appalachian stratigraphy have recognized a so-called transition zone of argillaceous limestone between the massive limestones of the Shenadoah group and the overlying great shale formation, the Martinsburg shale. These argillaceous limestones are thin bedded and quite fossiliferous in comparison with the underlying and overlying strata. They were classed as the closing phase of the Shenandoah group and their contained fossils established the Ordovician age of the upper part of that group. As their lithologic character is clearly enough intermediate between that of the underlying pure and magnesian limestones and the typical shale group above, it was natural to believe that they were really transition beds. However, detailed comparison of the faunas of these argillaceous beds in different parts of the Appalachian Valley in recent years has shown that these strata are either not transition beds at all or that the supposed transition occurred at widely different times in different parts of the valley. The fossils showed that as a rule shale deposition set in much earlier in the eastern bands of the Appalachian Valley than in the western. Also that these dates varied considerably even in north and south directions. The "transition" beds when closely studied proved to represent formations of totally different ages in various parts of the valley and that stratigraphic breaks, sometimes of considerable extent, commonly separate them from both the underlying and overlying strata. For example, in the eastern bands of the valley of east Tennessee this argillaceous limestone phase of deposition is the Lenoir limestone of middle Chazyan age, while at the western side of the valley the limy beds just under the first shale are late Trenton in age. Again, in southern Pennsylvania the Chambersburg limestone of Black River age directly or immediately precedes the Ordovician shale group in the eastern or Cumberland Valley, whereas in central Pennsylvania the shale is underlain by uppermost Trenton. The basal part of the shale itself varies correspondingly in age from upper Chazyan to Utica.

In Maryland, as in southern Pennsylvania, the fossiliferous, thin-bedded limestone with argillaceous partings, formerly regarded as the uppermost division of the Shenandoah group, is now called the Chambersburg limestone, so named by Stose from outcrops in the vicinity of Chambersburg, Pennsylvania. This limestone is subject to great variations not only in thickness, but in the character of the rocks from place to place along the strike and across it. The rather broad expanse in southern Pennsylvania exposing Cambrian and Ordovician strata exhibits many outcrops of Chambersburg limestone. This is particularly true in the Chambersburg and Mercersburg quadrangles in Pennsylvania where good collections of fossils have been made and numerous sections of the strata were studied. This broad area of outcrop is divided by a wide synclinal belt of Martinsburg shale that continues southward through Maryland into Virginia and lies in a continuation of the Massanutten syncline. As the towns of Chambersburg and Mercersburg are located respectively in the eastern and western belts, it has been found convenient to term these two belts of outcrop the Chambersburg and Mercersburg troughs. The very different composition and thickness of this formation in the two troughs has been used by Ulrich in his Revision of the Paleozoic Systems as a striking illustration of the instability of the continental floor during Middle Ordovician time. A résumé of these differences is presented under the discussion of the sections.

LITHOLOGIC CHARACTER.—The Chambersburg limestone as a whole is characterized by thin-bedded, fossiliferous, dark-blue, argillaceous limestone with clayey partings. Many of its layers upon weathering have a tendency to break up into rounded cobblestone-like fragments. This "cobbly" nature of the weathered outcrop is so noticeable and characteristic of the formation that it may be safely employed in the discrimination of this limestone. In natural or artificial cuts exposing the weathered and unweathered zones of the limestone a great abundance of cobblestones at the surface may always be noted. Roads which happen to pass along the strike of the cobbly beds where these are highly tilted often clearly show the arrangement of the cobblestones in definite thin-bedded layers.

FIG. 1.—TYPICAL EXPOSURE OF THE ECHINOSPHERITES BED OF THE CHAMBERSBURG LIMESTONE SHOWING CHARACTERISTIC COBBLY EFFECT. RAILROAD CUT AT PINESBURG STATION, MARYLAND.

FIG. 2.—TYPICAL OUTCROP OF STEEPLY DIPPING CHAMBERSBURG LIMESTONE ALONG ROAD BETWEEN PINESBURG AND PINESBURG STATION, MARYLAND.

The eobbly effect is eaused by the elay partings in the limestone crossing it at a high angle so that weathering breaks up the solid limestone into rounded fragments. Also eoneentration of the lime in weathering and the relative facility of its loss by the more elayey parts has mueh to do with the formation of the eobbles, as suggested by Ulrieh. Fresh exposures, as in quarries, indieate these partings very obseurely. The limestone then appears massive and solid and exhibits regular bedding planes five or six inehes apart. The ehange from the fresh, massive limestone to the eobblestones is well shown in railroad euttings where the surfaee outcrop capping the fresh eutting is preserved.

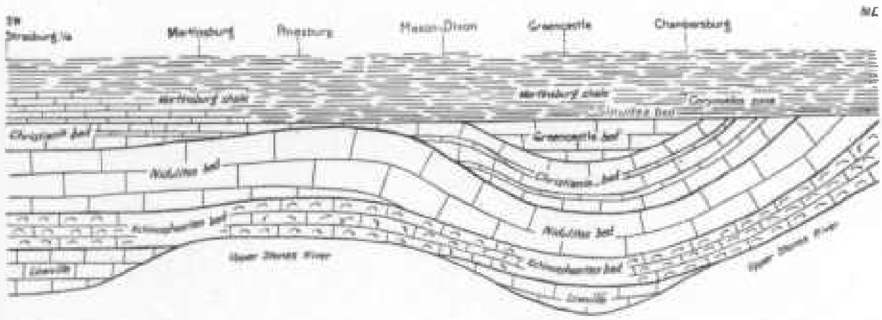

FIG. 17.—DIAGRAMMATIC SECTION OF CHAMBERSBURG LIMESTONE FROM CHAMBERSBURG, PA., TO STRASBURG, W. VA.

Although dark blue nodular limestone weathering eobbly eonstitutes the greater or at least the most eonspieuous part of the Chambersburg formation in Maryland, other types of roek are widely developed and often exposed in the eontinuation of the outcrop belts to the north and south. These strata eonsist of interbedded thin ealeareous shales and shaly limestones, thin-bedded, dark gray limestone, and bluish granoerystalline limestone. All these strata form a eomposite unit that is deeidedly different from any of the underlying limestone formations.

In Maryland the thiekness of the Chambersburg limestone does not exeeed 300 feet; in southern Pennsylvania it reaehes a maximum of 800 feet, although at the type exposure around Chambersburg, Pennsylvania, it is about 500 feet in thiekness. This great variation is expressed in the diagram on page 131, which shows that the diminished thickness in Maryland is due mainly to the absence of the lower divisions.

AREAL DISTRIBUTION.—The area of outcrop of the Chambersburg limestone in Maryland is less than that of any other formation west of the Blue Ridge. Faulting along the east side of the Martinsburg shale belt has cut out the Chambersburg limestone everywhere in this part of the valley except in the very northern part of the state, and a very small patch in the great bend of the Potomac River at the southern edge.

West of the shale belt the Chambersburg outcrops in an almost continuous band extending from Pinesburg Station northward to the Pennsylvania state line. West of this there is a second band of outcrop which, however, is cut out by faulting before half the state is traversed.

The outcrops east of the Martinsburg shale belt give very little idea of the formation, and in fact its presence can be recognized only by a few traces of cobbly, dark-blue limestone showing here and there along the roads and in the fields. These exposures are so incomplete that it is impossible to work out any adequate idea of the sequence and character of the beds. The few exposures, however, indicate the presence of the Echinospherites and Nidulites beds described below.

The two lines of outcrop in the western half of the valley afford a better opportunity for the study of the formation. At Pinesburg Station a good exposure of the rocks may be seen, particularly the Echinospherites bed. The road running north from Pinesburg Station to Pinesburg passes along the strike of these rocks and numerous outcrops may be seen on either side of it. At Wilson the Echinospherites bed is not so well exposed, but the overlying Nidulites bed is well shown in the bluff overlooking Conococheague Creek. North of this is a rather broad area of the formation, but here the rocks are hidden to a great extent by recent stream gravels. The line of outcrop west of the Pinesburg-Wilson area extends only half way across the state on account of faulting, and exposures are extremely few and poor throughout its length.

FAUNAL ZONES.—The researches of Ulrich in the Appalachian Valley of southern Pennsylvania, in which the present writer had an opportunity of assisting, have shown that the Chambersburg limestone can be divided into six faunal divisions or members. These members vary greatly in thickness from place to place, but retain their lithologic and faunal characters with little change. At no place is the composite section shown in the columnar section developed, but the strata shown here represent all the sedimentation so far as known, of Chambersburg age. These six divisions, which with one exception have received faunal designations for convenience of description, are as follows:

Divisions of Chambersburg Limestone in Pennsylvania and Maryland

	Feet
6. Greencastle bed. Heavy bedded impure limestones	0-200
5. Christiania bed. Thin bedded calcareous shales and shaly limestone.	0-270
4. Nidulites bed. Compact dark grey thick and thin bedded limestone	200-300
3. Echinospherites bed. Dark blue argillaceous cobbly limestone	40- 50
2. Tetradium cellulosum bed. Fine grained dove and subgranular limestone	0-200
1. Caryocystites bed. Bluish coarsely crystalline to subcrystalline limestone	0-175

The lithologic and faunal characteristics of these divisions are described in the following paragraphs:

Caryocystites Bed.—The lowest division of the general time scale represented in the typical exposures of Chambersburg limestone consists or dove-colored and other limestones. This division contains the *Tetradium cellulosum* fauna and is clearly of Lowville age. West of the Martinsburg shale belt in Pennsylvania, the several bands of Chambersburg limestone exposed in the lowland area between the northern and southern offsets of North Mountain contain a well-defined and easily recognized lentil of bluish crystalline limestone reaching a maximum thickness of 175 feet. This bed wedges in between the Lowville division of the Chambersburg and the underlying top of the Stones River. The abundant occurrence of a cystid plate of the genus *Caryocystites* and its apparent restriction to this division makes the name *Caryocystites* bed appropriate. The bands of outcrop containing this bed are not exposed in Maryland, but are probably buried under the younger strata of North Mountain and areas to the west.

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FIG. 18.—UPPER CHAZYAN (BLOUNT).

FIG. 19.—LOWER BLACK RIVER (LOWVILLE).

Fossils are rare in the lower two-thirds of the Caryocystites bed, but a fauna of over 50 species has been collected from the upper third, particularly from the upper 8 or 10 feet. As it is unlikely that this bed will ever be found exposed in Maryland, it was thought sufficient for present purposes to describe and illustrate only enough of its species to show its general faunal character. It contains such typical Chazyan brachiopods as *Camarotoechia plena* (Hall) and *Hebertella vulgaris* Raymond, with species of other classes indicating a similar early age in association with a few bryozoans and other fossils that have been found elsewhere only in Black River deposits. The determination of the age of the bed would therefore seem to be uncertain, but as it occupies the position between the earliest Black River (Lowville) formation and the latest Stones River division which elsewhere is filled by Upper Chazyan deposits with similar faunas, it is believed advisable to refer the Caryocystites bed to the Chazyan. On the other hand, since the main part of the fauna is developed only in the upper beds, it is possible that the entire division is of Chazyan age and that the upper part contains an earlier appearance of species commonly found elsewhere in the Black River. The fauna from this bed, as identified by Ulrich, is listed below. This faunal list, as well as others of the Chambersburg limestone which follow, is introduced only to give a general idea of the life characteristics of the various beds. Complete lists of each division can only be published when a monographic study of the Chambersburg faunas has been finished, a work which is far beyond the scope of the present volume. To give some idea of this fauna the specifically determined forms of the following list are described in this volume.

Fauna of the Caryocystites Bed, Chambersburg Limestone

Solenopora compacta (Billings)
Columnaria halli Nicholson
Tetradium columnare (Hall)
Carabocrinus sp. (plates)
Caryocystites sp. (plates)
Anolotichia sp.
Nicholsonella cf. *N. laminata*
Batostoma cfr. *B. magnoporum*

Hemiphragma irrasum (Ulrich)
Helopora divaricata Ulrich
Rhinidictya fidelis Ulrich
Pachydictya cfr. *P. robusta*
Escharopora confluens Ulrich
Graptodictya sp. (reticulate)
Chasmatopora reticulata (Hall)
Chasmatopora sublaxa (Ulrich)
Hebertella borealis (Billings)
Hebertella vulgaris Raymond
Hebertella bellarugosa (Conrad)
Rafinesquina champlainensis Raymond
Leptaena charlottae Winchell and Schuchert
Plectambonites sp.
Camarotoechia plena (Hall)
Zygospira recurvirostris (Hall)
Ctenodonta cf. *C. gibberula*
Cyrtodonta sp.
Gonioceras chaziense Ruedemann
Leperditia cf. *L. fabulites*
Isochilina cf. *I. gracilis*
Bathyurus sp.
Amphilichas cf. *trentonensis*

Tetradium cellulosum Bed.—One of the most widespread Paleozoic formations of North America is the dove limestone of early Black River age known as the Lowville limestone in the New York section. This formation has received various names in different parts of the country, but its fauna, and even its lithology, is unusually constant throughout an area extending from southern Canada to Alabama and from the Appalachians to the Mississippi River. The coral *Tetradium cellulosum*, distinguished by its colonies composed of small bunches of four-sided tubes each with four septa, is the guide fossil of the formation. In the Chambersburg limestone, the Lowville division of the general time scale, or the *Tetradium cellulosum* bed, as it is here called, is present locally and sometimes reaches a thickness of as much as 200 feet. As indicated in the sections on other pages, it usually consists of fine-grained, dove-colored limestone with some subgranular beds. In southern Pennsylvania the Lowville forms the basal member of the Chambersburg limestone in the area between Chambersburg and the Maryland state line. It is present also in the Mercersburg belts but in these it rests on the Caryocystites bed. If represented at all in northern Maryland, it is so thin as to be negligible.

The fauna of this zone, as represented just north of the Maryland state line, contains 15 described species, six of which are characteristic Lowville fossils and the rest Black River forms. The gastropods *Helicotoma planulatoides* Ulrich and *Omospira alexandra* (Billings) are particularly characteristic species of the upper Lowville, but the coral *Tetradium cellulosum*, found everywhere, is the best guide fossil. The list of species discovered by Ulrich in this bed in southern Pennsylvania a few miles north of the Maryland line is as follows. Only traces of the Louisville rocks and faunas can be found in Maryland and for that reason only the fifteen specifically identified faunas of this list are described.

Fauna of the Tetradium cellulosum Bed, Chambersburg Limestone

Camarocladia rugosum Ulrich
Beatricea sp.
Streptelasma profundum (Conrad)
Tetradium cellulosum (Hall)
Cleiocrinus sp.
Orbignyella wetherbyi (Ulrich)
Strophomena cf. *S. emaciata*
Zygospira recurvirostris (Hall)
Protorhyncha sp.
Ctenodonta gibberula Salter
Cyrtodonta sp.
Helicotoma planulatoides Ulrich
Helicotoma verticalis Ulrich
Lophospira cf. *L. procera*
Omospira alexandra (Billings)
Clathrospira sp.
Eunema cf. *E. salteri*
Orthoceras sp.
Leperditia fabulites (Conrad)
Leperditella tumida (Ulrich)
Isochilina cf. *I. gracilis*
Isochilina cf. *I. ottawa*
Macronotella ulrichi Ruedemann
Drepanella macra Ulrich
Aparchites sp.
Primitia sp.
Kloedenia sp.
Isotelus sp.
Pterygometopus callicephalus (Hall)
Ceraurus pleurexanthemus Green

FIG. 20.—MIDDLE BLACK RIVER (DECORAH).

FIG. 21.—UPPER BLACK RIVER (KIMMSWICK).

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Echinospherites Bed.—The massive, pure, dove-colored strata of the Stones River limestone are followed in Maryland by dark blue argillaceous cobbly limestone which is never over 50 feet in thickness. In fresh outcrops, such as in the railroad cut at Pinesburg Station, Maryland, this limestone appears quite massive, but close inspection shows thin, shaly seams dividing the main mass of the rock into dark blue strata. Upon weathering these strata give rise to rounded pieces much resembling cobble stones. This feature is especially characteristic of the Echinospherites bed, although other divisions of the Chambersburg limestone exhibit similar strata.

This bed contains a few highly fossiliferous bands which have yielded, in Pennsylvania outcrops, a fauna of about 27 species shown in the following list published by Ulrich. Of these the ball cystid *Echinospherites* is the most abundant and its remains may be found at almost every outcrop of the bed. Brachiopods and bryozoans of Black River types are associated with this cystid, although specimens are much less abundant.

Numerous exposures of this bed occur in the line of outcrop from Pinesburg Station northward through Wilson to the State line, the best places for fossils being in the Western Maryland Railway cut at Pinesburg Station and the bluffs overlooking Conococheague Creek at Wilson. In southern Pennsylvania excellent exposures of this bed are found in the railroad cut at Kauffman and one mile northwest. Excepting the characteristic fossil *Echinospherites,* the fauna of this bed seems most closely allied to the upper Black River Decorah shale of the Mississippi Valley and for this reason its age is placed as late Black River. The species in the following list marked with an asterisk have been found in Maryland:

Fauna of the Echinospherites Bed, Chambersburg Limestone

Licrophycus cf. *L. ottawaense*
Lockeia sp.
**Receptaculites occidentalis* Salter
Ischadites sp.
Orocystites ? sp.
Raphanocrinus ? sp.
**Echinospherites aurantium americanum* Bassler
**Helopora spiniformis* Ulrich

Rhinidictya neglecta Ulrich
Escharopora cf. *ramosa*
**Prasopora insularis* Ulrich
**Hemiphragma irrasum* (Ulrich)
**Dianulites petropolitanus* Dybowski
Dalmanella testudinaria small variety
**Dinorthis pectinella* (Emmons)
**Pianodema subaequata* (Conrad)
**Rafinesquina minnesotensis* Winchell
**Rafinesquina minnesotensis inquassa* (Sardeson)
Rafinesquina sp.
Strophomena cf. *S. filitexta*
Plectambonites sp.
Plectambonites pisum var.
**Hebertella bellarugosa* (Conrad)
Triplecia (*Cliftonia*) *simulatrix* Bassler
Leperditia cf. *L. fabulites*
Pterygometopus cf. *P. schmidti*
**Ampyx* (*Lonchodomas*) *normalis* Billings

The Echinospherites and Nidulites beds are well developed in all the sections of this area, but the considerable thickening of the Christiania bed north and also south of Maryland is a second interesting feature. Finally, the occurrence of the Greencastle bed only in the area extending from the Mason-Dixon line northeast to beyond Chambersburg shows that local depressions in an area can receive sufficient sedimentation representing a hiatus which would otherwise hardly be suspected. In these various sections the Upper Stones River below and the Sinuites zone at the base of the Martinsburg above, form two datum planes which are recognized without difficulty.

Nidulites Bed.—The Nidulites bed is the most conspicuous division of the Chambersburg in Maryland and forms the main part of the outcrops of the formation both east and west of the Martinsburg shale belt. The heaviest limestones of the formation are included in this bed which, as a rule, tends to weather in smooth, rounded outcrops like the underlying massive limestones of the Stones River and Beekmantown formations, instead of the usual cobbly layers. Cobbly layers do occur in this bed and their weathered outcrops have much the appearance of the underlying Echinospherites bed. In such cases a brief search will reveal the occurrence of the characteristic fossil of the Nidulites bed, *Nidulites pyriformis,* a pear-shaped organism one to two inches long, with the surface marked by sharp ridges forming polygonal spaces a millimeter in diameter. This fossil does not reappear in the section until the Greencastle member is reached, but the latter has not been identified in Maryland. These *Nidulites* are found throughout the 200 to 300 feet of thickness of the bed, but they are most abundant near the middle and the top. The different aspects of this fossil as seen on weathered surfaces of the limestone are shown on plate XLVI. Associated with the *Nidulites* and in equal abundance is a peculiar hemispherical or subglobular bryozoan-like organism described as *Diplotrypa ? appalachia* in this volume.

A fauna of about 40 species has been collected and identified by Ulrich from the excellent exposures of the Nidulites bed in Pennsylvania, but the outcrops in Maryland have afforded only a portion of these. With the exception of the exposures of the bed along the bluffs overlooking Conococheague Creek at Wilson, Maryland, its outcrops in the state are usually weathered edges of the highly tilted strata which do not as a rule afford good fossils. Cross-sections of the *Nidulites* and *Diplotrypa* can, however, be found in practically every exposure. So far as is known this bed and the overlying Christiania and Greencastle beds are not represented in the geological column elsewhere in North America. As the Sinuites bed at the base of the Martinsburg shales contain a fauna of early Trenton age and as the Echinospherites bed underlying the Nidulites bed contains an assemblage of species much like the upper part of the Decorah shales of the upper Black River, these three intervening divisions should be of latest Black River or earliest Trenton. In terms of the New York section these three divisions would represent an age between the top of the Black River and the base of the Trenton. The species marked with an asterisk are described in this volume.

Fauna of the Nidulites Bed, Chambersburg Limestone

Palaeophycus sp.
**Nidulites pyriformis* Bassler
New genus of Amygdalocystidae
New genus of Pleurocystidae
Bolboporites sp.

Carabocrinus sp. (plates)
Porocrinus sp.
**Diplotrypa appalachia* Bassler
Stromatotrypa sp.
Mesotrypa ? sp.
Stictoporella ? sp.
**Prasopora contigua* Ulrich
Hemiphragma cf. *irrasum*
**Corynotrypa inflata* (Hall)
**Corynotrypa delicatula* (James)
**Orthis tricenaria* Conrad
Plectorthis aff. *P. whitfieldi*
Dalmanella testudinaria var.
Pianodema cf. *P. subaequata*
**Scenidium anthonense* Sardeson
Strophomena cf. *S. filitexta*
Rafinesquina cf. *R. incrassata*
Leptaena sp.
Plectambonites cf. *P. pisum*
Plectambonites sp.
Triplecia (Cliftonia) simulatrix Bassler
Leperditia cf. *L. fabulites*
Ampyx cf. *A. normalis*
Illaenus sp.
Pterygometopus cf. *P. callicephalus*
**Ceraurus pleurexanthemus* Green
**Onchometopus simplex* Raymond and Narraway

Christiania Bed.—This division of the Chambersburg limestone is best developed on the east side of the Martinsburg shale belt in southern Pennsylvania where it reaches a maximum thickness of 270 feet. West of the shale belt it is absent from the section, but going southwestward into Maryland this division reappears and gradually increases in thickness until northern Virginia is reached, where it is 40 feet thick. The prevailing rock of this division is thin bedded, shaly limestone and calcareous shale sometimes quite fossiliferous. The brachiopod *Christiania trentonensis* is the most characteristic of the described species and specimens may usually be found at its outcrops. In Pennsylvania outcrops of the Christiania bed have yielded a fauna of over 40 species which indicates that the age of the division is latest Black River or earliest Trenton. The list of species, identified by Ulrich, is given below. As this bed is so poorly represented in Maryland only its more characteristic fossils are described in this volume.

Incomplete Faunal List of the Christiania Bed, Chambersburg Limestone

Echinospherites aurantium americanum Bassler
Crinoid plates
Hemiphragma cf. *H. irrasum*
Trematopora cf. *primigenia*
Arthropora bifurcata Ulrich
Rhinidictya cf. *R. neglecta*
Orbiculoidea lamellosa Hall
Orthis tricenaria Conrad
Scenidium cf. *S. anthonense*
Dinorthis sp. cf. *D. subquadrata*
Strophomena sp.
Leptaena cf. *L. charlottae*
Plectambonites sp.
Plectambonites pisum Ruedemann
Christiania trentonensis Ruedemann
Triplesia (*Cliftonia*) *simulatrix* Bassler
Triplecia cf. *T. nucleus*
Parastrophia hemiplicata Hall
Zygospira exigua (Hall)
Ctenodonta sp.
Lepidocoleus, 2 undet. sp. (near *L. jamesi*)
Illaenus sp.
Isotelus gigas Dekay
Fragments of *Cryptolithus* or *Tretaspis*

Greencastle Bed.—The thickest sections of Chambersburg limestone are in southern Pennsylvania in the vicinity of Greencastle, where 200 feet of heavy bedded, impure limestone follow the usual Christiania bed and underlie the base of the Martinsburg shales. Reference to the sections on another page shows that this member can be recognized as far north as Chambersburg, but that it does not appear in any of the sections west of the Martinsburg shale belt. It appears that after the deposition of the rather widely distributed Christiania bed, a local depression in the sea, extending from about the Maryland state line northward to and beyond Chambersburg, allowed the accumulation of this considerable thickness of calcareous sediments before the inauguration of the basal Martinsburg shale. This division, for which the local name Greencastle bed is employed for convenience of reference, is interesting from a paleontological standpoint, first because it contains fossils found also in the underlying Christiania zone and second because the guide fossils of still lower members of the Chambersburg limestone, *Nidulites* and *Echinospherites,* here reappear in well developed, apparently typical specimens. The number of species found in this bed is rather large but only two apparently characteristic forms, the cephalopods *Orthoceras arcuoliratum* and *Cyrtoceras camurum,* are described in the present volume.

SECTIONS OF THE CHAMBERSBURG LIMESTONE.—Extended outcrops of the Chambersburg limestone are so few in Maryland that in order to get an idea of the formation it is necessary to study the exposures in contiguous states. In Maryland there are only two places, namely, at Pinesburg Station and Wilson, where a detailed section of the formation can be studied, but in Pennsylvania there are numerous localities where all the members of the formation can be seen to great advantage.

As noted above the formation varies considerably from east to west and it has been found convenient to study the divisions in sections exposed east of the Martinsburg shale belt and west of the same area. Throughout the Maryland basin the datum plane for the base of the Chambersburg is the Upper Stones River dove limestone which is everywhere developed and easily recognized. The various sections quoted below were prepared by E. O. Ulrich, with whom the writer was associated in the study of this limestone. Most of them have since been published in the Chambersburg-Mercersburg folio.

Sections East of Martinsburg Shale Belt in Pennsylvania.—Although the Chambersburg limestone is named from Chambersburg, Pennsylvania, its outcrops at this place are too few or incomplete to give a good idea of the entire section. The Christiania and Greencastle beds forming the upper part of the Chambersburg are well exposed here, the Echinospherites bed is well shown along the railroad, but the Nidulites bed is mostly covered and the Tetradium cellulosum bed is not seen at all. This section, which is given below, is particularly interesting in showing the development of the Greencastle bed and also in exhibiting the different faunal zones of the lower part of the Martinsburg shale.

Section of Martinsburg Shale and Chambersburg Limestone Northwest Corner of Chambersburg, Pennsylvania

	Feet
Martinsburg shale.	
Unfossiliferous black fissile shale	...
Black shale with *Corynoides* fauna at base	32
Limy shales with *Cryptolithus*	10
Thin blue to black limestone holding the *Sinuites* fauna at the base	10
Chambersburg limestone.	
Greencastle bed.	
Massive dark bluish limestone	9
Yellowish limy and arenaceous shale with cobbly shaly and sandy limestones at base	66
Christiania bed.	
Shaly limestone with *Christiania trentonensis* (lower beds of formation not exposed in this section but shown elsewhere in vicinity)	50+
Nidulites bed.	
Compact, massive, dark gray limestone	...
Echinospherites bed.	
Argillaceous limestone weathering cobbly	...
Tetradium cellulosum bed.	
Massive fine grained dark limestone	...
Stones River limestone.	

South from Chambersburg along the same general line of outcrop an excellent section is exposed in the railroad cut two miles southwest of Marion. This is the most complete and continuous section of the formation known in the area east of the Martinsburg shale belt. Fossils are not as abundant in some of the beds as they are elsewhere, but the lithologic characters of the different divisions are well developed and the section exposes all of the members recognized east of the shale belt. The Greencastle member, however, is not shown in this particular section which ends at the Martinsburg shale on the west, but east of the section along the railroad near the pike, the Sinuites bed of lower Martinsburg shale is underlain by 150 feet of dark gray massive limestone containing the fauna of the Greencastle member.

Section of Chambersburg Limestone Two Miles Southwest of Marion, Pa.

	Feet
Martinsburg shale.	
Chambersburg limestone.	
Greencastle bed.	
Only residual shale and thin limestone seen. At the top are black carbonaceous limestone and a thin sandstone, capped by a thin, coarsely crystalline limestone bed containing *Lingula*, representing undoubtedly the *Corynoides* bed commonly found near the base of the succeeding Martinsburg shale	150
Christiania bed.	
Interbedded thin calcareous shale and shaly limestone with a few fossils which indicate the Christiania fauna	100
Nidulites bed.	
Dark, nodular, thin-bedded limestone; fossils rare	50
Dark, fine-grained, platy limestone; contains *Nidulites* and associated fossils	94
Compact, dark-gray, thick-bedded limestone; upper part very fossiliferous, containing numerous cystids and *Nidulites*	108
Echinospherites bed.	
Dark, argillaceous, cobbly limestone, shaly in lower part; very fossiliferous, containing a layer filled with the ball cystid *Echinospherites*	65
Limestone like overlying bed but even darker in color and interbedded with subcrystalline limestone layers; fossils scarce	40
Tetradium cellulosum bed.	
Grayish to dark, dense thin-bedded limestone, containing *Tetradium cellulosum* and *Leperditia*	150±
Stones River limestone—contact not exposed.	

Four miles south of this section the Cumberland Valley Railroad crosses the Chambersburg limestone at Greencastle, Pennsylvania, and exposes the Nidulites, Christiania, and Greencastle beds. This section is of particular interest in showing the extreme development of the Greencastle bed in the railroad cut starting at the bridge just north of the town where about 200 feet mainly of dark blue massive limestone with rather numerous fossils intervenes between the typical Christiania bed and the usual strata of the basal Martinsburg shale. The details of this section, as recently determined by Ulrich, are as follows:

Section of Upper Divisions of Chambersburg Limestone at Greencastle, Pennsylvania

	Feet
Martinsburg shale.	
Black fissile shale at top and shaly limestone below, not well exposed	...
Chambersburg limestone.	
Greencastle member.	
Rather massive, dark blue fine grained limestone with gastropods and hemispheric bryozoa	40
Argillaceous cobbly limestone, sandy at base	8
Massive grey to dark blue fine grained fossiliferous limestone. *Nidulites* abundant at base	50
Massive gray to blue subcrystalline limestone	12
Sandy shales	8
Massive granular limestone	60
Sandy limestone and sandstone	20
Christiania bed.	
Argillaceous thin bedded limestone with *Christiania trentonensis*, etc. (exposed at southwest end of bridge)	...
Nidulites bed.	
Massive grayish limestone with Nidulites fauna. (Underlying strata not exposed)	...

This eastern band of outcrop continues into Maryland, but disappears by faulting about a mile south of Cearfoss. The exposures of the Chambersburg in this part of Maryland are extremely poor, but the formation can be clearly recognized by the cobbly appearance of the weathered rock. No section could be made in this part of the state, nor were the rocks well enough exposed in the southern part in the big bend of the Potomac River where the formation outcrops again.

Sections West of Martinsburg Shale Belt in Pennsylvania.—In southernmost Pennsylvania numerous belts of Chambersburg limestone are brought to the surface by the geologic structure which causes the great cove in North Mountain in which Mercersburg is situated. This lowland area affords numerous sections of the limestone and many excellently preserved fossils have been collected. These sections are particularly interesting because they contain beneath the Tetradium cellulosum bed, which forms the base of the Chambersburg in the eastern lines of outcrop, a subcrystalline, massive limestone reaching 100+feet in thickness, characterized by a fauna which is related to both Chazyan and Black River faunas. Another interesting feature is that the Christiania bed which is so well developed east of the Martinsburg shale area is here entirely wanting, the Nidulites bed of the general section being succeeded immediately by the Martinsburg shale. The easternmost belt of outcrop in this western area affords the following section which is exposed south of St. Thomas. This section as described by Ulrich is interesting because it is in the most easternly belt of the trough in which the Caryocystites bed is developed. The next outcrop of the Chambersburg limestone to the east contains no representation of the 110 or more feet of the Caryocystites bed as here developed.

Section of Chambersburg Limestone 2½ Miles South of St. Thomas

	Feet
Martinsburg shale.	
Typical dark shale.	
Thin calcareous shale, underlain by calcareous black shale and hard thin black limestone with the Corynoides fauna at top.	31
Coarse granular fossiliferous limestone (Sinuites fauna).....	7
Chambersburg limestone.	
Nidulites bed.	
Black cobbly thin-bedded fossiliferous limestone................	53
Tetradium cellulosum bed.	
Massive granular or finely conglomeratic gray, highly fossiliferous limestone (*Beatricea* numerous)..................	15
Subcrystalline, very fossiliferous gray limestone (*Leperditia* numerous)	1
Granocrystalline unfossiliferous gray limestone, in part minutely conglomeratic	18
Caryocystites bed.	
Bluish subcrystalline limestone containing numerous *Caryocystites* plates and *Solenopora compacta*.....................	7
Cobbly dark subcrystalline limestone, more massive in upper part	105
Stones River limestone.	
Fine even-grained pure limestone, drab to dark gray, thin bedded above, less pure below................................	...

The railroad cut just north of Dickey's station, four or five miles southeast from Ft. Loudon, exposes a good section of the formation, particularly of the middle beds. The Echinospherites bed was not distinguished, but it is possible that it may be included in the cobbly limestone at the base of the Nidulites bed. As usual in these western bands of outcrop, the Christiania bed is missing.

Section of Chambersburg Limestone One-Half Mile Northwest of Dickey, Pa.

	Feet
Martinsburg shale.	
Fissile shale, limy at base	...
Thick bed of dark-gray coarse crystalline crinoidal limestone, fossiliferous (Sinuites bed)	6
Chambersburg limestone.	
Nidulites bed.	
Thin-bedded cobbly, dark, fine-grained limestone containing *Diplotrypa appalachia*, *Plectambonites* cf. *P. sericeus*, *Leptaena* sp., *Pianodema* cf. *P. subaequata*	37
Rather massive gray to dove-colored fine-grained mottled limestone banded in part	18
Fine-grained platy to cobbly gray limestone with few *Diplotrypa*	30
Tetradium cellulosum bed.	
Massive fine-grained dark limestone containing *Beatricea* and *Tetradium cellulosum*	34
Caryocystites bed.	
Dark compact subgranular to crystalline limestone, with *Caryocystites* plates	8
Concealed, 170 ± feet, of which probably at least 130 feet belongs to the Chambersburg	130±
Stones River limestone.	
Thin bedded pure fine even-grained drab limestone	...
	257±

The railroad cut just south of Fort Loudon exposes the Tetradium cellulosum bed to advantage and here good fossils from this zone can be had. Faulting has somewhat confused this section, but the locality is of particular interest in showing an unconformable contact between the Caryocystites and the overlying Tetradium cellulosum beds. The lowest six inches of the latter consist of compact clayey limestone filling irregularities in the surface of the underlying bed. Evidence of a time interval is also shown by the parasitic bryozoans and the expanded bases of *Cleiocrinus* which are attached to the eroded surface of the underlying bed.

Section of Chambersburg Limestone One-Half Mile South of Fort Loudon, Pa.

	Feet
Martinsburg shale.	
Fissile shale with thin, hard, dark calcareous beds on fresh exposure, 100 + feet, underlain by 40 feet of hard calcareous dark shale and thin limestones, weathering light gray, with graptolites at top.	
Sinuites bed.	
Subgranular black crinoidal limestone containing *Sinuites* and *Trinucleus*	2
Chambersburg limestone.	
Nidulites bed.	
Dark fine-grained limestone weathering cobbly	36
Echinospherites bed.	
Rather dark thin bedded and shaly limestone with fossils, among them fragments of *Echinospherites*	15
Massive dark subgranular limestone	12
Tetradium cellulosum bed.	
Pure dove-covered fine even-grained limestone, containing *Tetradium cellulosum* and *Leperditia* in fine conglomerate.	8
Pure granular and suboölitic limestone, upper beds coarsely granular; contains *Leperditia* and other ostracoda	9
Irregularly bedded compact clayey limestone filling irregularities in top surface of underlying bed. Contains *Helicotoma planulatoides*, *Beatricea* and other fossils	1
Caryocystites bed.	
Heavy-bedded gray granular to subcrystalline limestone; very fossiliferous; trilobites, brachiopods, *Caryocystites* plates, and *Solenopora*	10
Dark-blue flaggy limestone, few fossils	8
Poorly exposed dark granular limestone, estimated	100+
Stones River limestone.	
Pure dove-colored limestone with *Leperditia*	..
	200+

An excellent section showing the three divisions usually developed in this area is exposed on the banks of the west branch of Conococheague Creek two and one-half miles southeast of Mercersburg, just south of the Greencastle turnpike. In this section the Sinuites zone marking the base of the overlying Martinsburg shale is very fossiliferous and easily recognized. The fine-grained, pure limestone of the Stones River also clearly marks the base of the formation.

Section of Chambersburg Limestone on West Branch of Conococheague Creek, 2½ Miles Southeast of Mercersburg, Pennsylvania

	Feet
Martinsburg shale.	
Fissile shale, overlying calcareous black shale and hard thin black carbonaceous limestone, containing graptolites and *Lingula*	...
Granocrystalline, very fossiliferous limestone (*Sinuites* bed)	2
Chambersburg limestone.	
Nidulites bed.	
Cobbly dark subcrystalline limestone, both massive and thin bedded	73
Tetradium cellulosum bed (Lowville).	
Coarse, massive granocrystalline limestone with massive beds of pure fine-grained limestone containing *Beatricea* and *Tetradium cellulosum*	75
Caryocystites bed.	
Platy granocrystalline limestone, very fossiliferous	25
Dark subcrystalline limestone with wavy partings of shale; fossils rare	150±
Stones River limestone.	
Very thin bedded pure fine-grained drab limestone underlain by more massive pure beds with magnesian layers and fine laminations containing *Leperditia*	...
	323±

In the few bands of outcrops of this limestone in Maryland and West Virginia its development is interesting for several reasons. First, the Lowville limestone portion or Tetradium cellulosum bed, and also the Caryocystites bed are both absent. Second, the Nidulites bed forms the main mass of the formation, and, third, the Christiania bed is present west of the shale belt, but in greatly diminished thickness.

The following section at Pinesburg Station, Maryland, is typical for the state. At this place the Echinospherites bed is well exposed, but the best exposures of the Nidulites bed are farther north at Wilson, Maryland. Nowhere are there good outcrops of the Christiania bed.

Section of Chambersburg Limestone at Pinesburg Station, Maryland

	Feet
Martinsburg shale.	
Black fissile shale	...
Calcareous shale and argillaceous shaly limestone with graptolites near base	...

Chambersburg limestone.	
Christiania bed.	Feet
Calcareous shales and shaly limestone with traces of *Christiania*.	10
Nidulites bed.	
Massive dark blue to dark gray limestone with abundant *Nidulites*	270
Echinospherites bed.	
Thin bedded subgranular limestone weathering cobbly and holding *Echinospherites*	30
Stones River limestone.	
Pure dove limestone with *Leperditia fabulites* and *Tetradium syringoporoides*	...

Essentially the same section is exposed at Martinsburg, West Virginia, where the southern continuation of the same line of outcrops affords the following sequence:

Section of Chambersburg Limestone at Martinsburg, West Virginia

	Feet
Martinsburg shale.	
Black fissile shale	...
Argillaceous shaly limestone	125
Chambersburg limestone.	
Christiania bed.	
Thin bedded dark gray limestone with *Christiania trentonensis*.	20
Nidulites bed.	
Dark gray massive and thin bedded limestone weathering light gray cobbly, holding *Nidulites*	300
Echinospherites bed.	
Dark shaly and subgranular limestone with *Echinospherites*	20
Stones River limestone.	
Pure dove limestone	...

Variations in Distribution.—The distribution of the various members of the Chambersburg limestone in the eastern and western parts of the Appalachian Valley in southern Pennsylvania is expressed in the following table:

General Sequence of Beds in Chambersburg Limestone

West of Martinsburg shale belt	East of Martinsburg shale belt
...	Greencastle bed.
...	Christiania bed.
Nidulites bed	Nidulites bed.
Echinospherites bed	Echinospherites bed.
Tetradium cellulosum bed	Tetradium cellulosum bed.
Caryocystites bed	...

As noted before, this area has been selected by Ulrich as a striking example of the instability of the floor of the continent during Middle Ordovician time. The differences between the two areas seem to indicate that the eastern half of the valley received no sedimentation during earliest Chambersburg time, while in the western half 150 feet or more of granular limestone were deposited. During the periods of deposition registered by the Tetradium cellulosum, Echinospherites, and Nidulites beds, there was no great interruption of sedimentation, but following this time the Christiania bed reaching as much as 270 feet in thickness and the Greencastle bed with a maximum of 200 feet were deposited in the eastern half, while the absence of such deposits in the western half indicates a time of emergence. Fig. 17, on page 131, illustrates the unequal deposition of these several beds in a northeast-southwest line running from northeast of Chambersburg, Pennsylvania, to Strasburg, Virginia. The Caryocystites bed is not present in any of these sections and the entire area belongs to the Chambersburg belt of outcrop. The thinning of the Lowville limestone at the base of the section in southern Pennsylvania, its absence in Maryland and West Virginia, and its reappearance in northern Virginia, is the first example of the variation in the formation along the strike. The succeeding beds continue across Maryland in varying thicknesses with the exception of the Greencastle bed, which disappears in southern Pennsylvania and apparently does not reappear to the south. Whatever the local expression of the Chambersburg limestone may be, the next succeeding beds in all of the sections are the argillaceous limestones and shales of the overlapping Martinsburg shale.

AGE AND CORRELATION.—The Chambersburg limestone, with a thickness not exceeding 300 feet in Maryland, is the thinnest formation of the Cambrian-Ordovician section of the state and its surface outcrops are decidedly small in comparison with any of the other formations. East of the shale belt its areas of outcrop are so small as to be negligible, and west of the same belt there are but two narrow bands, only one of which is continuous across the state. From the paleontologic standpoint, however, the Chambersburg limestone is most important since its contained faunas are more numerous in species and individuals than any other formation.

Just north of the Maryland-Pennsylvania state line the areas of outcrop of the Chambersburg limestone are not only more numerous, but also often broader. Here also natural and artificial cuttings have afforded much better opportunities to study the formation and to collect its faunas. The identification of the Chambersburg fossils described in the following pages has been based primarily upon the much better preserved material from Pennsylvania, although the Echinospherites and Nidulites beds in Maryland have yielded equally good faunas. The divisions of the Chambersburg limestone and their approximate position in the time scale are as follows:

Divisions of Chambersburg Limestone in Pennsylvania and Maryland

Greencastle bed (Late Black River or Early Trenton)
Christiania bed (Late Black River)
Nidulites bed (Late Black River)
Echinospherites bed (Late Black River)
Tetradium cellulosum bed (Early Black River-Lowville)
Caryocystites bed (Upper Chazyan or Earliest Black River)

The relations of these faunas to each other and the distribution of their strata in different portions of the middle Appalachian valley have been described on previous pages.

UPPER ORDOVICIAN SHALES

THE MARTINSBURG SHALE

The shale phase of sedimentation which concludes Ordovician deposition in the Middle Appalachians is best known from outcrops in the middle of the Great Valley where these strata occupy part of the well-known syncline named from Massanutten Mountain in Virginia. Martinsburg, West Virginia, lies on the western edge of this syncline, whence the name for this shale formation. The Massanutten syncline crosses Maryland in a southwest-northeast direction, occupying an area several

FIG. 22.—UPPER BLACK RIVER (LATEST CHAMBERSBURG).

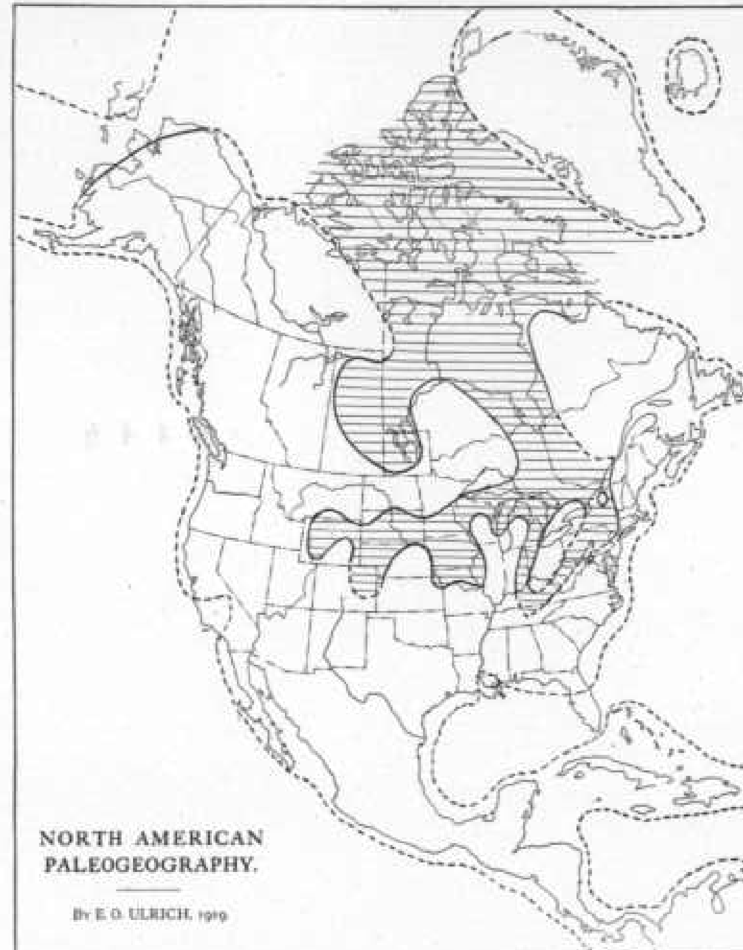

FIG. 23.—EARLY TRENTON.

miles wide just west of Williamsport. In its course through Maryland, Conococheague Creek is confined to this belt of Martinsburg shale, and the rugged topography caused by its erosion affords many outcrops of the strata. Exceptionally fine exposures occur, however, along the Western Maryland Railway from Williamsport west to Pinesburg Station. The underlying shale rock is shown almost continuously between these two places. Perhaps nowhere else in the Appalachian Valley is there such a continuous section of this formation exposed with all its attendant folding and faulting, and these railroad cuts will long remain classic ground for the study of this great syncline.

This section clearly brings out two well-marked divisions in the formation, the lower part consisting of a thick mass of black shale, and the upper portion for the most part of yellowish-green sandy strata. These two portions are distinct enough in the Massanutten syncline to be mapped as separate divisions, but in the North Mountain uplift to the west they grade into each other so gradually that it is impossible to map them separately.

Sufficient fossil evidence has been found in Maryland, but especially in southern Pennsylvania, to show that these two lithologic divisions correspond to definite portions of the general time scale. The lower black shale division contains, near the base, several horizons with faunas of Trenton age. It is probable, although not yet established by paleontologic evidence, that the upper part of these black shales corresponds to the Utica shale of the New York section. In the area west of the Massanutten syncline the sandy division has furnished numerous fairly well preserved fossils of Eden age. In the North Mountain uplift this sandy Eden division is followed by gray sandstones with a maximum thickness of 450 feet in which a considerable number of Cincinnatian (Lower Maysville) fossils has been found. These gray sandstones are still included in the Martinsburg shale, but the overlying soft red sandstone and red shale are so distinct that they have been separated as the Juniata formation. The Martinsburg shale as here developed, therefore, ranges in age from the Lower Trenton to at least the Lower Maysville and comprises portions of the Mohawkian and Cincinnatian series.

LITHOLOGIC CHARACTERS AND SECTIONS.—As just noted above, the Martinsburg shale consists in general of black shale forming the lower division and light-colored sandy shales the upper, but its lowest beds are of thin-bedded limestone and calcareous shale, while the uppermost beds are gray sandstone. The formation thus includes a variety of rock types, but shale is the predominating rock, so that the lithologic designation "shale" for the formation as a whole is appropriate. Depending more particularly on fossil evidence, four distinct divisions can be recognized in this shale, although all may not be present in the same section. These divisions with their approximate thicknesses are expressed in the following general section:

General Section of the Martinsburg Shale in Southern Pennsylvania and Maryland

	Feet
Juniata Formation of Earliest Silurian or Highest Ordovician Age.	
Martinsburg shale.	
Upper Maysville division.	
Unfossiliferous sandstone (Oswego sandstone). (Probably represented under cover west of North Mountain, in Maryland)	150
Lower Maysville division.	
Fossiliferous gray sandstone with *Orthorhynchula linneyi* bed at top. (Probably present west of North Mountain under cover)	300
Eden division.	
Yellow shale and calcareous sandstone interbedded, with upper Eden fossils	500±
Soft greenish to yellow shaly sandstones and shale with Eden fossils not uncommon at several horizons	500±
Trenton and ? Utica division.	
Dark-gray unfossiliferous shale breaking up into "shoe peg" fragments and often weathering into soft whitish clay	500±
Black carbonaceous fissile unfossiliferous shale	500±
Calcareous dark shale and thin limestone weathering gray containing graptolites (*Corynoides* fauna)	20-100
Granocrystalline fossiliferous limestone and shale holding the *Sinuites* fauna	2-10
Chambersburg limestone	...
Total	2500±

Although the above section applies in general to all of the Martinsburg shale areas in Maryland and adjoining states, a conspicuous exception to the development of the Eden division is to be noted in the Massanutten syncline area. Here the lower part is the usual thick mass of black carbonaceous shale with the Sinuites bed at the base and the Corynoides bed higher, but the upper portion consists of yellowish-green speckled sandstone so easily recognized that it has been mapped as a separate member. On fresh exposure this rock is found to be a greenish-gray arkose of feldspar and sand with the speckled appearance due to the weathering of the feldspar into kaolin. Small streams draining into Conococheague Creek have cut very rugged picturesque ravines in these strata.

The black carbonaceous shale becomes quite calcareous at the base and appears to grade into the underlying Chambersburg limestone. However, a distinct line of unconformity separates the two formations as evidenced by the varying age of the topmost bed of the Chambersburg in different parts of the valley. Fossils are sometimes abundant in these basal calcareous beds of the shale and the frequent occurrence of the gastropod *Sinuites* gives its name to the bed. A fauna of almost 50 species has been recognized in the Sinuites bed of Pennsylvania and Virginia, but in Maryland the bed, although recognized, has yielded few fossils.

Thirty or more feet above the base of the shale a second faunal zone is encountered. Here the small comma-shaped graptolite *Corynoides* is so abundant that it forms a convenient designation for the bed. This Corynoides bed has been recognized in several places in Maryland particularly at Williamsport and at Pinesburg Station on the east and west sides respectively of the Massanutten syncline. This fauna is small in numbers, but it constitutes an interesting horizon throughout this part of the Appalachians.

Following the Corynoides bed are the typical black carbonaceous and dark gray unfossiliferous shales of the lower Martinsburg which are so readily recognized on surface outcrops by the "shoe peg" fragments left

FIG. 24.—EARLY CINCINNATIAN (UTICA).

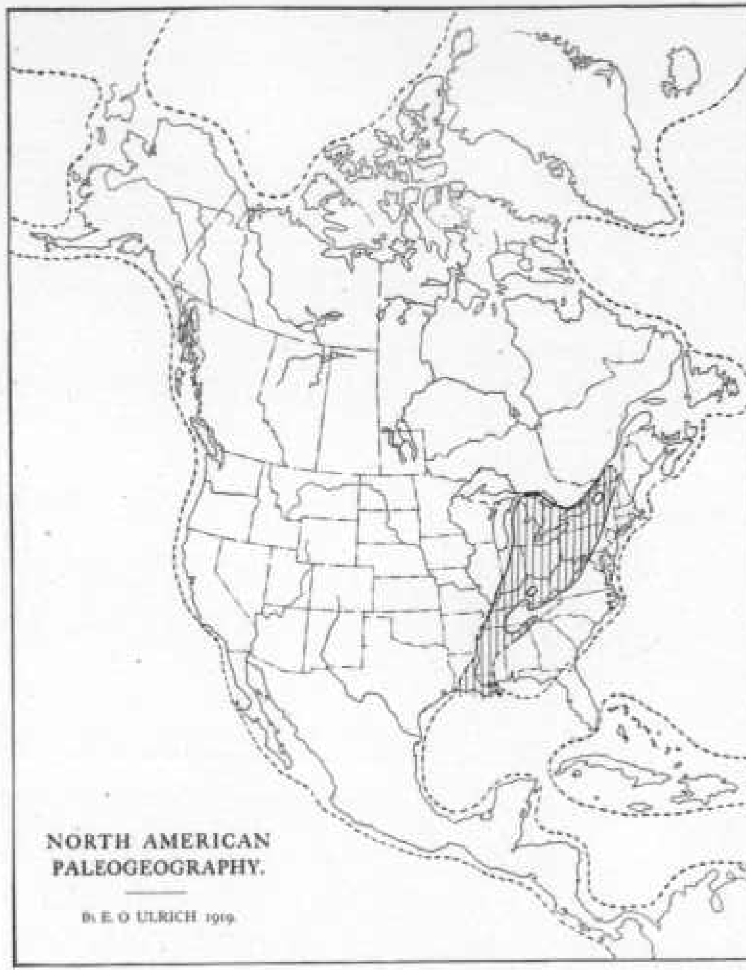

FIG. 25.—CINCINNATIAN (EDEN).

by weathering. In fresh exposures these beds are hard and sometimes reach several feet in thickness, but weathering brings out the intense squeezing and folding to which they have been subjected. Slaty cleavage usually obscures the original bedding, but occasionally a weathered surface clearly shows the relation between cleavage and stratification. The rock breaks down into small fragments not unlike shoe pegs and finally weathers into soft whitish clay. With the introduction of sandy sediments in the Martinsburg shale, fossils again are encountered and give a clew as to the age relations. At least three distinct fossiliferous zones have been discovered in these upper sandy shales. Two of these contain numerous species characterizing the Eden division of the Cincinnatian, whereas the third zone shows fossils of Lower Maysville age. As noted before, these fossiliferous zones are encountered only in areas west of the Massanutten syncline as the conditions for the preservation of organic remains were not favorable during the deposition of the sandy strata in the syncline itself.

Because of the lack of good exposures of the upper Martinsburg in the mountainous areas of western Maryland, it has not been possible to prepare detailed sections showing the position of the fossiliferous beds accurately. In southern Pennsylvania, however, especially in the vicinity of McConnellsburg and Fort Loudon, there are several extensive exposures of these beds. In the Eden portion of the Martinsburg shale 42 species have been recognized.

The interval between the top of the formation and the highest zone in which Eden fossils were found is occupied by gray sandstone about 450 feet thick. This is locally divisible into two unequal parts, the lower 300 feet thick, the upper 150 feet, by a fossiliferous stratum in which the brachiopod *Orthorhynchula linneyi* is a common fossil. Elsewhere in the Appalachian Valley and in the Ohio Valley this Orthorhynchula bed lies near the top of the Lower Maysville. This fossil zone has yielded a fauna of 18 species in southern Pennsylvania, all of which are characteristic Lower Maysville fossils. The overlying unfossiliferous gray sandstone

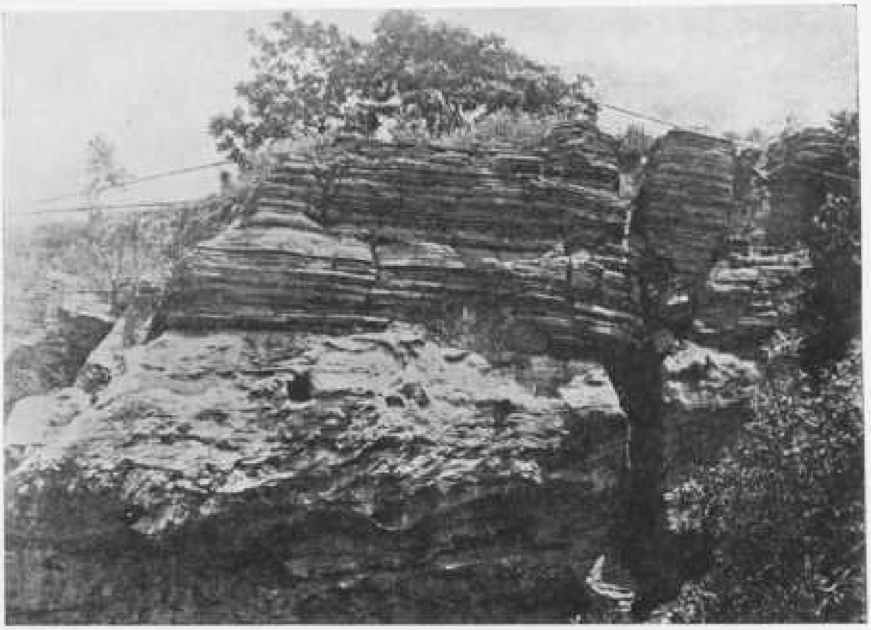

FIG. 1.—VIEW IN THE TABLER QUARRY JUST SOUTH OF FREDERICK, MARYLAND, SHOWING THE MASSIVE BEEKMANTOWN LIMESTONE OVERLAID BY THE THIN-BEDDED FREDERICK LIMESTONE WITH A DISTINCT LINE OF UNCONFORMITY SEPARATING THEM.

FIG. 2.—FOLD IN SANDY UPPER (EDEN) PORTION OF MARTINSBURG SHALE ALONG WESTERN MARYLAND RAILWAY, THREE-FOURTHS MILE WEST OF WILLIAMSPORT, MARYLAND.

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bringing Martinsburg shale deposition to a close is equivalent on stratigraphic grounds to the Oswego sandstone of New York, and like it, is apparently either of continental origin or its formation is connected with some phase of sea withdrawal. It is fairly well agreed upon by geologists that the Juniata shales or Red Medina immediately following the Oswego sandstone, is a continental expression of the marine Richmond group of the Ohio Valley. Indeed the two formations have actually been traced into each other. The underlying fossiliferous Upper Maysville (McMillan) formation of the Ohio Valley, which occurs between the Richmond above and the Orthorhynchula bed at or near the top of the Lower Maysville (Fairview) below, is thus almost certainly the equivalent of the unfossiliferous Oswego sandstone which has the same boundary planes. This correlation is further indicated by the fact that in both instances the Lower Maysville strata pass into the Upper Maysville without any clear evidence of a stratigraphic break.

TOPOGRAPHIC FEATURES AND AREAL DISTRIBUTION.—The largest area of Martinsburg shale in Maryland forms a low plateau averaging two and one-half miles in width. This crosses the state in a belt trending southwest-northeast through the central part of the Appalachian Valley. These shales resist weathering much more effectively than the subjacent limestones, the result being the low, yet topographically conspicuous plateau already mentioned. Although it is much dissected by Conococheague Creek and its tributaries, the upland part of this plateau has an altitude of about 580 feet at the Mason-Dixon line, but descends to about 540 feet at the Potomac River. These upland areas are remnants of an old peneplain that is still well preserved in the vicinity of Harrisburg, Pennsylvania, and after which it has been named. The excellent and almost continuous exposures of the Massanutten syncline belt of Martinsburg shale along the Western Maryland Railway between Williamsport and Pinesburg Station have been mentioned before.

In the limestone valley west of the Massanutten syncline a narrow strip of this shale has been brought down to the surface by faulting. The only

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FIG. 26.—CINCINNATIAN (FAIRVIEW).

FIG. 27.—CINCINNATIAN (OSWEGO-McMILLAN).

other areas in Maryland are in the North Mountain uplift, one forming the eastern slope of Powell Mountain, a second occupying Blair Valley between Rickard and Sword Mountains, and the third and smallest being the Punchbowl area of Bear Pond Mountain. These North Mountain areas show few outcrops of rock and are generally covered by debris of the sandstone formations which form the tops of the adjacent mountains.

FAUNAS.—Although fossils must be considered as quite rare in the Martinsburg shale, sufficient paleontologic evidence has been found to show that faunas of Trenton, Eden, and Maysville age are represented. Two zones with Trenton fossils occur near the base of the formation, the Eden fauna is found in the upper sandy portion, and the topmost sandstones hold Maysville species.

Fauna of the Basal Martinsburg Shale (*Sinuites Bed of Trenton Age.*) The most prolific zone for fossils in the Martinsburg shale is a thin band of limestone near the base of the formation which locally is crowded with organic remains. This zone has been recognized at numerous places in southern Pennsylvania, Maryland, and Virginia, although exposures of it are less frequent in Maryland and its contained fossils here are quite few in comparison with the other two states. In southern Pennsylvania the 35 species described in the following pages have been found represented by fairly good specimens, while an additional dozen or more forms are known from poorly preserved fragments. A still larger fauna occurs in this bed at Strasburg, Virginia, where excellent exposures for collecting occurred in the past.

The most striking and common fossil of this zone is the gastropod *Sinuites cancellatus* which has given rise to the name of the *Sinuites* bed. In the Chambersburg-Mercersburg folio of the U. S. Geological Survey, this zone has been considered as a transition bed between the Black River and Trenton and placed at the top of the Chambersburg limestone. As indicated later by Ulrich in his Revision of the Paleozoic Systems, the early Trenton aspect of its fauna is more marked than that of the Black River, and the reference of the bed to the basal Martinsburg is believed to be more correct. Stratigraphic evidence also shows that the Sinuites bed follows a considerable interruption of deposition, since the thickness of strata between it and the Nidulites bed of the Chambersburg is most variable.

The best localities for obtaining collections of the Sinuites fauna are just north of the Mason-Dixon line in southern Pennsylvania. East of the Martinsburg shale belt in this region the following fossils have been found:

Fauna of Basal Martinsburg Shale (Sinuites Bed), Chambersburg Quadrangle

Lingula riciniformis Hall
Leptobolus ovalis n. sp.
Conotreta rusti Walcott
Strophomena sculpturata n. sp.
Dalmanella testudinaria (Dalman) var.
Microceras inornatum Hall
Sinuites cancellatus Hall
Sinuites granistriatus Ulrich
Cyclora minuta Hall
Cyclora parvula (Hall)
Cyclora hoffmani Miller
Coleolus iowensis James
Conularia trentonensis Hall
Orthoceras junceum Hall
Trocholites ammonius Conrad
Eoharpes ottawaensis (Billings)
Cryptolithus tesselatus Green
Triarthrus fischeri Billings
Triarthrus becki Green
Bumastus trentonensis Emmons
Proetus latimarginatus Weller
Cyphaspis matutina Ruedemann
Calymene senaria Conrad

West of the shale belt in the Mercersburg quadrangle a larger number of species has been identified in the Sinuites zone, but many of them are identical with those in the more eastern belt of outcrop.

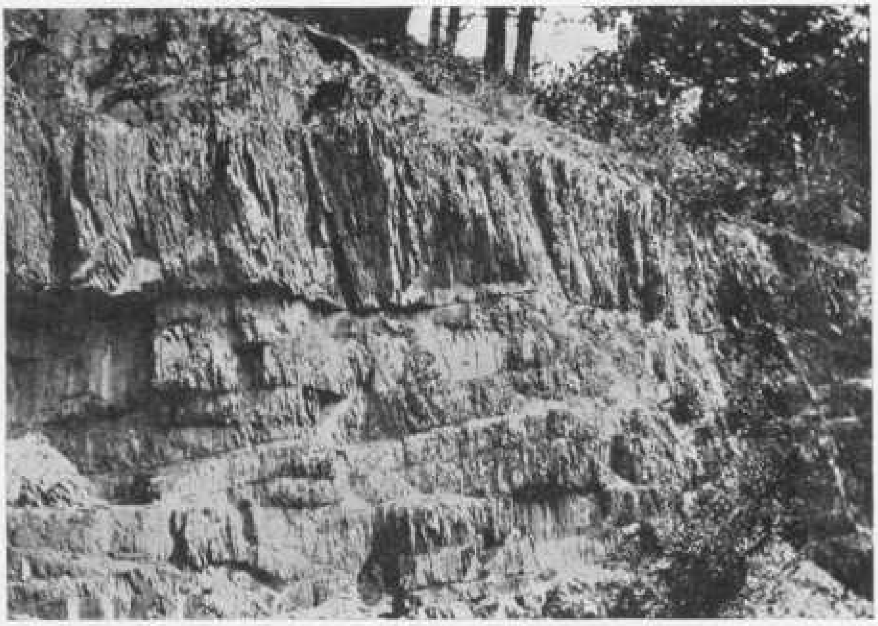

FIG. 1.—EXPOSURE OF LOWER PART OF MARTINSBURG SHALE ALONG WESTERN MARYLAND RAILWAY, ABOUT ONE-HALF MILE EAST OF PINESBURG STATION, MARYLAND. THE GENTLE DIP OF THE STRATA AND THE CLEAVAGE AT RIGHT ANGLES ARE WELL SHOWN.

FIG. 2.—VIEW ACROSS VALLEY OF CONOCOCHEAGUE AND BEEKMANTOWN LIMESTONES, FROM A POINT TWO MILES EAST OF LITTLE GEORGETOWN, WEST VIRGINIA. CONOCOCHEAGUE CHERT STREWS THE FOREGROUND. NORTH MOUNTAIN IN THE DISTANCE CONTAINS THE JUNIATA AND TUSCARORA FORMATIONS.

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Fauna of Sinuites Bed in Mercersburg Quadrangle, Pennsylvania

Hindia parva Ulrich
Lingula riciniformis Hall
Leptobolus ovalis n. sp.
Dalmanella testudinaria (Dalman) var.
Dalmanella edsoni n. sp.
Christiania lamellosa n. sp.
Strophomena sculpturata n. sp.
Leptaena tenuistriata Sowerby var.
Triplecia (Cliftonia) simulatrix n. sp.
Scenidium ? merope (Billings)
Cyrtolitina nitidula (Ulrich)
Microceras inornatum (Hall)
Sinuites cancellatus (Hall)
Sinuites granistriatus (Ulrich)
Strophostylus textilis Ulrich and Scofield
Cyclora hoffmanni Miller
Cyclora minuta Hall
Cyclora parvula (Hall)
Eccyliomphalus trentonensis (Conrad)
Colcolus iowensis James
Orthoceras junceum Hall
Spyroceras bilineatum (Hall)
Cryptolithus tesselatus Green
Triarthrus becki Green
Illaenus americanus Billings
Cyphaspis matutina Ruedemann
Amphilichas trentonensis (Conrad)

The complete list of identified species in the Sinuites bed with their occurrence in the best localities for collecting in southern Pennsylvania is shown in the table on next page.

Fauna of the Lower Martinsburg Shale (Corynoides Bed of Trenton Age).—Thirty feet or more of unfossiliferous black calcareous shale and thin-bedded limestone overlie the Sinuites bed and are in turn followed by a fossiliferous zone crowded with graptolites and other organisms, some of which have a Utica aspect, although the majority are known in the Trenton limestone. The abundant occurrence of the small, peculiar graptolite *Corynoides calicularis* in this zone occasions its name. A second char-

FAUNA OF THE SINUITES BED

	Chambersburg, Pa.	5 m. SSW. Chambersburg, Pa.	2 m. S. St. Thomas, Pa.	3 m. SE. Mercersburg, Pa.
Hindia parva Ulrich	..	..	*	..
Lingula riciniformis Hall	*	*	*	..
Leptobolus ovalis n. sp.	*	*	*	*
Conotreta rusti Walcott	..	*	*	..
Dalmanella testudinaria (Dalman) var.	*	*	..	..
Dalmanella edsoni n. sp.	..	..	*	..
Christiania lamellosa n. sp.	..	..	*	..
Strophomena sculpturata n. sp.	*	..	*	..
Leptaena tenuistriata Sowerby var.	..	..	*	..
Triplecia (Cliftonia) simulatrix n. sp.	..	..	*	..
Scenidium ? merope (Billings)	..	..	*	..
Cyrtolitina nitidula (Ulrich)	..	..	*	*
Microceras inornatum (Hall)	..	*	*	..
Sinuites cancellatus (Hall)	*	..	*	*
Sinuites granistriatus (Ulrich)	*	..	*	*
Strophostylus textilis Ulrich and Scofield	..	..	*	*
Cyclora minuta Hall	..	*	*	..
Cyclora parvula (Hall)	..	*	*	..
Cyclora hoffmanni Miller	..	*	*	..
Eccyliomphalus trentonensis (Conrad)	..	..	*	*
Coleolus iowensis James	..	*	*	..
Conularia trentonensis Hall	..	*	..	..
Orthoceras junceum Hall	*	..	*	..
Spyroceras bilineatum (Hall)	..	..	*	..
Trocholites ammonius Conrad	*	..	..	..
Eoharpes ottawaensis (Billings)	..	*	..	..
Cryptolithus tesselatus Green	*	*	*	*
Triarthrus fischeri Billings	..	*	..	..
Triarthrus becki Green	..	*	*	..
Illaenus americanus Billings	..	..	*	*
Bumastus trentonensis Emmons	*	*	..	..
Proetus latimarginatus Weller	*	*	..	..
Cyphaspis matutina Ruedemann	*	..	*	..
Amphilichas trentonensis (Conrad)	..	..	*	..
Calymene senaria Conrad	..	*	..	..

acteristic fossil is the pod-shaped crustacean *Caryocaris silicula,* individuals of which are often quite common in the shaly limestones.

The Corynoides bed has been recognized in the Appalachian Valley from Pennsylvania south to Virginia. In Maryland the shale outcrops in the vicinity of Williamsport and Pinesburg Station have furnished the few fossils so far discovered in this bed.

Fauna of the Corynoides Bed

Climacograptus putillus (Hall)
Climacograptus spinifer (Ruedemann)
Corynoides calicularis Nicholson
Leptobolus insignis Hall
Schizocrania filosa (Hall)
Cyclora minuta Hall
Cryptolithus tesselatus Green
Triarthrus becki Green
Lepidocolcus jamesi (Hall and Whitfield)
Caryocaris silicula n. sp.

Fossils of the Eden Division, Martinsburg Shale.—The splendid exposures of the lower Cincinnatian shales, later designated the Eden shale, in the vicinity of Cincinnati, Ohio, have afforded a wealth of excellently preserved fossils which have been so widely studied by paleontologists that a large described fauna has resulted. The occurrence of this same fauna, well enough preserved for the accurate recognition of at least 42 species, in the sandy upper portion of the Martinsburg shale of Pennsylvania, Maryland, and Virginia, is one of the interesting discoveries of recent years in Appalachian geology.

Numerous exposures of this sandy upper portion of the Martinsburg shale occur along the Western Maryland Railway between Williamsport and Pinesburg Station, but the conditions of sedimentation in this part of the valley seem to have been unfavorable for life, as no fossils could be found. The northward and southward extensions of this Martinsburg shale belt likewise have furnished no fossils, but the shale exposures in the mountains to the west exhibit several fossiliferous zones. In Maryland it happens that no good exposures of the upper Martinsburg occur along the roads crossing the mountains, and here the fauna is known only from sandstone debris along their lower slopes. In southern Pennsylvania, on the contrary, good exposures of the fossiliferous strata are found along several turnpikes crossing the mountains. The best fossils have been procured from such outcrops along Jordan Knob, one and a half miles northeast of Fort Loudon, Tuscarora Mountain, two and a half miles southeast of McConnellsburg, and Cowans Gap, five miles northeast of McConnellsburg. Two fossiliferous zones are known in the Eden portion of the Martinsburg shale, one at the top of this portion and the second 400 feet lower. The faunas, listed on next page, show that there is little difference between these two zones.

Fossils of the Maysville Sandstone Division, Martinsburg Shale.—As explained on a previous page the unfossiliferous red sandstones and shales immediately overlying the Martinsburg shale have been distinguished and mapped in southern Pennsylvania as the Juniata formation. Upon stratigraphic grounds these red beds are undoubtedly the equivalent of the Lower or Red Medina (Queenston) shales of New York. Lithologically the rocks are similar and in each area they are underlaid by strata with Cincinnatian (Maysville) fossils and followed by the White Medina (Tuscarora) sandstone. The sandstone underlying the Juniata formation and following the sandy shales of Eden age, although covering the well-defined Middle Cincinnatian (Maysville) division of geological time have not hitherto been separated from the Martinsburg shales in Pennsylvania and Maryland. As their area of occurrence in Maryland is so small and good outcrops are almost wanting, the practice of uniting these strata with the Martinsburg shale is continued in this volume.

Exposures along the turnpike crossing Tuscarora Mountain, one and one-half miles southeast of McConnellsburg, Pennsylvania, have afforded fairly well-preserved specimens of the species listed below. All of these fossils occur at the top of the lower division of these sandstones in a bed characterized by *Orthorhynchula linneyi*. This Orthorhynchula bed everywhere marks the dividing line between the Lower Maysville (Fair-

LIST OF FOSSILS IN EDEN PORTION OF MARTINSBURG SHALE

	Jordan Knob, Pa. (400 feet below top)	Jordan Knob, Pa. (Top)	Tuscarora Mt. (400 feet below top)	Cowans Gap, Pa.
[2] *Climacograptus bicornis* (Hall) var.	*	*	..	..
Diplograptus vespertinus (Ruedemann)	..	*	..	..
[2] *Cornulites flexuosus* (Hall)	*	*	*	..
[1] *Heterocrinus heterodactylus* Hall	*	*	*	..
Merocrinus species undetermined	*	*	*	..
Hudsonaster clarki n. sp.	..	..	*	..
Berenicea vesiculosa Ulrich	..	*	..	..
Bythopora arctipora (Nicholson)	*	..	..	..
[1] *Hallopora onealli sigillarioides* (Nicholson)	*	..	*	*
[1] *Batostoma jamesi* Nicholson	*	..	..	*
[1] *Arthropora cleavelandi* (James)	..	*	*	..
[1] *Pholidops cincinnatiensis* Hall	*	*	*	*
[1] *Dalmanella multisecta* (Meek)	*	..	*	*
[2] *Plectorthis plicatella* Hall var.	..	..	*	..
[1] *Strophomena hallie* (S. A. Miller)	..	..	*	..
[1] *Strophomena sinuata* James var.	..	..	*	..
[1] *Rafinesquina squamula* (James)	*	..	..	..
[2] *Plectambonites rugosus* (Meek)	*	*	*	*
[1] *Leptaena gibbosa* (James)	..	..	*	..
[2] *Zygospira modesta* (Hall)	..	*	*	*
[2] *Ctenodonta obliqua* Hall	*	..	..	..
[1] *Ctenodonta filistriata* Ulrich	..	*	..	..
[2] *Clidophorus planulatus* (Conrad)	..	..	*	..
[1] *Byssonychia vera* Ulrich	..	..	*	..
[1] *Lyrodesma conradi* Ulrich	..	..	*	..
[2] *Sinuites cancellatus* (Hall)	..	*	*	..
[2] *Sinuites granistriatus* (Ulrich)	..	*	..	..
[2] *Tetranota obsoleta* Ulrich	..	..	*	*
[2] *Hormotoma gracilis* (Hall)	*	..	..	..
[1] *Lophospira (Ruedemannia) lirata* (Ulrich)	..	..	..	*
[2] *Liospira micula* (Hall)	*	..	*	..
[1] *Orthoceras transversum* Miller	..	..	*	*
[1] *Cryptolithus bellulus* (Ulrich)	*	*	*	*
[2] *Cryptolithus recurvus* (Ulrich) n. sp.	*	*	*	..
[2] *Triarthrus becki* Green	*	..	..	..
[1] *Isotelus stegops* Green	..	*	*	*
[1] *Calymene granulosa* (Foerste)	*	*	*	*
[2] *Aparchites minutissimus* (Hall)	*	..	..	..
[2] *Ceratopsis chambersi* (Miller)	*	*	..	..
[2] *Ulrichia bivertex* (Ulrich)	..	*	..	..
[2] *Bythocypris cylindrica* (Hall)	*	*	*	..
[2] *Lepidocoleus jamesi* (Hall and Whitfield)	*	*	*	..

[1] Restricted to Eden. [2] Occurs in Eden and other formations.

view) and the Upper Maysville (McMillan) divisions, the latter in the Appalachian region being an unfossiliferous, gray sandstone apparently of continental origin and equivalent to the Oswego sandstone of the New York section.

List of Maysville Fossils (Orthorhynchula Bed), Southern Pennsylvania

Lingula nicklesi n. sp.
Plectorthis plicatella Hall
Rafinesquina alternata (Emmons)
Rafinesquina squamula (James)
Orthorhynchula linneyi (James)
Zygospira modesta (Hall)
Zygospira ? erratica (Hall)
Ischyrodonta unionoides (Meek)
Pterinea (Caritodens) demissa (Conrad)
Byssonychia radiata (Hall)
Byssonychia praecursa Ulrich
Allonychia ovata Ulrich
Modiolopsis modiolaris (Conrad)
Modiolodon truncatus (Hall)
Orthodesma nasutum (Conrad)
Liospira micula (Hall)
Orthoceras lamellosum Hall
Isotelus megistos Locke

THE JUNIATA FORMATION

Until quite recently American geologists have been in accord in regarding the boundary between the Ordovician and Silurian systems as lying at the base of the Red Medina. Indeed, by many, the base of the Silurian was placed still lower, namely, at the bottom of the Oneida conglomerate which was supposed to underlie the Medina and to be equivalent in age to the Oswego sandstone which actually does occur under the Red Medina. The Oneida conglomerate, however, has been proved to belong at the top of the Medina and may indeed represent the initial deposit of the Clinton. The Oswego sandstone therefore became a valid formation, and the name Oswegan series was coined by Clarke and Schuchert to include the Oswego

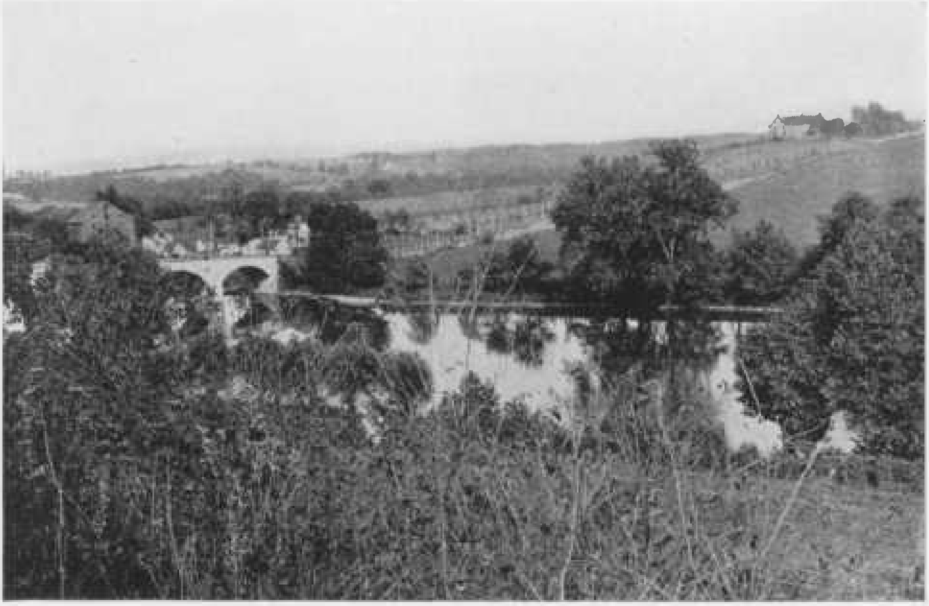

FIG. 1.—VIEW OF MARTINSBURG SHALE TOPOGRAPHY, LOOKING NORTHEAST FROM A POINT ONE-HALF MILE SOUTH OF WILSON, MARYLAND. CONOCOCHEAGUE CREEK IS SEEN IN THE FOREGROUND AND THE NATIONAL HIGHWAY IN THE MIDDLE.

FIG. 2.—VALLEY OF MARTINSBURG SHALE (BLAIR VALLEY, MARYLAND) VIEWED FROM ROAD, JUST WEST OF UNION BETHEL CHURCH. THE MOUNTAINS ON BOTH SIDES ARE FORMED OF THE JUNIATA AND TUSCARORA FORMATIONS.

sandstone and the Red and White Medina formations as the earliest major division of the Silurian. The reason for regarding the Oswego sandstone as Ordovician in age has been given on a preceding page.

In the standard Ordovician-Silurian section of New York the last fauna of Ordovician age is found in the Pulaski shale where species identical with Lower Maysville fossils of the Cincinnatian section occur. Above the Pulaski shale are unfossiliferous gray sandstones (Oswego sandstone) which in turn are succeeded by the Lower ("Red") Medina forming the base of the Silurian, according to the New York geologists. This Lower Medina is unfossiliferous, but in the overlying Upper ("White") Medina a fauna of Silurian types is preserved.

In Pennsylvania and Maryland practically the same section is developed. The sandstones at the top of the Martinsburg shale contain the Pulaski shale representative with the Lower Maysville fauna and above this a gray unfossiliferous sandstone very similar to the Oswego sandstone occurs, followed in turn by the typical Red Medina here termed the Juniata formation, and by the White Medina or Tuscarora sandstone.

In the extremely fossiliferous Upper Ordovician, Cincinnatian rocks of the Ohio Valley, the equivalent of the Pulaski shale of New York is included in the Lower Maysville, Fairview formation. This is succeeded by the fossiliferous Upper Maysville (McMillan) formation, which in turn is followed by the equally fossiliferous Richmond group. Lately it has been proved by actual tracing that the Richmond group passes laterally into the Lower (Red) Medina of New York. Until the recent researches of Ulrich upon the paleontology and stratigraphic distribution of the Richmond and related formations, the Upper Ordovician age of the Richmond fauna had been taken for granted. In his paper on the Ordovician-Silurian boundary, published in the Proceedings of the Twelfth Session of the International Geological Congress, Ulrich has reviewed the faunal and physical aspects of the data relating to the age of the Richmond group and concludes that the choice of the Medina including the Queenston-Richmond formations by the New York geologists as the base of the

Silurian has strong evidence in its favor. The present writer has had the opportunity of studying the Richmond group over a large portion of the United States with the result that in previous publications he has classified it at the base of the Silurian. His treatement of the equivalent Juniata formation in this volume under the Ordovician is not due to a change of view, but to the fact that in the Silurian volume of the Maryland Geological Survey the base of the Silurian is placed at the Tuscarora sandstone. As the Juniata is unfossiliferous and, moreover, is very poorly exposed in Maryland, further details are believed unnecessary here, and the reader is referred to the publication by Ulrich cited above for more data as to its age.

In Pennsylvania and Maryland the red sandstone and shales of the Juniata formation form the upper slope of the mountains just west of the Great Valley. These mountain slopes usually show only reddish sandstone blocks and it is only in cliffs or in road sections that the interbedded red shales can be seen. The sandstone frequently shows cross bedding and sometimes conglomerate beds of white quartz or red jasper boulders or occasionally red shale pebbles are developed. The occurrences of the formation in Maryland consists of small areas on Bear Pond Mountain, a narrow strip on Fairview Mountain and another narrow strip along the eastern side of Sword Mountain. None of these areas shows a section of the rocks and the red shales and sandstones are known only from surface debris.

The relations and general characters of the Juniata and associated formations are well shown in the following generalized section of Upper Ordovician and Early Silurian strata made by E. O. Ulrich and the writer. This section is exposed along the west slope of Tuscarora Mountain between McConnellsburg, Pennsylvania, and the summit of the mountain, along the Mercersburg pike starting about a mile and a half southeast of McConnellsburg and continuing southeast and south for about two and one-half miles.

Section Along West Slope of Tuscarora Mountain, Southeast of McConnellsburg, Pennsylvania

	Feet
Silurian—Tuscarora sandstone.	
Massive granular white quartz sandstone	200+
Ordovician or Silurian—Juniata formation.	
Soft red unfossiliferous sandstone and red shale, interbedded	400+
Ordovician-Martinsburg shale.	
Oswego gray sandstone member	150
Maysville (Fairview) fossiliferous gray sandstone (Orthorhynchula bed at top)	300
Upper Eden shale and calcareous sandstone interbedded	400
Middle Eden fossiliferous shale weathering yellow	...
Lower Eden shales, not exposed	...
Trenton and Utica ? black fissile unfossiliferous shale with black shale at base bearing graptolites	...
Chambersburg limestone	...

Note:
1 = Stonehenge Member
2 = Cryptozoon steeli Bed
3 = Ceratopea Bed
4 = Turritoma Bed
5 = Greencastle Bed
6 = Caryocystites Bed
7 = Tetradium Bed
8 = Echinospherites Bed
9 = Nidulites Bed
10 = Christiania Bed
11 = Eden Division
12 = Sinuites Bed
13 = Corynoides Bed
14 = Fairview Division

		CAMBRIAN																					ORDOVICIAN					
		WAUCOBAN										ACADIAN		OZARKIAN									CANADIAN					
		Harpers Shale		Antietam Sandstone					Tomstown Limestone			Waynesboro Form	Elbrook Limestone	Conococheague Limestone									Beekmantown Limestone					
	SPECIES	Eakles Mills	W. side Blue Ridge	Eakles Mills	W. side Blue Ridge	Little Antietam Cr.	Smithsburg	Chambersburg Quad.	Eakles Mills	Near Smithsburg	Near Waynesboro, Pa.	Near Waynesboro, Pa.	Near Waynesboro, Pa.	Sharpsburg	Near Antietam Station	Near Funkstown	Chambersburg Quad.	New York	Virginia	Utah	Colorado	New Mexico	Near Hagerstown	Near Funkstown	Williamsport	Near Charlton	Huyett	Chambersburg Quad.
	THALLOPHYTA. Algae																											
1	*Cryptozoon proliferum* Hall													*	*			*	*									
2	*Cryptozoon undulatum* Bassler n. sp.													*		*		*										
3	*Cryptozoon steeli* Seely																						2					
4	*Palæophycus tubulare* Hall																						1					
5	*Solenopora compacta* (Billings)																											
6	*Nidulites pyriformis* Bassler																											
7	*Receptaculites occidentalis* Salter																											
	PORIFERA. Spongiae																											
1	*Rhabdaria fragilis* (Billings)																						2					2
2	*Camarocladia rugosa* Ulrich																											
3	*Hindia parva* Ulrich																											
	COELENTERATA. Anthozoa																											
1	*Columnaria (?) halli* Nicholson																											
2	*Streptelasma profundum* (Conrad)																											
3	*Tetradium ? simplex* Bassler n. sp.																						2					
4	*Tetradium syringoporoides* Ulrich																											
5	*Tetradium columnare* (Hall)																											
6	*Tetradium cellulosum* (Hall)																											
	COELENTERATA. Graptolitoidea																											
7	*Climacograptus putillus* (Hall)																											
8	*Climacograptus spinifer* (Ruedemann)																											
9	*Climacograptus bicornis* (Hall)																											
10	*Diplograptus vespertinus* (Ruedemann)																											
11	*Corynoides calicularis* Nicholson																											
	ECHINODERMATA. Cystoidea																											
1	*Echinosphaerites aurantium americanum* Bassler n. var.																											
2	*Caryocystites* sp.																											
	ECHINODERMATA. Crinoidea																											
3	*Reteocrinus ?* sp.																											
4	*Carabocrinus* sp.																											
5	*Heterocrinus heterodactylus* Hall																											
6	*Merocrinus* sp.																											
	ECHINODERMATA. Stelleroidea																											
7	*Hudsonaster clarki* Bassler n. sp.																											
	MOLLUSCOIDEA. Bryozoa																											
1	*Corynotrypa inflata* (Hall)																											
2	*Corynotrypa delicatula* (James)																											
3	*Berenicea vesiculosa* Ulrich																											
4	*Orbignyella wetherbyi* (Ulrich)																											
5	*Prasopora insularis* Ulrich																											
6	*Prasopora contigua* Ulrich																											
7	*Dianulites petropolitanus* Dybowski																											
8	*Hemiphragma irrasum* (Ulrich)																											
9	*Diplotrypa ? appalachia* Bassler n. sp.																											
10	*Batostoma jamesi* Nicholson																											
11	*Bythopora arctipora* (Nicholson)																											
12	*Hallopora onealli sigillaroides* (Nicholson)																											
13	*Escharopora confluens* Ulrich																											

ORDOVICIAN																																												
Canadian						?	Chazyan						Mohawkian and Cincinnatian																															
Beekmantown Limestone						Frederick Limestone	Stones River Limestone						Chambersburg Limestone																Martinsburg Shale															
Mercersburg Quad.	Canada	Vermont	New York	New Jersey	Virginia	East of Frederick	Pinesburg Station	Wilson	Near Mauganville	Chambersburg Quad.	Canada	New York	Pinesburg Station	Wilson	Chambersburg Quad.	Mercersburg Quad.	New Jersey	New York	West Virginia	Virginia	Ohio	Kentucky	Tennessee	Iowa	Wisconsin	Minnesota	Canada	Esthonia, Russia	Washington County	Rickard Mt.	Fairview Mt.	Williamsport	Mercersburg Quad.	Chambersburg Quad.	New York	Virginia	Ohio	Kentucky	Tennessee	Missouri	Wisconsin	Minnesota	Canada	
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Note:
1 = Stonehenge Member
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		CAMBRIAN																					ORDOVICIAN					
		WAUCOBAN										ACADIAN		OZARKIAN									CANADIAN					
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	MOLLUSCOIDEA. Bryozoa.—*Continued*																											
14	*Arthropora bifurcata* Ulrich																											
15	*Arthropora cleavelandi* (James)																											
16	*Chasmatopora reticulata* (Hall)																											
17	*Chasmatopora sublaxa* (Ulrich)																											
18	*Helopora divaricata* Ulrich																											
19	*Helopora spiniformis* (Ulrich)																											
20	*Rhinidictya neglecta* Ulrich																											
	MOLLUSCOIDEA. Brachiopoda																											
21	*Lingulella* sp.											*																
22	*Leptobolus ? ovalis* Bassler n. sp.																											
23	*Leptobolus insignis* Hall																											
24	*Lingula riciniformis* Hall																											
25	*Lingula nicklesi* Bassler n. sp.																											
26	*Obolella minor* (Walcott)					*	*																					
27	*Orbiculoidea lamellosa* (Hall)																											
28	*Conotreta rusti* Walcott																											
29	*Schizocrania filosa* (Hall)																											
30	*Pholidops cincinnatiensis* Hall																											
31	*Eoorthis cf. desmopleura* (Meek)															*	*											
32	*Hebertella borealis* (Billings)																											
33	*Hebertella vulgaris* Raymond																											
34	*Hebertella bellarugosa* (Conrad)																											
35	*Orthis tricenaria* Conrad																											
36	*Plectorthis plicatella* Hall																											
37	*Plectorthis plicatella* Hall var.																											
38	*Dalmanella testudinaria* (Dalman) var.																											
39	*Dalmanella edsoni* Bassler n. sp.																											
40	*Dalmanella multisecta* (Meek)																											
41	*Dalmanella electra* (Billings)																						3		3			3
42	*Dalmanella wemplei* Cleland																						1	1				
43	*Dinorthis (Plaesiomys) platys* (Billings)																											
44	*Dinorthis pectinella* (Emmons)																											
45	*Pianodema subaequata* (Conrad)																											
46	*Strophomena stosei* Bassler n. sp.																											
47	*Strophomena sculpturata* Bassler n. sp.																											
48	*Strophomena hallie* (S. A. Miller)																											
49	*Strophomena sinuata* James																											
50	*Plectambonites pisum* Ruedemann																											
51	*Plectambonites rugosus* (Meek)																											
52	*Christiania trentonensis* Ruedemann																											
53	*Christiania lamellosa* Bassler n. sp.																											
54	*Leptaena charlottae* Winchell & Schuchert																											
55	*Leptaena gibbosa* (James)																											
56	*Leptaena tenuistriata* Sowerby var.																											
57	*Rafinesquina champlainensis* Raymond																											
58	*Rafinesquina minnesotensis* (Winchell)																											
59	*Rafinesquina minnesotensis inquassa* (Sardeson)																											
60	*Rafinesquina squamula* (James)																											
61	*Rafinesquina alternota* (Emmons)																											

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Canadian						?	Chazyan						Mohawkian and Cincinnatian																															
Beekmantown Limestone						Frederick Limestone	Stones River Limestone						Chambersburg Limestone																Martinsburg Shale															
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		CAMBRIAN																					ORDOVICIAN					
		Waucoban										Acadian		Ozarkian									Canadian					
		Harpers Shale		Antietam Sandstone					Tomstown Limestone			Waynesboro Form	Elbrook Limestone	Conococheague Limestone									Beekmantown Limestone					
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	MOLLUSCOIDEA. Brachiopoda.—*Continued*																											
62	*Triplecia (Cliftonia) simulatrix* Bassler n. sp.																											
63	*Syntrophia lateralis* (Whitfield)																						2		2			
64	*Scenidium anthonense* Sardeson																											
65	*Scenidium ? merope* (Billings)																											
66	*Parastrophia hemiplicata* Hall																											
67	*Camarotoechia plena* (Hall)																											
68	*Orthorhynchula linneyi* (James)																											
69	*Zygospira recurvirostris* (Hall)																											
70	*Zygospira exigua* (Hall)																											
71	*Zygospira modesta* (Hall)																											
72	*Zygospira ? erratica* (Hall)																											
	VERMES. Tubicola																											
1	*Cornulites flexuosus* (Hall)																											
2	*Scolithus linearis* (Haldemann)	*	*	*	*																							
	MOLLUSCA. Pelecypoda																											
1	*Ctenodonta gibberula* Salter																											
2	*Ctenodonta obliqua* (Hall)																											
3	*Ctenodonta filistriata* Ulrich																											
4	*Clidophorus planulatus* (Conrad)																											
5	*Ischyrodonta unionoides* (Meek)																											
6	*Byssonychia vera* (Ulrich)																											
7	*Byssonychia radiata* (Hall)																											
8	*Byssonychia praecursa* Ulrich																											
9	*Allonychia ovata* Ulrich																											
10	*Pterinea (Caritodens) demissa* (Conrad)																											
11	*Lyrodesma conradi* Ulrich																											
12	*Modiolopsis modiolaris* (Conrad)																											
13	*Modiolodon truncatus* (Hall)																											
14	*Orthodesma nasutum* (Conrad)																											
	MOLLUSCA. Gastropoda																											
15	*Pleurotomaria ? canadensis* Billings																								3			
16	*Pleurotomaria ? gregaria* Billings																										4	
17	*Pleurotomaria ? floridensis* Cleland																						1					
18	*Hormotoma artemesia* (Billings)																								3			
19	*Hormotoma gracilis* (Hall)																											
20	*Hormotoma gracilens* (Whitfield)																										4	4
21	*Turritoma acrea* (Billings)																										4	4
22	*Lophospira bicincta* (Hall)																											
23	*Lophospira (Ruedemannia) lirata* (Ulrich)																											
24	*Liospira micula* (Hall)																											
25	*Maclurites affinis* (Billings)																						2		2			
26	*Maclurites magnus* Lesueur																											
27	*Maclurites sordidus* (Hall)																						3		3			
28	*Maclurites oceanus* (Billings)																										4	
29	*Ceratopea keithi* Ulrich																						3					
30	*Helicotoma planulatoides* Ulrich																											
31	*Helicotoma verticalis* Ulrich																											

ORDOVICIAN

	Canadian						?	Chazyan						Mohawkian and Cincinnatian																														
	Beekmantown Limestone						Frederick Limestone	Stones River Limestone						Chambersburg Limestone																Martinsburg Shale														
	Mercersburg Quad.	Canada	Vermont	New York	New Jersey	Virginia	East of Frederick	Pinesburg Station	Wilson	Near Mauganville	Chambersburg Quad.	Canada	New York	Pinesburg Station	Wilson	Chambersburg Quad.	Mercersburg Quad.	New Jersey	New York	West Virginia	Virginia	Ohio	Kentucky	Tennessee	Iowa	Wisconsin	Minnesota	Canada	Esthonia, Russia	Washington County	Rickard Mt.	Fairview Mt.	Williamsport	Mercersburg Quad.	Chambersburg Quad.	New York	Virginia	Ohio	Kentucky	Tennessee	Missouri	Wisconsin	Minnesota	Canada
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		CAMBRIAN																				ORDOVICIAN					
		Waucoban									Acadian		Ozarkian									Canadian					
		Harpers Shale		Antietam Sandstone					Tomstown Limestone			Waynesboro Form.	Elbrook Limestone	Conococheague Limestone									Beekmantown Limestone					
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	MOLLUSCA. Gastropoda.—*Continued*																											
32	*Eccyliopterus disjunctus* (Billings)																										4	4
33	*Eccyliopterus triangulus* (Whitfield)																									2		
34	*Ophileta complanata* Vanuxem																						1	1				
35	*Ophileta levata* Vanuxem																						1	1				
36	*Ophileta compacta* Salter																						2	2	2	2		2
37	*Eccyliomphalus multiseptarius* Cleland																						1	1				
38	*Eccyliomphalus trentonensis* (Conrad)																						1	1				
39	*Raphistoma obtusum* Cleland																											
40	*Raphistoma ? columbianum* Weller																						1					
41	*Raphistomina laurentina* (Billings)																											3
42	*Omospira alexandra* (Billings)																											
43	*Bucania sulcatina* (Emmons)																											
44	*Tetranota obsoleta* Ulrich																											
45	*Cyrtolitina nitidula* (Ulrich)																											
46	*Microceras inornatum* (Hall)																											
47	*Sinuites cancellatus* (Hall)																											
48	*Sinuites granistriatus* (Ulrich)																											
49	*Strophostylus textilis* Ulrich & Scofield																											
50	*Cyclora minuta* Hall																											
51	*Cyclora parvula* (Hall)																											
52	*Cyclora hoffmanni* Miller																											
53	*Hyolithes communis* Billings			*																								
54	*Salterella* sp.										*																	
55	*Coleolus iowensis* James																											
56	*Conularia trentonensis* Hall																											
	MOLLUSCA. Cephalopoda																											
57	*Cameroceras* sp.																											
58	*Orthoceras primigenium* Vanuxem																						1					
59	*Orthoceras arcuoliratum* Hall																											
60	*Orthoceras junceum* Hall																											
61	*Orthoceras transversum* Miller																											
62	*Orthoceras tamellosum* Hall																											
63	*Spyroceras bilineatum* (Hall)																											
64	*Trocholites internistriatus* (Whitfield)																											
65	*Trocholites ammonius* Conrad																										4	4
66	*Gonioceras chaziense* Ruedemann																											
67	*Ooceras kirbyi* (Whitfield)																						1	1				
68	*Cyrtoceras gracile* Cleland																							1				
69	*Cyrtoceras beekmanense* Whitfield																							1				
70	*Cyrtoceras camurum* Hall																											
71	*Cyrtocerina mercurius* Billings																										4	4
72	*Cyclostomiceras cassinense* (Whitfield) ?																							1				
	ARTHROPODA. Crustacea																											
1	*Eoharpes ottawaensis* (Billings)																											
2	*Cryptolithus bellulus* (Ulrich)																											
3	*Cryptolithus recurvus* (Ulrich) Bassler n. sp																											
4	*Cryptolithus tesselatus* Green																											
5	*Ampyx (Lonchodomas) normalis* (Billings)																											

ORDOVICIAN																																												
CANADIAN						?	CHAZYAN						MOHAWKIAN AND CINCINNATIAN																															
Beekmantown Limestone						Frederick Limestone	Stones River Limestone						Chambersburg Limestone																Martinsburg Shale															
Mercersburg Quad.	Canada	Vermont	New York	New Jersey	Virginia	East of Frederick	Pinesburg Station	Wilson	Near Maugansville	Chambersburg Quad.	Canada	New York	Pinesburg Station	Wilson	Chambersburg Quad.	Mercersburg Quad.	New Jersey	New York	West Virginia	Virginia	Ohio	Kentucky	Tennessee	Iowa	Wisconsin	Minnesota	Canada	Esthonia, Russia	Washington County	Rickard Mt.	Fairview Mt.	Williamsport	Mercersburg Quad.	Chambersburg Quad.	New York	Virginia	Ohio	Kentucky	Tennessee	Missouri	Wisconsin	Minnesota	Canada	
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		CAMBRIAN																					ORDO-VICIAN					
		WAUCOBAN										Aca-dian		OZARKIAN									CANADIAN					
		Harpers Shale		Antietam Sandstone					Tomstown Limestone			Waynesboro Form.	Elbrook Limestone	Conococheague Limestone									Beekmantown Limestone					
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	ARTHROPODA. Crustacea.—*Continued*																											
6	*Ampyx (Lonchodomas) halli* Billings																											
7	*Dolichometopus* sp.												*															
8	*Olenellus thompsoni* (Hall)			*			*		*	*																		
9	*Hystricurus conicus* (Billings)																											
10	*Goniurus caudatus* (Billings)																						2		2			
11	*Triarthrus fischeri* Billings																						3		3			
12	*Triarthrus becki* Green																											
13	*Isotelus stegops* Green																											
14	*Isotelus megistos* Locke																											
15	*Isotelus gigas* DeKay																											
16	*Isotelus* sp.																											
17	*Asaphellus gyracanthus* Raymond																											
18	*Hemigyraspis collieana* Raymond																						1					
19	*Symphysurus convexus* (Cleland)																						1					
20	*Onchometopus simplex* Raymond & Narraway																						1	1				
21	*Illaenus americanus* Billings																											
22	*Bumastus trentonensis* Emmons																											
23	*Saukia stosei* Walcott																											
24	*Proetus latimarginatus* Weller															*	*											
25	*Cyphaspis matutina* Ruedemann																											
26	*Amphilichas trentonensis* (Conrad)																											
27	*Acidaspis ulrichi* Bassler n. sp.																											
28	*Calymene granulosa* (Foerste)																											
29	*Calymene senaria* (Conrad)																											
30	*Ceraurus pleurexanthemus* Green																											
31	*Pliomerops salteri* (Billings)																											
32	*Pterygometopus callicephalus* (Hall)																						3					
	ARTHROPODA. Branchiopoda																											
33	*Ribeiria ? nuculitiformis* Cleland																						1					
	ARTHROPODA. Ostracoda																											
34	*Isochilina gregaria* (Whitfield)																						2		3			
35	*Isochilina seelyi* (Whitfield)																										4	
36	*Leperditia fabulites* (Conrad)																											
37	*Leperditella tumida* (Ulrich)																											
38	*Aparchites minutissimus* (Hall)																											
39	*Drepanella macra* Ulrich																											
40	*Macronotella ulrichi* Ruedemann																											
41	*Ceratopsis chambersi* (Miller)																											
42	*Ulrichia bivertex* (Ulrich)																											
43	*Bythocypris cylindrica* (Hall)																											
44	*Lepidocoleus jamesi* (Hall & Whitfield)																											
	MALACOSTRACA																											
45	*Caryocaris silicula* Bassler n. sp.																											

ORDOVICIAN																																												
Canadian						?	Chazyan						Mohawkian and Cincinnatian																															
Beekmantown Limestone						Frederick Limestone	Stones River Limestone						Chambersburg Limestone																Martinsburg Shale															
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SYSTEMATIC PALEONTOLOGY

OF

THE CAMBRIAN AND ORDOVICIAN DEPOSITS OF MARYLAND

BY

R. S. BASSLER

SYSTEMATIC PALEONTOLOGY

CAMBRIAN AND ORDOVICIAN

THALLOPHYTA ....R. S. BASSLER.
PORIFERA ....R. S. BASSLER.
COELENTERATA ....R. S. BASSLER.
ECHINODERMATA ....R. S. BASSLER.
VERMES ....R. S. BASSLER.
MOLLUSCOIDEA ....R. S. BASSLER.
MOLLUSCA ....R. S. BASSLER.
ARTHROPODA ....R. S. BASSLER.

THALLOPHYTA

CLASS ALGAE

Genus CRYPTOZOON Hall

CRYPTOZOON PROLIFERUM Hall *

Plate XXVIII, Figs. 1, 2; Plate XXIX, Fig. 1

Cryptozoon proliferum Hall, 1884, 36th Rept. New York State Mus. Nat. Hist., pl. vi.

Cryptozoon proliferum Walcott, 1912, Smithsonian Misc. Coll. 57, p. 258, pl. xxxvii, figs. 1-3.

Description.—"These bodies are made up of irregular, concentric laminae of greater or less density and of very unequal thickness. The substance between the concentric lines, in well-preserved specimens, is traversed by numerous, minute, irregular canaliculi which branch and anastomose without regularity. The central portions of the masses are usually filled with crystalline, granular, and oölitic material and many specimens show the intrusion of these extraneous and inorganic substances between the concentric laminae. That these are intrusions, and not inclusions, is shown from the fact that they can be traced to a vertical fissure or break leading to the exterior of the fossil and which allowed the crystalline matter to enter."—Hall, 1884.

As noted under the following species, *Cryptozoon proliferum* is characterized by its growth from a widely expanded, almost flat, series of lamellae into confluent heads of a size varying from four or more inches in diameter at the center of a growth to small, concentric areas an inch or less wide on the edge.

* In the specific bibliography throughout this volume only the original and the more important subsequent references are cited. The complete bibliography for the Post-Cambrian forms may be consulted in the Bibliographic Index of American Ordovician and Silurian fossils published as Bulletin 92, U. S. National Museum.

Occurrence.—CONOCOCHEAGUE LIMESTONE.—In Pennsylvania, Maryland, and Virginia this is a characteristic fossil at the base of the Conococheague limestone. Specimens may be found at practically all of the normal contacts between the Elbrook and Conococheague limestones. The species is particularly abundant in the vicinity of Sharpsburg, Maryland, and also in a cut of the Norfolk and Western Railroad, one mile southwest of Antietam Station where a reef of these algae is exposed.

The original types came from the Ozarkian (Hoyt) limestone of Saratoga County, New York.

Collections.—Maryland Geological Survey, U. S. National Museum.

CRYPTOZOON UNDULATUM n. sp.

Plate XXIX, Figs. 2, 3; Plate XXX

Description.—The Conococheague limestone in the Appalachian Valley from Virginia to northeastern Pennsylvania and the corresponding strata in New York State afford a second well-defined species of *Cryptozoon* which occurs in association with *C. proliferum.* Comparison of the two species will bring out the essential characters of the present new one. *Cryptozoon proliferum* grows from a widely expanded almost flat series of lamellae into numerous confluent heads of unequal size. In *C. undulatum* the laminae are at first evenly undulating, forming in edge view, a pseudo-columnar structure, the columns averaging 20 mm. in width. A cross-section through this part of the fossil shows these column-like areas to be of equal size and totally unlike the corresponding portion of *C. proliferum.* Following the undulating zone in *C. undulatum* the laminae go through a stage in which the distinct lamination disappears. Then, with a new growth, the characteristic undulations of the species reappear.

Occurrence.—CONOCOCHEAGUE LIMESTONE. Associated with *Cryptozoon proliferum.* The types are from a locality two and one-half miles southeast of Funkstown, Maryland, where examples were numerous. Sharpsburg and vicinity also show numerous specimens, particularly in the stone fences. This species and *C. proliferum* have also been found in the Conococheague limestone as far north as the Reading area of Pennsylvania. They both occur in the Hoyt limestone near Saratoga Springs, New York.

Collections.—Maryland Geological Survey, U. S. National Museum.

Cryptozoon steeli Seely

Plate XXXIV, Fig. 1

Cryptozoon steeli Seely, 1906, Rept. State Geol. Vermont, vol. v, p. 161, pls. xxxiv, xxxvi, xliii, fig. 1.

Description.—The Beekmantown rocks of New York, Vermont, and northward into Canada contain a species of Cryptozoon several inches to a foot in diameter which differs from the other species of the genus in that the organism is usually made up of a single globular or hemispherical mass of lamellae. The successive layers are quite parallel and arranged concentrically even in the largest specimens. These layers are composed of a dense material apparently without definite organic structure.

In the Cumberland Valley this particular form of *Cryptozoon* is apparently restricted to a definite zone in the Lower Beekmantown. As the fossil weathers out in large, silicified masses accompanied by much platy chert, this zone is generally easily recognized. *Cryptozoon steeli* therefore forms an excellent guide fossil in mapping, as it not only assists in the recognition of the strata, but the chert masses accompanying it indicate the outcrops of this zone. These, if plotted, help to decipher the geological structure. The *Cryptozoon steeli* zone of chert has been a most valuable aid in determining the structure of the Beekmantown in the Valley west of the Martinsburg shale belt where frequently lack of rock outcrops has caused great difficulty in mapping.

Occurrence.—Beekmantown Limestone (*Cryptozoon steeli* zone). In the Appalachian Valley of Maryland and southern Pennsylvania this is a common fossil about 800 feet above the base of the Beekmantown. Numerous specimens may be found among the residual cherts of this zone at practically every outcrop both east and west of the Martinsburg shale belt of Maryland, particularly in the vicinity of Hagerstown.

Collections.—Maryland Geological Survey, U. S. National Museum.

Genus PALÆOPHYCUS Hall

PALÆOPHYCUS TUBULARE Hall

Plate XXXI, Fig. 1

Palæophycus tubulare Hall, 1847, Pal. New York, vol. i, p. 7, pl. ii, figs. 1, 2, 4, 5.

Description.—Although formerly considered as seaweeds, the fossil remains described under this name, and related so-called genera and species, are of very doubtful origin. The particular form here illustrated is interesting because it occurs in such widely separated areas, although the two formations in which it is found are believed to be of the same age. The specimens as observed on weathered surfaces consist of unevenly bent or flexuose cylindrical stems sometimes gradually tapering to a point, irregularly branched and often bifurcated. In Maryland, as in New York, these stems when weathered appear as if hollow. The stems and branches are usually much compressed, smooth, and preserve no traces of structure.

Occurrence.—BEEKMANTOWN LIMESTONE (Stonehenge member). Several localities in the vicinity of Hagerstown, Maryland. Tribes Hill Limestone. Amsterdam, Canajoharie, etc., New York.

Collection.—U. S. National Museum.

Genus SOLENOPORA Dybowski

SOLENOPORA COMPACTA (Billings)

Plate XLI, Figs. 1-3

Stromatopora compacta Billings, 1865, Pal. Foss., vol. i, Geol. Surv. Canada, pp. 55, 212.

Tetradium peachii Nicholson and Etheridge, 1877, Ann. and Mag. Nat. Hist., 4th ser., vol. xx, p. 166, text figs. d-g.

Solenopora spongioides Dybowski, 1877, Die Chaetetiden der ostbaltischen Silur. Formation, p. 124, pl. ii, figs. 11a-b.

Tetradium peachii var. *canadense* Foord, 1883, Cont. Micro-Pal., Geol. Surv. Canada, p. 24, pl. vi, figs. 1-1f.

Solenopora compacta trentonensis Brown, 1894, Geol. Mag. London, dec. 4, vol. i, p. 146, text fig. 2.

Solenopora compacta Winchell and Schuchert, 1895, Geol. Minnesota, Pal., vol. 3, pt. i, p. 80, pl. F, figs. 21-23.

Actinostroma trentonensis Weller, 1893, Geol. Surv. New Jersey, Pal., vol. 3, p. 139, pl. vi, fig. 8; pl. vii, figs. 3, 4.

Description.—This species forms small, sub-globular masses, from one to two inches in diameter. The concentric lamellae are thin and closely packed together, there being in some specimens from 6 to 12 layers in the thickness of two lines.

The internal structure is described by Dr. Nicholson as follows: "Composed of radiating capillary tubes, arranged in concentric strata. The tubes vary from 1/12 to 1/20 mm. in size, and are in direct contact throughout, no interstitial tissue of any kind being developed. The tubes are irregular in form, with thin often undulated walls, which are not pierced by any apertures or pores, but are often crossed by more or fewer transverse partitions of 'tabulae.' Very commonly the tubes exhibit more or fewer inwardly directed partitions, which extend to a greater or less distance into the cavity of the tube, and are the result of the cleavage or 'fission' of the tubes."

An intensive study of this wide-spread and long-ranged fossil will in all probability reveal the fact that a number of distinct species are included under the name *Solenopora compacta.*

Occurrence.—CHAMBERSBURG LIMESTONE (Caryocystites bed). Fort Loudon and localities south to Blue Spring, Franklin County, Pennsylvania. A wide-spread and abundant fossil in almost all of the divisions of the Middle and Upper Ordovician in North America.

Collections.—Maryland Geological Survey, U. S. National Museum.

SPONGIAE ? (CALCAREOUS ALGAE ?)

Genus NIDULITES Salter

NIDULITES PYRIFORMIS Bassler.

Plate XLVI, Figs. 1-5

***Nidulites* sp. Bassler, 1909, Bull. Virginia Geol. Surv., vol. iia, pl. vii, fig. 11.**
***Nidulites pyriformis* Bassler, 1915, Bull. U. S. Nat. Mus., no. xcii, p. 855.**

Description.—The body of this interesting organism, which is such an abundant fossil at certain horizons in the Chambersburg limestone of the Appalachian Valley, is pyriform and pedunculate, with an outer covering of hexagonal, cuplike plates fused or articulated by their edges. On the exterior each plate is deeply concave and marked off at the surface by a sharp wall. The plates are smallest at the narrow end of the organism, but increase in size in the more swollen part where an average diameter for them of one millimeter is the rule. The interior of the organism is hollow (pl. XLVI, fig. 5) and is frequently filled with crystalline calcite (pl. XLVI, fig. 3). Specimens about 35 mm. in length are the rule, but some individuals attain a length of 50 mm.

Small fragments of *Nidulites*, especially where partly imbedded in the rock, much resemble a massive bryozoan with large zooecia, but examination with a lens reveals the very different nature of the hexagonal plates or cups.

The systematic position of *Nidulites* is still quite uncertain. These bodies were supposed by Salter to be the egg-ribbons of marine gastropods. Later paleontologists placed them among the Protozoa, but to-day the prevalent opinion is that they are allied to *Receptaculites, Cerionites, Ischadites* and related genera, and are either sponges or calcareous algae.

Occurrence.—CHAMBERSBURG LIMESTONE (Nidulites bed). Pennsylvania, Maryland, and Virginia. Wilson, Pinesburg Station, and other localities in Maryland furnish numerous specimens of the species, embedded in the rather massive strata of the Nidulites bed.

Collection.—Maryland Geological Survey, U. S. National Museum.

Genus RECEPTACULITES Defrance

RECEPTACULITES OCCIDENTALIS Salter

Plate XLV, Fig. 7

Receptaculites occidentalis Salter, 1859, Canadian Org. Remains, dec. i, p. 45, pl. x, figs. 1-7.

Receptaculites occidentalis Billings, 1865, Pal. Foss., vol. i, Geol. Surv. Canada, p. 381, text figs. 354-356.

Receptaculites occidentalis Weller, 1903, Geol. Surv. New Jersey, Pal., vol. iii, p. 135, pl. vi, figs. 2-4.

Description.—"Sponge forming discoid or flattened, saucer-like expansions; attaining a diameter of 200 mm., and having a thickness varying from 4 mm. at the center of the disk to 12 mm. at the margin. The disk itself composed of vertical rods or spicules, with their extremities expanded and more or less flattened to form the two surfaces of the disk. The shafts of the spicules are cylindrical, about 1 mm. or slightly more in thickness, and separated from each other by interspaces about equal to their own thickness. The arrangement of the terminations of the spicules upon the surface of the disk is in curved, radiating lines, crossing after the manner of the engine-turned ornamentation of a watch. The expanded outer extremities of the spicules are rhomboidal in outline, leaving narrow, linear interstices on each side between adjoining spicules. A short distance above the flattened, rhomboidal extremity there are four connecting processes, which join the spicule with each of the adjoining ones. The inner extremities of the spicules are also expanded and joined together to form the inner surface of the disk."—Weller, 1903.

Occurrence.—CHAMBERSBURG LIMESTONE (Echinospherites bed). Southern Pennsylvania and at Pinesburg Station, Maryland. Black River group of Canada, New Jersey, Kentucky, and Arctic America.

Collection.—U. S. National Museum.

PORIFERA

CLASS SPONGIAE

Genus RHABDARIA Billings

RHABDARIA FRAGILIS (Billings)

Rhabdaria fragilis Billings, 1865, Pal. Foss., vol. i, Geol. Surv. Canada, p. 357.
Rhabdaria fragilis Rauff, 1894, Paleontographica, vol. xl, p. 245.

Description.—"Small cylindrical stems, with a rough exterior, and a central perforation or canal. At first these were thought to be silicified specimens of *Stenopora fibrosa,* but when others were procured showing the central canal, it became evident that they could not be thus referred. They have the form of crinoidal columns, but are not jointed. No structure can be made out in thin slices under the microscope."—Billings, 1865.

Specimens of a ramose bryozoan-like fossil with a central canal have been found at several localities in the Beekmantown of the Appalachian Valley in Maryland and Pennsylvania. These agree in all respects with the species described above by Billings, which unfortunately has never been figured. In order to establish the species the original types or specimens from the type locality must be further investigated and illustrated. Until this has been done the identification of the species in the Appalachian Valley must be considered as provisional. The type specimens are from the Romaine division of the Canadian, Mingan Islands, Quebec.

Occurrence.—BEEKMANTOWN LIMESTONE. Lower part above the Stonehenge horizon, just east of Hagerstown, Maryland. Also at the same zone in the Chambersburg quadrangle of Pennsylvania.

Collection.—U. S. National Museum.

Genus CAMAROCLADIA Ulrich and Everett

CAMAROCLADIA RUGOSA Ulrich

Plate XLII, Fig. 6

Camarocladia rugosa Ulrich, 1897, Geol. Minnesota, vol. iii, pt. 2, p. xcv, foot note.

Description.—The fucoid-like remains upon which this species is based appear to be the cast of a branching sponge, although the specimens seldom show structure and appear most frequently as flattened, stony branches with more or less obscure oblique and transverse furrows. These compressed flexuous branches bifurcate sometimes close together and other times far apart. The branches vary from 5 to over 12 mm. in width and are sometimes so crowded in the rock as to form a regular network or matting. In the best preserved examples, the surface is covered with an irregular network of coarse, nodulose threads often arranged longitudinally and generally on one side of the branch only. When removed from the rock the stems are found to be composed of two fairly well-defined portions, (1) a siphuncle-like, subcylindrical rod, with annulations and constrictions 3 to 6 mm. apart, and (2) a series of oblique septa-like partitions, generally two to each annulation, clasping the annulated rod so as to leave about one-third of its circumference exposed to view. Sometimes the rod changes suddenly from one side of the branch to the other.

Occurrence.—CHAMBERSBURG LIMESTONE (Tetradium cellulosum bed). Fort Loudon, Franklin County, Pennsylvania. An abundant species in the Decorah shales division of the Black River in Goodhue County, Minnesota, and at the same horizon in Mercer County, Kentucky.

Collections.—Maryland Geological Survey, U. S. National Museum.

Order TETRACTINELLIDA

Family HINDIIDAE

Genus HINDIA Duncan

HINDIA PARVA Ulrich

Plate L, Figs. 11-13

Hindia parva Ulrich, 1889, Amer. Geol., vol. iii, p. 244.
Hindia parva Winchell and Schuchert, 1895, Geol. Minnesota, vol. iii, pt. 1, p. 79, pl. G, figs. 7-9.
Hindia parva Weller, 1903, Geol. Surv. New Jersey, Pal., vol. iii, p. 135, pl. vi, fig. 1.

Description.—This small sponge forms free, rounded masses with a smooth surface. Most of the specimens are about 7 mm. in diameter, although this dimension varies between 5 and 10 mm. The internal structure is very similar to the common *Hindia sphaeroidalis* Duncan of the Silurian and Early Devonian, but the radiating canals of *H. parva* are somewhat smaller, being not over 0.27 mm. in diameter. More refined methods of study of these sponges will no doubt reveal other important differences.

Occurrence.—MARTINSBURG SHALE (Sinuites bed). Chambersburg, Pennsylvania, and Strasburg, Virginia. Black River of Minnesota and Wisconsin, Trenton of Kentucky, Tennessee, New Jersey and other states.

Collections.—Maryland Geological Survey, U. S. National Museum.

COELENTERATA

CLASS ANTHOZOA

Subclass TETRACORALLA

Family CYATHOPHYLLIDAE

Genus COLUMNARIA Goldfuss

COLUMNARIA (?) HALLI Nicholson

Plate XLI, Fig. 5

Columnaria alveolata Hall, 1847, Pal. New York, vol. i, p. 47, pl. xii, figs. 1a-1c. (not Goldfuss).

Columnaria (?) *halli* Nicholson, 1879, Tab. Corals Pal. Period, p. 198, text figs. 28, 2; p. 200, text fig. 29; pl. x, figs. 3, 3a.

Columnaria (?) *halli* Winchell and Schuchert, 1895, Geol. Minnesota, Pal., vol. iii, pt. 1, p. 85, pl. G, figs. 14-16.

Description.—" Corallum forming large massive colonies which vary from a few inches to several feet in diameter, and which are composed of various sized polygonal corallites, in close contact with one another throughout their entire length. The walls of the corallites are not excessively thickened, and they are so completely amalgamated in contiguous tubes that even under tho microscope the original lines of demarcation between the tubes can be made out with difficulty or not at all. The large tubes are usually from two to three lines in diameter, though occasionally considerably more than this, and the smaller corallites are of all sizes. Septa marginal, in the form of obtuse longitudinal ridges which vary in number from 20 to 40, do not extend to any distance into the visceral chambers, and are not divisible into an alternating longer or short series. Tabulae strong, horizontal and complete, about half a line apart or sometimes closer. Mural pores not recognized with certainty."—Winchell & Schuchert, 1895.

Occurrence.—CHAMBERSBURG LIMESTONE (Caryocystites bed). From Fort Loudon south to Blue Spring, Franklin County, Pennsylvania. Generally an abundant fossil in the Mohawkian rocks of Canada and the United States.

Collections.—Maryland Geological Survey, U. S. National Museum.

Family ZAPHRENTIDAE

Genus STREPTELASMA Hall

STREPTELASMA PROFUNDUM (Conrad)

Plate XLII, Figs. 1, 2

Cyathophyllum profundum Conrad, 1843, Proc. Acad. Nat. Sci., Philadelphia, p. 335.

Streptelasma profunda Hall, 1847, Pal. New York, vol. i, p. 49, pl. xii, figs. 4a-d.

Streptelasma profundum Winchell and Schuchert, 1895, Geol. Minnesota, Pal., vol. iii, pt. i, p. 88, pl. G, figs. 17-19.

Description.—"Obliquely turbinate, often slightly curved near the base, expanding above more or less abruptly; cell profoundly deep, extending nearly to the base of the coral; margin of the cup reflexed; surface scarcely marked by transverse rugae; lamellae from 36 to 60, strong, nearly equal to the margin, but distinctly alternating in length within; no transverse dissepiments or celluliferous structure."—Hall, 1847.

This well-marked form can readily be separated from other species of the genus by its deep, visceral cavity, by its sharply defined lateral fossulae and great development of the primary septum, and by its septa which are never twisted in approaching the center.

Occurrence.—CHAMBERSBURG LIMESTONE (Tetradium cellulosum bed). Fort Loudon, Franklin County, Pennsylvania. A characteristic and abundant Black River fossil of the United States and Canada.

Collections.—Maryland Geological Survey, U. S. National Museum.

Suborder TABULATA

Family CHAETETIDAE

Genus TETRADIUM Dana

TETRADIUM ? SIMPLEX n. sp.

Plate XXXIII, Figs. 13-15

Description.—The discovery of a coral in the Beekmantown limestone is of especial interest since hitherto no typical representative of the corals has been recorded from strata of this age. The species here noted occurs abundantly in the lower Beekmantown just above the top of the Stonehenge member, where it appears in lamellose masses on the weathered rock surfaces. Unfortunately all trace of the structure is lost in the solid rock and the generic determination cannot therefore be confirmed by thin sections. The corallites are polygonal, with rather thick walls which sometimes show a distinct line of separation. Three corallites occur on an average in 2 mm. No septa are seen, but their apparent absence may be due to the poor preservation of the specimens. The vertical sections exposed by weathering show no tabulae.

If this species should prove to be an early representative of *Tetradium* it will be readily distinguished from the other species of that genus by its small corallites.

Occurrence.—BEEKMANTOWN LIMESTONE. Just above the Stonehenge member. The best specimens were found in the old brick yard on the eastern edge of Hagerstown.

Collections.—Maryland Geological Survey, U. S. National Museum.

TETRADIUM SYRINGOPOROIDES Ulrich

Plate XXXVIII, Figs. 13-15

Tetradium sp. Bassler, 1909, Va. Geol. Surv., Bull., vol. iia, pl. iv, fig. 2.
Tetradium syringoporoides Ulrich, 1910, in Stose, Folio U. S. Geol. Surv., 170, p. 58.

Description.—This species, which is very characteristic of the Stones River group, has been known for a number of years by the students of Appalachian geology as the "single-tubed *Tetradium.*" Certain beds of the Stones River limestone are so charged with these tubes that they give the rock a coarse, spongy appearance. Upon weathering the individual tubes stand out in relief like pieces of cord, but in fractured fragments of limestone the tubes are equally distinct, although here appearing as stringers of calcite. Upon close examination the coral nature of this organism becomes evident, for the tubes divide, giving rise to either two or four individual tubes which, after adhering together for a short distance, separate and in turn subdivide as before. No tabulae are visible nor are any signs of septa to be observed until just before a tube divides when the characteristic four septa of *Tetradium* are developed. A normal corallite is quadrangular and about two-thirds of a millimeter across.

Occurrence.—STONES RIVER LIMESTONE. Abundant especially in the upper division, in the Appalachian Valley. In Maryland exposures along the line of outcrop from Pinesburg Station north through Wilson to the state line exhibit numerous examples.

Collections.—Maryland Geological Survey, U. S. National Museum.

TETRADIUM COLUMNARE (Hall)

Plate XLI, Fig. 4

Chaetetes columnaris Hall, 1847, Pal. New York, vol. i, p. 68, pl. xxiii, figs. 4, 4a.

Tetradium columnare Safford, 1856, Amer. Jour. Sci. and Arts, 2d ser., vol. xxii, p. 237.

Description.—" Coral massive, hemispherical or subglobose, consisting of a series of parallel or diverging polygonal tubes; tubes four- or five-sided, simple, without visible transverse dissepiments or connecting pores; interior of the cells apparently rugose or denticulate.

" The rugose structure within the cell probably indicates the existence of diaphragms which have disappeared. The fossil, in its general form and structure, has the appearance of a *Favosites,* from which a cursory examination would not induce us to separate it. A closer examination proves that the tubes are usually four-sided, and that there are no connecting pores in the walls of the cells. These characters had decided me to separate it from the genus *Favosites,* before knowing fully the characters on which the genus *Chaetetes* is founded. It appears referable to the latter genus from its general similarity to some of the species, the character of quadrangular cells probably being unimportant and not constant. The apparent absence of diaphragms, or transverse dissepiments, is perhaps due to their subsequent destruction, or solution and removal."—Hall, 1847.

Occurrence.—CHAMBERSBURG LIMESTONE (Caryocystites bed). Fort Loudon, Pennsylvania.

Not uncommon in the Trenton rocks of New York, Kentucky, and Tennessee. Similar forms occur in the Black River and Stones River formations of the United States and Canada.

Collections.—Maryland Geological Survey, U. S. National Museum.

TETRADIUM CELLULOSUM (Hall)

Plate XLII, Figs. 3-5

Phytopsis cellulosum Hall, 1847, Pal. New York, vol. i, pp. 39, 315, pl. ix, figs. 1a-d.

Description.—The principal features of this index fossil of the Lowville limestone are well shown in Hall's original illustrations reproduced in the present volume. As is well known, the main specific character of the fossil is the occurrence of the corallites in small bunches which, in the course of growth, form elongated, subcylindrical or compressed stems. These stems sometimes anastomose, forming a network. In transverse sections the generic character of the coral, the quadrangular corallites with four regularly placed septa, is well brought out. This most characteristic coral of the Lowville limestone has a wide distribution in New York and Canada and the Appalachian and Ohio valleys.

Occurrence.—CHAMBERSBURG LIMESTONE (Tetradium cellulosum bed). Fort Loudon and the railroad cut two miles southwest of Marion, Franklin County, Pennsylvania.

Collections.—Maryland Geological Survey, U. S. National Museum.

CLASS GRAPTOLITOIDEA

Order GRAPTOLOIDEA

Family DIPLOGRAPTIDAE

Genus CLIMACOGRAPTUS Hall

CLIMACOGRAPTUS PUTILLUS (Hall)

Plate LII, Figs. 5-7

Graptolithus putillus Hall, 1865, Geol. Surv. Canada, Org. Rem., dec. 2, pp. 27, 44, pl. A, figs. 10-12a.

Climacograptus putillus Ruedemann, 1908, Mem. New York State Mus., vol. xi, pt. 2, pp. 415-419, pl. xxviii, figs. 14, 15, text figs. 368-374, 376, 377.

Description.—"Rhabdosome very small (9 mm. mostly less) and slender (1-1.3 mm. wide), elliptic in section, widening gradually, possessing a gently wavy median furrow on each lateral face. Sicula small (1.3 mm.) and very slender, provided with a short apertural spine; its slender virgella protruding from the rhabdosome. Thecae tubular, little inclined to the axis of the rhabdosome in the proximal half and subparallel to it in the distal free half; closely arranged (12-14 in the space of 10 mm. or 32 in 1 inch); apertures straight, at right angles to longer axes of thecae. Nemacaulus thin."—Ruedemann, 1908.

A common species of the Ohio and Mississippi valleys, New York, Canada, etc., ranging from the Trenton to the Richmond.

Occurrence.—MARTINSBURG SHALE (Corynoides bed). Chambersburg, Pennsylvania, and Williamsport, Maryland.

Collections.—Maryland Geological Survey, U. S. National Museum.

CLIMACOGRAPTUS SPINIFER (Ruedemann)

Plate LII, Figs. 3, 4

Climacograptus typicalis mut. *spinifer* Ruedemann, 1908, New York State Mus. Mem., vol. xi, pt. 2, pp. 411, 412, pl. xxviii, figs. 8, 9, text fig. 236.
Climacograptus spiniferus Ruedemann, 1912, New York State Mus., Bull. 162, p. 84.

Description.—This species is distinguished from the well-known *Climacograptus typicalis* Hall, which it most closely resembles, in the presence of two straight, thin spaces and in the closer arrangement of the thecae, the majority of the specimens having 14 thecae in 10 mm. In the presence of the two spines this species resembles *Climacograptus bicornis* Hall, but in the latter species these spines grew from the first two thecae and are not prolongations of the sicular spines as in *C. spinifer.*

Occurrence.—MARTINSBURG SHALE (Corynoides bed). Chambersburg, Pennsylvania, and Williamsport, Maryland. Trenton shale of eastern New York.

Collections.—Maryland Geological Survey, U. S. National Museum.

CLIMACOGRAPTUS BICORNIS (Hall)

Plate LIII, Fig. 1

Graptolithus bicornis Hall, 1847, Pal. New York, vol. i, p. 268, pl. lxxiii, figs. 2a-s.

Climacograptus bicornis Elles and Wood, 1906, Mon. British Grapt., pt. 5, pp. 193, 194, fig. 125, pl. 26, figs. 8a-f.

Climacograptus bicornis Ruedemann, 1908, Mem. New York State Mus., vol. xi, pt. 2, pp. 433-437, pl. xxviii, figs. 24-26, figs. 404, 405.

Description.—" Synrhabdosome not observed. Rhabdosome linear in the middle and antisicular portions; attaining great length (10 cm. and more); gradually widening from the sicular extremity to a width of 2.6+mm., attained in about 30 mm. and maintained close to the antisicular extremity. The former extremity is always armed with two diverging lateral spines, which grow from the first two thecae, and the virgella which greatly varies in length. The sicula is 1 mm. long, its greater portion embedded. The thecae number 12 in the sicular region and seven in the mature part and overlap about one-third their length; their proximal walls are curved, the free distal wall straight and parallel to the axis of the rhabdosome. The apertural margins are horizontal, the apertural excavations wide (one-third length of theca) and attaining in depth one-fourth the width of the rhabdosome in mature part, and one-third in the earlier part. Nemacaulus not observed."—Ruedemann, 1908.

The typical form of this wide-spread species has been recognized in North America only in the Chazyan, but varieties or very closely related species occur in younger formations of the Ordovician. In southern Pennsylvania and Washington County, Maryland, the upper beds (Eden) of the Martinsburg shale furnish a species of *Climacograptus* exhibiting the diverging points at the base characteristic of *C. bicornis.*

Occurrence.—MARTINSBURG SHALE (Eden division). Washington County, Maryland.

Collections.—Maryland Geological Survey, U. S. National Museum.

Genus DIPLOGRAPTUS McCoy

Diplograptus vespertinus (Ruedemann)

Plate LIII, Figs. 2-4

Diplograptus pristis (parte) Hall, 1847, Pal. New York, vol. i, pl. lxxii, figs. 1, 1a, 1b, 1k, 1l.

Diplograptus foliaceus mut. *vespertinus* Ruedemann, 1908, Mem. New York State Mus., vol. xi, pt. 2, pp. 352-354, pl. xxv, figs. 4, 5, 18, text figs. 296-298.

Description.—" Synrhabdosome not observed. Rhabdosomes as a rule short (15 mm., greatest length observed 42 mm.), widening gradually from an initial width of 1 mm. to a maximum width of 2.5 which is attained in a distance of 15 mm. from the sicular extremity and then maintained. Sicula not observed. Sicular extremity furnished with a short blunt virgella (about .4 mm. long) and two equally short straight lateral spines. Thecae numbering 11 to 13 in 10 mm. (30-32 in 1 inch), inclined at an angle of 30°-40°, overlapping a little more than one-third, the outer margin distinctly convex, the proximal part frequently slightly concave. The aperture horizontal, concave, the interthecal excavation about one-fourth the width. Nemacaulus very thin and inconspicuous within the rhabdosome and not seen protruding beyond the antisicular end."—Ruedemann, 1908.

The types are from the Normanskill (Chazyan) shales of New York and the species has been identified also from the Trenton shales of the same state.

Occurrence.—Martinsburg Shale (Eden division). Jordans Knob, one and one-half miles northeast of Fort Loudon, Pennsylvania, and in the same horizon on the west slope of Rickard Mountain, Maryland.

Collection.—U. S. National Museum.

POSITION UNCERTAIN

Genus CORYNOIDES Nicholson

CORYNOIDES CALICULARIS Nicholson

Plate LII, Figs. 1, 2

Graptolite germs Hall, 1859, Pal. New York, vol. iii, p. 508, fig. 7.
Corynoides calicularis Nicholson, 1867, Geol. Magazine, vol. iv, p. 108, pl. vii, figs. 9-11.
Corynoides calicularis Weller, 1903, Geol. Surv. New Jersey, Pal., vol. iii, pp. 52, 214, pl. xvi, figs. 12, 13.
Corynoides calicularis Ruedemann, 1908, New York State Museum, Mem., vol. xi, pt. 2, pp. 234-237, pl. xiii, figs. 1, 6-8, text figs. 122-132.

Description.—"Rhabdosome short (6-8 mm.) and relatively broad (about 1 mm.), of uniform width, consisting of a sicula and three thecae. Sicula small (2 mm.), conical, without apertural processes, in mature specimens slightly recurving, suspended from a long and slender nema. Thecae slender tubes of uniform width, all originating close to the sicula, arranged in a bundle which forms an angle of 50° with the sicula. Apertures straight, normal to the axes of the thecae, all adjoining at the distal extremity of the rhabdosome, each provided with a pair of usually curved strong spines, which often appear to be raised upon a tongue-like process. Nema thin and filiform."—Ruedemann, 1908.

This curious little graptolite is so small and usually so poorly preserved in the shales that its presence is often not detected without careful search. Weathered shale fragments in which the color of the fossil has been changed to reddish brown or even white, show specimens to the best advantage.

Occurrence.—MARTINSBURG SHALE (Corynoides bed). Chambersburg, Pennsylvania, Williamsport, Maryland, and in other outcrops to the south. Chazyan (Normanskill) shales, New York, and south in the Appalachian Valley to Tennessee.

Collection.—U. S. National Museum.

ECHINODERMATA

Class CYSTOIDEA

Family ECHINOSPHAERITIDAE

Genus ECHINOSPHAERITES Wahlenberg

Echinosphaerites aurantium americanum n. var.

Plate XLV, Figs. 15-20

Compare *Echinus aurantium* Gyllenhal, 1772, Kongl. Vet. Akad. Handl., vol. xxxiii, p. 245, pl. viii, figs. 4, 5; pl. 9, figs. 6-9.

Description.—One of the most interesting paleontological discoveries in the Ordovician limestone of the Appalachian Valley of Pennsylvania and Maryland was that of numerous large globular cystids belonging to the genus *Echinospherites,* which had heretofore not been recognized in America. One division of the Chambersburg limestone is so crowded with these cystids that the name *Echinospherites* bed has been applied to it. At first sight these cystids appear as so many boulders in the rock, and indeed in the past the strata containing them have doubtless been considered as conglomerates. Unweathered specimens show no definite structure to these organisms other than that they appear to be globular masses with a thick, smooth outer covering. When weathered, however, they are seen to be composed of irregularly arranged plates with the numerous canals forming the pore rhombs especially visible.

The various species of *Echinospherites* seem to have been distinguished by European paleontologists mainly by their differences in shape. Comparing the figures on pl. XLV with typical *E. aurantium* from the Middle Ordovician of Esthonia, Russia, it will be noted that the American form is larger and more ovate. For this reason it has been thought best to distinguish it as a variety pending a thorough study of the group by some specialist. The common name of "crystal apple" applied to species of *Echinospherites* in Europe is very appropriate, first because of their shape and second because the interior of the cystid is often a mass of calcite crystals. American specimens are often found with a crystalline interior.

This large globular cystid, as noted above, is so abundant in a lower division of the Chambersburg limestone that it has received the name of the Echinospherites bed. The reappearance of the species in the Christiania bed was noted only in southern Pennsylvania where a few specimens were found at the higher horizon.

Occurrence.—CHAMBERSBURG LIMESTONE (Echinospherites bed). Appalachian Valley of Pennsylvania, Maryland, West Virginia, and Virginia. In Maryland specimens have been found at Pinesburg Station and northward along the line of outcrop through Wilson to the state line. The same form reappears, although rarely, in the Christiania bed of the Chambersburg limestone in southern Pennsylvania.

Collections.—Maryland Geological Survey, U. S. National Museum.

Genus CARYOCYSTITES Von Buch

CARYOCYSTITES sp.

Plate XLI, Fig. 7

Description.—The strata of the Chambersburg limestone underlying the Lowville division contain plates of a species of the cystid genus *Caryocystites* so abundantly that the name Caryocystites bed has been applied to them. The calyx of this cystid has not yet been found, but the plates are easily recognized by the elevated, prominent pore rhombs on their external surface. When weathered the plates also show the pores or canals connecting with the pore rhombs and passing vertically through the plate.

Occurrence.—CHAMBERSBURG LIMESTONE (Caryocystites bed). Fort Loudon and south to Blue Spring, Franklin County, Pennsylvania.

Collections.—Maryland Geological Survey, U. S. National Museum.

CLASS CRINOIDEA

Order CAMERATA

Family RETEOCRINIDAE

Genus RETEOCRINUS Billings

RETEOCRINUS ? sp.

Plate XXXVII, Fig. 5

Description.—Small plates showing six or seven rays are not uncommon on the surface of the thin-bedded Frederick limestone. These are of echinoderm nature, but whether cystid or crinoid cannot be determined. They appear most like the minute pieces forming the pliant integument of the interbrachial areas in such crinoidal genera as *Reteocrinus.*

Occurrence.—FREDERICK LIMESTONE. In the vicinity of Frederick, Maryland.

Collections.—Maryland Geological Survey, U. S. National Museum.

Order INADUNATA

Family CYATHOCRINIDAE

Genus CARABOCRINUS Billings

CARABOCRINUS sp.

Plate XLI, Fig. 10

Description.—Associated with the small plates of the cystid *Caryocystites* in the lowest bed of the Chambersburg limestone are larger, strongly marked plates of a crinoid. These bear the characteristic markings of the genus *Carabocrinus,* and as such plates are known only from this division of the Chambersburg limestone an illustration of one has been given on pl. XLI as a characteristic, although unnamed fossil.

Occurrence.—CHAMBERSBURG LIMESTONE (Caryocystites bed). Fort Loudon south to Blue Spring, Franklin County, Pennsylvania.

Collections.—Maryland Geological Survey, U. S. National Museum.

Family HETEROCRINIDAE

Genus HETEROCRINUS Hall

HETEROCRINUS HETERODACTYLUS Hall

Plate LIII, Figs. 6, 7

Heterocrinus heterodactylus Hall, 1847, Pal. New York, vol. 1, p. 279, pl. lxxvi, figs. 1a-o.

Heterocrinus heterodactylus Meek, 1873, Geol. Surv. Ohio, Pal., vol. 1, p. 12, pl. i, figs. 1a-b.

Description.—" Body short, rounded, subcylindrical, tapering above and below; pelvis composed of five small pentagonal plates, which are succeeded by the same number of larger costal plates, and these again by five scapulars; arms irregularly subdivided; column pentagonal, composed of thick joints, which are nodulose at the angles; joints alternating in size as they approach the pelvis.

" This is a peculiar species, remarkable for the small size of the body when compared with the column. The irregularity of the arrangement of the plates in the arms and fingers is likewise a striking characteristic of the species, which is constant in two specimens from different localities. In one of the arms, the scapular plate supports a regular series of six or more plates of similar form without division. The arms at the right and left of this one are again unlike each other. The one on the left has three regular and gradually diminishing joints above the scapular, and of the same form; the last one supports the cuneiform joint, which again supports a double row of joints (or a pair of fingers). The arm on the right of the first mentioned consists of a pair of quadrangular joints, each of which supports a cuneiform joint. In the remaining two arms, no plates have been traced beyond the scapulars, and consequently the entire form of the species cannot be determined. Sufficient is visible, however, to show the irregular character of the arms, from which its name is given."—Hall, 1847.

Occurrence.—MARTINSBURG SHALE (Eden division). Pennsylvania and Maryland. A splendid mold of a well-preserved, entire calyx with a considerable column attached was found at Jordans Knob, one and one-half miles northeast of Fort Loudon, Pennsylvania. Eden shale of New York and the Ohio Valley.

Collections.—Maryland Geological Survey, U. S. National Museum.

Family DENDROCRINIDAE

Genus MEROCRINUS Walcott

MEROCRINUS sp.

Plate LIII, Fig. 5

Description.—Only stem segments of this crinoid have been found in the upper Martinsburg shale, but the genus itself is so characteristic of the Trenton and Eden formations that it was thought advisable to figure an example as a characteristic fossil. It is possible that the segments here illustrated will be found to belong to the only known Eden species, *M. curtus* Ulrich, from the Cincinnati region.

Occurrence.—MARTINSBURG SHALE (Eden division). Jordans Knob, one and one-half miles northeast of Fort Loudon, and other localities in southern Pennsylvania, and in the sandy debris on the west slope of Rickard Mountain, Washington County, Maryland.

Collections.—U. S. National Museum.

CLASS STELLEROIDEA

Family HUDSONASTERIDAE

Genus HUDSONASTER Stürtz

HUDSONASTER CLARKI n. sp.

Plate LIII, Fig. 8

Description.—This new species is based upon two specimens preserved as a mold in sandy shale and exhibiting the actinal side. The species is closely related to *H. matutinus* (Hall) from the Trenton, and is indeed probably descended from it, but the Eden form differs in having coarse tuberculations on the axillary plates and more slender and more regularly tapering arms. Further differences will no doubt be detected when better specimens are found, but the above seem sufficient to discriminate the species.

The specific name is in honor of the late Professor William Bullock Clark in appreciation of his work upon fossil echinoderms.

Occurrence.—MARTINSBURG SHALE (Eden division). Jordans Knob, one and one-half miles northeast of Fort Loudon, Pennsylvania.

Collection.—U. S. National Museum.

MOLLUSCOIDEA

CLASS BRYOZOA

Order CYCLOSTOMATA

Family DIASTOPORIDAE

Genus CORYNOTRYPA Bassler

CORYNOTRYPA INFLATA (Hall)

Plate XLVII, Figs. 15-17

Alecto inflata Hall, 1847, Pal. New York, vol. i, p. 77, pl. xxvi, figs. 7a, b.
Stomatopora inflata Ulrich, 1893, Geol. Minnesota, vol. iii, p. 117, pl. i, figs. 13-21.
Corynotrypa inflata Bassler, 1911, Proc. U. S. Nat. Mus., vol. xxxix, p. 515, text figs. 12-14.

Description.—"Zoœcia resembling those of *Hippothoa,* short and wide, pyriform, the proximal end contracted and springing from the under side of the anterior end of the cell beneath; eight or nine in 5 mm. Apertures circular, direct, with a peristome, about 0.09 mm. in diameter, situated near the anterior end. Mural perforations minute and but rarely preserved.

"In the Trenton or typical form of this species the zoœcia, as a rule, are less swollen and the adnate zoarium divides less frequently than in the better known Cincinnati form. In the latter, therefore, the network is closer, and occasionally the growth is so luxuriant that the rows cross each other to such an extent that but little space is left between the cells. No distinction, however, can be based upon these characters since, when good series of specimens are studied, it is found that among those from

Trenton localities some have more than commonly swollen and crowded cells, while in some of those from the geologically higher localities the growth is lax and the zoœcia comparatively narrow."—Ulrich, 1893.

Occurrence.—CHAMBERSBURG LIMESTONE (Nidulites bed). Wilson, Maryland.

Found in the Black River-Richmond at many localities in the United States and Canada.

Collections.—Maryland Geological Survey, U. S. National Museum.

CORYNOTRYPA DELICATULA (James)

Plate XLVII, Figs. 12-14

Hippothoa delicatula James, 1878, The Paleontologist, No. 1, p. 6.
Stomatopora tenuissima Ulrich, 1893, Geol. Minnesota, vol. iii, pt. 1, p. 116, pl. i, figs. 16, 17.
Stomatopora proutana Ulrich, 1893, Geol. Minnesota, vol. iii, pt. 1, p. 117, pl. i, figs. 8-12.
Corynotrypa delicatula Bassler, 1911, Proc. U. S. Nat. Mus., vol. xxxix, p. 506, text figs. 3a, 4-7.

Description.—This neat incrusting fossil is extremely abundant in America where it is known in most of the Ordovician formations, beginning with the Stones River. The zoœcia vary considerably in size in the different forms of the species, but maintain the same relative proportions.

In both the large and small forms the zoarium is incrusting and consists of uniserially arranged, slender, club-shaped zoœcia, increasing gradually in size from the narrow proximal end to the rounded anterior portion. The aperture is small, subterminal, with a slightly elevated border, and about one-third the diameter of the anterior third of the zoœcia. The measurements for the two forms are as follows: Typical specimens have zoœcia 0.04 mm. in diameter at the proximal end, increasing to 0.12 to 0.15 mm. at the widest part of the rounded anterior portion. The zoœcia vary from 0.6 to 0.8 mm. in length, and 8 to 10 occur in 5 mm. The larger form varies from 0.8 to 1.1 mm. in length and from 0.2 to 0.3 mm. in diameter at the anterior portion. The stolon is of variable length. The angle of divergence in both large and small zoœcia is about 15°.

Occurrence.—CHAMBERSBURG LIMESTONE (Nidulites bed). Wilson, Maryland. Stones River-Richmond at many localities in the United States and Canada.

Collections.—Maryland Geological Survey, U. S. National Museum.

Genus BERENICEA Lamouroux

BERENICEA VESICULOSA Ulrich

Plate LIII, Fig. 9

Berenicea vesiculosa Ulrich, 1882, Jour. Cincinnati Soc. Nat. Hist., vol. v, p. 158, pl. vi, fig. 5.

Description.—" Zoarium adnate, very delicate, growing usually upon smooth crinoid columns. Cells showing distinctly upon the surface as elliptical convex spaces, with the circular aperture situated upon the forward slope of the same. The cells are closely arranged in rather irregularly alternating series; measured along the length of the cells, about eight may be counted in the space of one inch; and across their width 11 or 12 occupy the same space."—Ulrich, 1882.

Occurrence.—MARTINSBURG SHALE (Eden division). Jordans Knob, one and one-half miles northeast of Fort Loudon, Pennsylvania. Eden shale of the Ohio Valley.

Collections.—Maryland Geological Survey, U. S. National Museum.

Order TREPOSTOMATA

Family MONTICULIPORIDAE

Genus ORBIGNYELLA Ulrich and Bassler

ORBIGNYELLA WETHERBYI (Ulrich)

Plate XLII, Figs. 7, 8

Monticulipora wetherbyi Ulrich, 1882, Jour. Cincinnati Soc. Nat. Hist., vol. v, p. 239, pl. 10, figs. 4-4b.

Monticulipora wetherbyi Ulrich, 1893, Geol. Minnesota, vol. iii, p. 218, pl. xv, figs. 7, 8.

Description.—Zoarium attached, forming thin crusts or small depressed conical masses with slightly monticulose, or smooth surfaces. Zoœcia polygonal, with very thin walls, those of the ordinary size with a diameter of 0.25 mm. Clusters of larger zoœcia form the monticules, or are scattered over the surface of the smooth zoœcia at intervals of about 2.5 mm., measuring from center to center. These zoœcia measure from 0.30 to 0.38 mm. in diameter. At the center of the monticules a few mesopores, or more probably young zoœcia, are present. Acanthopores rather large and numerous.

In longitudinal sections the zoœcial tubes exhibit thin walls with the characteristic granulose structure. The diaphragms are curved and occur at intervals of a tube-diameter or more in the lower half of the tubes and about one-third that distance apart near the surface. In tangential sections the zoœcial walls are angular and thin with a strong acanthopore at most of the angles. The method of growth, small, angular, thin-walled zoœcia, large acanthopores, granulose wall structure and the presence of curved diaphragms are the important features of this characteristic and wide-spread Lowville fossil.

Occurrence.—CHAMBERSBURG LIMESTONE (Tetradium cellulosum bed). Several localities south of Chambersburg in Franklin County, Pennsylvania. Lowville limestone of the Ohio Valley, etc.

Collections.—Maryland Geological Survey, U. S. National Museum.

Genus PRASOPORA Nicholson and Etheridge, Jr

PRASOPORA INSULARIS Ulrich

Plate XLIV, Figs. 15-17

Prasopora insularis **Ulrich, 1893, Geol. Minnesota, vol. iii, p. 251, pl. 16, figs. 18-23.**

Description.—"Zoarium small, discoid, plano- or concavo-convex, commonly from 15-20 mm. in diameter and 5 or 6 mm. in height. In a very large example these dimensions are respectively 28 and 12 mm., while in the smallest seen they are 1.5 and 0.5 mm. Under surface with a central scar, and beyond it delicate radiating lines, fine concentric striae, and, at intervals indicating stages of growth, stronger wrinkles. Very often the zoaria are evidently made up of distinct superimposed layers, but these are not usually distinguishable internally. Upper or convex surface without monticules, but exhibiting, at intervals of about 4 mm., distinct clusters of large zoœcia. Generally, at the center of each of these clusters, the mesopores which are small and in nearly all cases just about numerous enough to isolate the zoœcia, are gathered into groups of varying size. Zoœcial apertures circular, those in the clusters attaining a diameter of 0.4 mm., while those of the smaller size in the inter-macular spaces average about 0.22 mm., with 11 or 12 in 3 mm.

"*Internal Characters:* The first peculiarity to be noticed in tangential sections is the relatively great abundance of the mesopores. In most specimens they form a complete ring around the zoœcia, and it is chiefly the large cells in the clusters that are occasionally in contact at limited points. The zoœcial walls are thin. The cystiphragms are more numerous and extend to a less distance from the walls than in any other American species. The opening left by them is of various shapes, generally subangular, and often removed from the walls. True acanthopores have not been detected.

"In vertical sections the abundance of the mesopores, the narrowness of the cystiphragms, and the unusual crowding of the tabulation in both sets of tubes, are the distinctive features. In the mesopores the average number of diaphragms in 1 mm. is over 25, while the cystiphrams may number as high as 20 in 1 mm., though the average is not likely to be over 15 in that space."—Ulrich, 1893.

Occurrence.—CHAMBERSBURG LIMESTONE (Echinospherites bed). Pinesburg Station, Maryland. This species has hitherto been known only from the lower Trenton (Prosser limestone) of Minnesota.

Collections.—Maryland Geological Survey, U. S. National Museum.

PRASOPORA CONTIGUA Ulrich

Plate XLVII, Figs. 7, 8

Prasopora contigua **Ulrich, 1886, Fourteenth Ann. Rept. Geol. Nat. Hist. Surv. Minnesota, p. 87.**

Prasopora contigua **Ulrich, 1893, Geol. Minnesota, vol. iii, p. 249, pl. xvi, figs. 24-26.**

Description.—"Zoarium hemispheric, base flat or slightly concave, usually less than 30 mm. in diameter. Zoœcia with very thin walls and polygonal apertures, 10 or 11 of the average size in 3 mm. Clusters of zoœcia, some of them attaining a diameter of 0.37 mm., occur at intervals of less than 4 mm. Mesopores comparatively few, often difficult to detect at the surface.

"*Internal Structure:* Tangential sections show that the zoœcial walls are polygonal and very thin, with neighboring cells in contact, except at many of the angles of junction, these being occupied by one or two small mesopores. The latter often form very inconspicuous clusters at the center of the groups of large zoœcia, but in the intermediate spaces not over half of the angles of junction between the ordinary zoœcia are occupied by mesopores. A few very small acanthopores are developed. The opening left by the cystiphragms is generally of ovate form and more often eccentric than central in its position within the tube cavity.

"Vertical sections are peculiar chiefly because they exhibit a marked decrease in the number of mesopores when compared with other species of the genus."—Ulrich, 1893.

Occurrence.—CHAMBERSBURG LIMESTONE (Nidulites bed). Pennsylvania, Maryland, and Virginia. The cliffs along Conococheague Creek at Wilson, Maryland, exhibit specimens of this bryozoan. A not uncommon fossil of the Decorah shale division of the Black River group of Minnesota.

Collections.—Maryland Geological Survey, U. S. National Museum.

Family CONSTELLARIIDAE

Genus DIANULITES Eichwald

DIANULITES PETROPOLITANUS Dybowski

Plate XLIV, Figs. 6, 7

Dianulites petropolitanus Dybowski, 1877, Die Chaetetiden der Ostbaltischen Silurform., p. 24, pl. 1, figs. 4, 5.

Dianulites petropolitana Bassler, 1911, Bull. U. S. Nat. Mus. No. 77, pp. 232, 237, pl. ii, figs. 4-6a; pl. x, figs. 7-11; text figs. 129-132.

Monotrypa (*Chaetetes* ?) *cumulata* Ulrich, 1893, Geol. Minnesota, vol. iii, pt. 1, p. 307, pl. xxvii, figs. 26, 27.

Description.—Zoarium massive, usually hemispheric with a slightly concave, epithecated base, and about 2.5 cm. wide, but ranging from this to large expansions 10 or more centimeters across. Some specimens are of irregular shape, but almost always show their origin from the usual hemispheric forms. Celluliferous side usually smooth, but sometimes divided into polygonal, usually hexagonal, areas bounded by crestlike elevations formed of mesopores. At the center of these areas is a similarly elevated cluster of mesopores forming the macula. Zoœcia thin-walled, polygonal, averaging four in 2 mm. Mesopores few, restricted usually to the macula and to the edges of the polygonal areas noted above. Acanthopores absent. Diaphragms placed at irregular intervals in the zoœcial tubes, but usually at distances varying between one and two tube diameters. In the mesopores three diaphragms occur in a distance of their own diameter. Walls exhibiting the minute granules seen in the typical species of *Dianulites.*

Occurrence.—CHAMBERSBURG LIMESTONE (Echinosphcrites bed). Pinesburg Station, Maryland. Middle Ordovician of Esthonia, Russia, and Goodhue County, Minnesota (Prosser limestone).

Collections.—Maryland Geological Survey, U. S. National Museum.

Family TREMATOPORIDAE

Genus HEMIPHRAGMA Ulrich

HEMIPHRAGMA IRRASUM (Ulrich)

Plate XLIV, Figs. 1-5

Batostoma irrasa Ulrich, 1886, Fourteenth Ann. Rept. Geol. Nat. Hist. Surv. Minnesota, p. 94.

Hemiphragma irrasum Ulrich, 1893, Geol. Minnesota, vol. iii, p. 299, pl. xxiv, figs. 5-19.

Hemiphragma irrasum Bassler, 1911, Bull. U. S. Nat. Mus., No. 77, pp. 284-286, text figs. 172, 173.

Description.—" Zoarium consisting of small, subcylindrical, frequently and rather irregularly dividing branches, commonly 5 or 6 mm. in diameter, but varying from 4 to 8 mm., the latter extreme probably only when an extra layer of tubes has grown over the original branch. Monticules wanting, but under fully matured conditions the surface is abundantly spinulose. Zoœcia with subangular apertures and thin walls when young, and with smaller, subcircular or oval apertures and more or less thick walls in fully matured examples; arrangement of apertures rather regular in rows about small solid spots, in the immediate vicinity of which the zoœcia may be of larger size than elsewhere; seven to nine in 3 mm. Interspaces apparently solid and generally with shallow irregular depressions in most specimens, but in very young stages a variable number of irregular mesopores may be recognized. Acanthopores numerous, two or more to each zoœcium, situated in the angles of junction and interspaces, and increasing in size with age. They are large and a conspicuous external feature of well-preserved mature examples.

"*Internal Characters:* In the axial region of vertical sections the tubes have thin and irregularly fluctuating walls, and few or no diaphragms. The latter are complete here and the proximal end of the tube expands to full size with unusual rapidity. In the peripheral region, which is narrow and abruptly distinguished from the axial, the walls are more or less thickened, and the tubes intersected by semi-diaphragms, about four in 0.5 mm. I have satisfied myself that all the transverse partitions in this outer part of the zoœcial tubes are really incomplete. That many may appear entire in sections is only because their inner edge happens to be vertical instead of horizontal. Mesopores are difficult to make out in these sections, being short and usually filled, in part at least, with solid tissue. In the axial part of transverse sections the tubes are unusually irregular and their walls comparatively thick."—Ulrich, 1893.

Occurrence.—Chambersburg Limestone (Echinospherites bed). Several localities in southern Pennsylvania and at Pinesburg Station, Maryland. Black River and Early Trenton of the Upper Mississippi Valley.

Collections.—Maryland Geological Survey, U. S. National Museum.

Genus DIPLOTRYPA Nicholson

Diplotrypa ? appalachia n. sp.

Plate XLVII, Figs. 9-11

Description.—Zoarium a small hemisphere or subconical mass averaging 20 mm. in width and 10 to 15 mm. high. The under surface exhibits extremely small tubes which indicate that the reference of the fossil to the Bryozoa may be incorrect. The upper surface shows extremely large openings for a bryozoan, averaging 1 mm. in diameter, with thin walls. In thin sections these cells are seen to be separated by small, irregular mesopore-like structures. Vertical sections are particularly interesting because here the rapid increase in diameter of the tubes from the minute pores of the base to the wide openings of the outer part is well shown. The walls in such sections are seen to be thin and slightly undulating. No diaphragms are developed in either the larger or smaller tubes.

It is possible that more extended study of this organism will show it to be a coral related to *Lichenaria,* but most of the evidence at present seems to indicate its relationship to the Bryozoa.

Occurrence.—CHAMBERSBURG LIMESTONE. This fossil and *Nidulites pyriformis* are the two most abundant and characteristic species of the Nidulites bed of the Chambersburg formation. The comparatively large tubes of this bryozoan may be seen in weathered cross-sections wherever the more massive layers of the Nidulites beds are exposed. Pinesburg and Wilson, Maryland, afford numerous specimens.

Collections.—Maryland Geological Survey, U. S. National Museum.

Genus BATOSTOMA Ulrich

BATOSTOMA JAMESI Nicholson

Plate LIV, Figs. 1, 2

Chaetetes jamesi Nicholson, 1874, Quart. Jour. Geol. Soc. London, vol. xxx, p. 506, pl. xxix, figs. 10, 10b.

Chaetetes jamesi Nicholson, 1875, Pal. Ohio, vol. ii, p. 200, pl. xxi, figs. 11, 11a.

Monticulipora (Heterotrypa) jamesi Nicholson, 1881, Genus Monticulipora, p. 147, figs. 25, 26.

Batostoma jamesi Cumings, 1908, 32d Ann. Rep. Dep. Geol. Nat. Res. Indiana, p. 775, pl. vii, figs. 8, 8a; pl. viii, fig. 1; pl. xxvii, figs. 6, 6a.

Description.—Zoarium of small, rounded, solid stems marked at the surface by large oval zoœcia, rather conspicuous acanthopores and numerous mesopores. In tangential sections the walls in the mature region consist of thick, dark rings of dense tissue usually widely separated from each other by angular, irregularly shaped mesopores. Embedded in these walls numerous acanthopores may be noticed. In longitudinal sections the zoœcia are provided with rather infrequent complete diaphragms and mesopores with partitions which are four or five times as numerous.

Occurrence.—MARTINSBURG SHALE (Eden division). Abundant and characteristic in the Eden shale of the Ohio Valley. Impressions of a ramose bryozoan in the upper part (Eden) of the Martinsburg shale at Jordans Knob, one and one-half miles northeast from Fort Loudon, Pennsylvania, and Cowans Gap, five miles northeast of McConnellsburg, Pennsylvania, have the external features of this species.

Collections.—Maryland Geological Survey, U. S. National Museum.

Family BATOSTOMELLIDAE

Genus BYTHOPORA Miller and Dyer

BYTHOPORA ARCTIPORA (Nicholson)

Plate LIII, Figs. 11-13

Ptilodictya ? arctipora Nicholson, 1875, Ann. Mag. Nat. Hist., 4th ser., vol. xv, p. 180, pl. xiv, figs. 4-4b.

Ptilodictya ? arctipora Nicholson, 1875, Pal. Ohio, vol. ii, p. 262, pl. xxv, figs. 9-9b.

Bythopora arctipora Bassler, 1906, Proc. U. S. Nat. Mus., vol. xxx, p. 90, pl. ii, figs. 1, 2.

Description.—This minute species is characterized by its long, slender, cylindrical branches, a millimeter or less in diameter, made up of zoœcial tubes which open at the surface in elongate, often attenuate, orifices. The internal structure is that of the genus Bythopora, that is, the zoœcial walls are fused in the mature region, diaphragms are practically absent, the apertures are oblique and narrowed above, and the interspaces are canaliculate. Mesopores are present but small, and on account of the small size and little development of the zoœcia in this species, they are inconspicuous.

Occurrence.—MARTINSBURG SHALE (Eden division). An abundant and characteristic Eden fossil of the Ohio Valley. Not so abundant in the upper part (Eden) of the Martinsburg shale at Jordans Knob, one and one-half miles northeast of Fort Loudon, Pennsylvania, and west slope of Rickard Mountain, Washington County, Maryland.

Collections.—Maryland Geological Survey, U. S. National Museum.

Family HALLOPORIDAE

Genus HALLOPORA Bassler

HALLOPORA ONEALLI SIGILLARIOIDES (Nicholson)

Plate LIII, Fig. 10

Chaetetes sigillarioides Nicholson, 1875, Pal. Ohio, vol. ii, p. 203, pl. xxii, figs. 9, 9a.

Callopora sigillarioides Nickles, 1905, Kentucky Geol. Surv., Bull. v, p. 50, pl. ii, figs. 10, 11.

Callopora onealli sigillaroides Bassler, 1906, Proc. U. S. Nat. Mus., vol. xxx, pl. vi, figs. 3, 4.

Description.—Zoarium ramose, consisting of narrow, dichotomously dividing branches from 2 to 4 mm. in diameter. Surface of branches usually smooth, although occasionally the clusters of larger cells (maculae) are slightly elevated. Apertures of zoœcia oval, about six in 2 mm. measuring along the length of the branch, and eight in the same space transversely with their longer diameter in the direction of the branch. Mesopores numerous. Diaphragms few in the axial region of the tubes, but rather numerous in the mature zone. In the mesopores the diaphragms are closely spaced throughout their length.

Occurrence.—MARTINSBURG SHALE (Eden division). Very abundant and characteristic of the Eden shale in the Ohio Valley. Upper part (Eden) of Martinsburg shale at Jordans Knob, one and one-half miles northeast of Fort Loudon; Cowan's Gap, five miles northeast of McConnellsburg, and Tuscarora Mountain, two and one-half miles southeast of McConnellsburg, Pennsylvania. The corresponding horizon in Maryland on Rickard Mountain, Washington County, also furnishes specimens. In all of the eastern localities the species occurs as molds in the sandy matrix, but the preservation is so good that gutta percha squeezes readily show all of the specific characters of the surface.

Collections.—Maryland Geological Survey, U. S. National Museum.

Order CRYPTOSTOMATA

Family PTILODICTYONIDAE

Genus ESCHAROPORA Hall

ESCHAROPORA CONFLUENS Ulrich

Plate XL, Figs. 11-14

Escharopora confluens Ulrich, 1893, Geol. Minnesota, vol. iii, p. 171, pl. xiii, figs. 1-11.

Description.—" Zoarium branching, the smallest seen less than 25 mm. high, with the branches averaging about 2.5 mm. in width; the largest fragments indicate a hight of from 80 to 120 mm., and in these the width of the branches varies from 4 to 8 mm. The two surfaces of the branches are generally obtusely ridge-shaped, and in the largest a row of monticules, or simply clusters of large cells, occurs on the summit of the ridge. Edges thin and sharp, commonly with a coarsely striated or pitted narrow border. Through all stages, though less distinct in the oldest, the zoœcial apertures are narrow and appear to be drawn out at the ends so as to connect by means of a narrow channel. This confluent character of the zoœcial apertures is better shown and more regular in the central rows, where they are also narrower and on the whole considerably smaller than toward the margins. In the central rows, 10 in 5 mm. lengthwise; 18 or 19 in 5 mm. diagonally, and five and one-half in 1 mm., and 10 in 2 mm., transversely; of longitudinal rows there are 19 or 20 in 2 mm.

" Tangential sections show that the base of the zoœcia, excepting those in the marginal rows, is bounded by very thin, straight, longitudinal wall, and equally thin transverse partitions. This portion of the zoœcium therefore may be described as a parallelogram, with the length and breadth respectively as four is to one. At about the middle of the hight of the primitive cell its sides have spread a little and the ends contracted in a corresponding degree. Just as the posterior half is about to be roofed over two projections from the side walls, at a point a little behind the middle, gradually converge until they meet and thereby cut off and enclose the elliptical primitive aperture. In the succeeding stages the principal change is a reduction in the size of the apertures, caused by an internal deposit."—Ulrich, 1893.

Occurrence.—CHAMBERSBURG LIMESTONE (Caryocystites bed). Blue Spring, Franklin County, Pennsylvania. The type specimens of this species were found in the Decorah shales division of the Black River at Minneapolis, Minnesota.

Collections.—Maryland Geological Survey, U. S. National Museum.

Genus ARTHROPORA Ulrich

ARTHROPORA BIFURCATA Ulrich

Plate XLVIII, Figs. 13-15

Arthropora bifurcata Ulrich, 1893, Geol. Minnesota, vol. iii, p. 178, pl. xiv, figs. 22-25.

Description.—" Segments small, thin, with sharp edges and rather wide nonporiferous border, the lower ones bifurcating, usually only once; so far as observed not over 8 mm. long, and from 1.2 to 1.8 mm. wide; the upper joints shorter, their length occasionally less than 5 mm., bifurcating or with a single lobe-like projection on one or both sides. Young segments with comparatively large, ovate zoœcial apertures, not very regularly arranged in longitudinal and diagonally intersecting series, with about nine in 3 mm. lengthwise, and five in 1 mm. diagonally. Apertures enclosed in distinct granulose rims, connecting longitudinally. Interspaces depressed, sometimes with a few indistinct striae. With age the zoœcial apertures become more circular and smaller, and the peristomes and connecting ridges thicker."—Ulrich, 1893.

Occurrence.—CHAMBERSBURG LIMESTONE (Christiania bed). Greencastle and other localities in southern Pennsylvania.

Black River and early Trenton of Minnesota, Kentucky, Tennessee, and Canada.

Collections.—Maryland Geological Survey, U. S. National Museum.

ARTHROPORA CLEAVELANDI (James)

Plate LIII, Figs. 14, 15

Ptilodictya cleavelandi James, 1881, Paleontologist, No. 5, p. 38.
Arthropora cleavelandi Bassler, 1906, Proc. U. S. Nat. Mus., vol. xxx, p. xiv, pl. 3, figs. 13-16; pl. 4, fig. 6.

Description.—*Ptilodictya cleavelandi* James, as shown by the type, is founded upon segments of a rather well-marked species of *Arthropora* occurring abundantly throughout the various subdivisions of the Eden shale. The species is characterized by slender, generally nonbifurcating segments (in consequence of which the complete zoarium must have consisted of comparatively only a few rigid branches) and by the numerous and small lateral branchlets springing out at nearly right angles from the main stem. The segments are usually found separated, specimens retaining more than a sequence of two or three being extremely rare. Ir length they vary but little from the average of 7 mm. The basal segment is bifurcated and drawn out acuminately below.

The zoœcial apertures are as usual in this genus, elliptical, surrounded by a delicate peristome. The interspaces have one or more thread-like ridges, variously disposed and with a row of minute papillae.

Occurrence.—MARTINSBURG SHALE (Eden division). Pennsylvania and Maryland. Jordans Knob, one and one-half miles northeast of Fort Loudon and Tuscarora Mountain, two and one-half miles southeast of McConnellsburg, in Pennsylvania, and the western slopes of Fairview and Rickard Mountains, Washington County, Maryland, are localities where the species may be found.

A characteristic and abundant species of the Eden shale at Cincinnati, Ohio, and vicinity.

Collections.—Maryland Geological Survey, U. S. National Museum.

Family PHYLLOPORINIDAE

Genus CHASMATOPORA Eichwald

CHASMATOPORA RETICULATA (Hall)

Plate XL, Figs. 4-6

Intricaria ? reticulata Hall, 1847, Pal. New York, vol. i, p. 77, pl. xxvi, figs. 8a-c.

Phylloporina reticulata Ulrich, 1890, Geol. Surv. Illinois, vol. viii, pp. 332, 639, pl. liii, figs. 2, 2a.

Phylloporina reticulata Ulrich, 1893, Geol. Minnesota, vol. viii, p. 210, pl. iv, figs. 8-15.

Chasmatopora reticulata Bassler, 1911, Bull. U. S. Nat. Mus., No. 77, pp. 170, 171, text fig. 86.

Description.—" Specimens as seen, consisting of small, flat or undulating, reticulate expansions, being in each case evidently fragments of a depressed, funnel-shaped zoarium, probably not exceeding 5 cm. in diameter. Branches rounded in section, 0.2 to 0.3 mm. in diameter, inosculating at unusually frequent and regular intervals. Fenestrules somewhat elongate, about as wide as the branches, subrhomboidal in shape in the more regularly constructed fragments; their number in a given space is fairly constant, the extremes noticed in 1 cm. being 10 and 12. Reverse of branches convex finely striated lengthwise.

" Obverse strongly convex, with three rather irregular rows of zoœcia, their apertures subcircular, with a distinct peristome, about 0.1 mm. in diameter, eight or nine in 2 mm. Acanthopores abundant, irregularly distributed, rather large, especially so in the earliest forms of the species. Interspaces slightly concave, occasionally faintly pitted and striated.

" In tangential sections the zoœcia are rather short, with a row on each side directed obliquely outward, and one series between them. The latter are wedge-shaped, and in deep sections appear as a more or less narrow central space. Diaphragms, one in each tube, have been observed." Ulrich, 1893.

Occurrence.—CHAMBERSBURG LIMESTONE (Caryocystites bed). Fort Loudon and Blue Spring, Franklin County, Pennsylvania. The original types are from the Trenton limestone of New York, but the species has a wide distribution in both the Black River and Trenton rocks.

Collections.—Maryland Geological Survey, U. S. National Museum.

CHASMATOPORA SUBLAXA (Ulrich)

Plate XL, Figs. 7-10

Phylloporina sublaxa Ulrich, 1890, Journ. Cincinnati Soc. Nat. Hist., vol. xii, p. 179, fig. 6.

Phylloporina sublaxa Ulrich, 1893, Geol. Minnesota, vol. iii, p. 209, pl. iv, figs. 1-7.

Description.—" Zoarium an undulating flabelliform expansion, attaining a diameter of 5 cm. or more, consisting of irregularly inosculating slender subcylindrical branches, varying in width from 0.3 to 0.6 mm., but averaging about 0.45 mm. Fenestrules large, subacutely elliptical, varying considerably in shape and size, generally two or three times longer than wide; measuring longitudinally, the average number in 1 cm is between five and six; transversely, nine or ten in the same space. These measurements apply to the Tennessee specimens. In the Minnesota form of this species the fenestrules are smaller, averaging between six and seven in 1 cm. lengthwise.

" Reverse of the Tennessee specimens strongly rounded, nearly smooth, or with faint longitudinal striae. In very young examples the latter would probably be more distinct."—Ulrich, 1893.

Occurrence.—CHAMBERSBURG LIMESTONE (Caryocystites bed). Fort Loudon and Blue Spring, Franklin County, Pennsylvania.

Specimens from the Stones River, Black River, and Chazyan rocks have been identified with the types of this species which were found in the Upper Stones River limestone of Central Tennessee.

Collections.—Maryland Geological Survey, U. S. National Museum.

Family ARTHROSTYLIDAE

Genus HELOPORA Hall

HELOPORA DIVARICATA Ulrich

Plate XL, Figs. 1-3

Helopora divaricata Ulrich, 1886, Fourteenth Ann. Rept. Geol. Surv. Minnesota, p. 59.

Helopora divaricata Ulrich, 1893, Geol. Minnesota, vol. iii, p. 191, pl. iii, figs. 1-3.

Helopora divaricata Bassler, 1911, Bull. U. S. Nat. Mus., No. 77, pp. 149-150, text fig. 72.

Description.—"Zoarium jointed; segments about 7.0 mm. long, obtuse at both extremities, subcylindrical, polygonal in cross-section, the number of the angles and corresponding rows of zoœcial apertures six, seven or eight. Their diameter varies with age and according to the number of zoœcia contained from 0.5 to 0.9 mm. Zoœcial apertures comparatively large, oblique, ovate, seeming to widen anteriorly, arranged in troughs between strong longitudinal ridges, 12 in 5 mm. lengthwise and generally in regular transverse rows. Posterior border of apertures thick, prominent, sloping backward into the aperture next below. This border is continued upon the sides of the zoœcial aperture as two diverging ridges which extend on each side to the summit of the longitudinal keels where they meet with similar ridges from the adjoining rows. These divaricating ridges cause the strong vertical keels to appear as being marked by a succession of narrow Λ-shaped furrows and ridges. Occasionally, and this is true more especially of the young and slender segments, the rounded posterior slope is divided by a central furrow into two small ridges."—Ulrich, 1893.

Occurrence.—CHAMBERSBURG LIMESTONE (Caryocystites bed). Fort Loudon, Franklin County, Pennsylvania. This species has heretofore been recorded from the Decorah shales of the Black River group of Minnesota and the Kuckers shales of Esthonia, Russia.

Collections.—Maryland Geological Survey, U. S. National Museum.

HELOPORA SPINIFORMIS (Ulrich)

Plate XLIV, Figs. 8-10

Arthroclema spiniformis Ulrich, 1882, Jour. Cincinnati Soc. Nat. Hist., vol. v, p. 161, pl. vi, figs. 10, 10a.

Helopora spiniformis Ulrich, 1893, Geol. Minnesota, vol. iii, pl. iii, figs. 4-6.

Description.—"Zoarium composed of numerous segments, which are cylindrical, poriferous on all sides, and pointed more or less obtusely at each end; their length varies from two- to four-tenths of an inch, their diameter from .015 inch to .04 inch. Cell apertures oblique, arranged between slightly elevated longitudinal lines, and in transverse rows around the stem. On account of their obliquity, well-preserved examples have the lower margin of the aperture prominently elevated. There are from 8 to 16 longitudinal series of cell-apertures around the segments; seven of the transverse series occupy the space of .1 inch. Longitudinal sections show that the cells radiate from a central axis, that their walls are thin near the axis, and become much thickened as they approach the surface. No diaphragms. In transverse sections the cells radiate from the central axis, and appear as so many wedges arranged around a central point."—Ulrich, 1893.

Occurrence.—CHAMBERSBURG LIMESTONE (Echinospherites bed). Pinesburg Station, Maryland. Lebanon limestone division of the Stones River group at Lebanon and other localities in Central Tennessee.

Collections.—Maryland Geological Survey, U. S. National Museum.

Family RHINIDICTYONIDAE

Genus RHINIDICTYA Ulrich

RHINIDICTYA NEGLECTA Ulrich

Plate XLIV, Figs. 11-14

Stictopora paupera (in part) Ulrich, 1886, Fourteenth Ann. Rept. Geol. Nat. Hist. Surv. Minnesota, p. 69.

Rhinidictya neglecta Ulrich, 1893, Geol. Minnesota, vol. iii, p. 130, pl. v, figs. 22-25.

Description.—"Zoarium small, branches dividing dichotomously at intervals of from 4 to 7 mm., rather convex, the margins parallel, not very sharp, and with non-celluliferous border variable. Width of branches rather constant at about 1.5 mm. Zoœcia in 8 to 11 ranges, the usual number nine, with rather small, elliptical, oblique apertures, about 17 in 5 mm. lengthwise, and six in 1 mm. transversely. In most cases all the apertures are directed longitudinally or parallel with the edges of the branches; in others, however, those forming the marginal row on each side may be turned slightly outward. Interspaces comparatively thick, less ridge-shaped than usual, often slightly zigzag, with the range of granules well developed.

"Internal structure chiefly diagnostic in vertical sections. These show that the primitive or prostrate cell is comparatively elongate, and that at the turn into the 'vestibule' the wall is merely sharply curved and not angular, as in *R. mutabilis*."—Ulrich, 1893.

Occurrence.—CHAMBERSBURG LIMESTONE (Echinospherites bed). Southern Pennsylvania and Pinesburg Station, Maryland. Lower Trenton of Kentucky, Tennessee, and Minnesota.

Collections.—Maryland Geological Survey, U. S. National Museum.

BRACHIOPODA

Order ATREMATA

Family OBOLIDAE

Genus LINGULELLA Salter

LINGULELLA sp.

Description.—No fossils have been found in the Waynesboro formation in Maryland, but Stose records the discovery of a few poorly preserved shells in the sandy shales at the top, just each of Waynesboro in Pennsylvania. These were identified as an undetermined species of *Lingulella* suggesting Middle Cambrian age. Better preserved material is necessary before any stratigraphic use can be made of this species, and for that reason it has not been figured.

Occurrence.—WAYNESBORO FORMATION. Just east of Waynesboro, Pennsylvania.

Collection.—U. S. National Museum.

Genus LEPTOBOLUS Hall

LEPTOBOLUS ? OVALIS n. sp.

Plate XLIX, Figs. 14-16

Description.—This interesting little brachiopod is associated with the quite similar *Lingula riciniformis* Hall from which it can be distinguished externally by its more rounded beak. Internally the valves of this new *Leptobolus* show the two or three diverging, slightly elevated septa characteristic of the genus, but these are so faintly developed that the species cannot be considered typical. *Paterula,* which differs from *Leptobolus* in having the inner margins of the valves thickened, must also be considered in determinating its final generic position.

Compared with other species of *Leptobolus, L. ovalis* is distinguished at once by its larger size, more elongated, oval shape, more rounded beak and less clearly marked interior.

Occurrence.—MARTINSBURG SHALE (Sinuites bed). Many localities in the Chambersburg and Mercersburg quadrangles of Pennsylvania and in the southern extension of the same strata into Maryland. The figured specimens are from the locality two miles northeast of Kauffman, Pennsylvania.

Collections.—Maryland Geological Survey, U. S. National Museum.

LEPTOBOLUS INSIGNIS Hall

Plate LII, Fig. 13

Leptobolus insignis Hall, 1871, Fossils from Hudson River Group, p. 3, pl. iii, fig. 17 (Twenty-fourth Rept. New York State Cab. Nat. Hist., p. 227, pl. vii, fig. 17).

Leptobolus insignis Hall and Clarke, 1892, Pal. New York, vol. viii, pt. i, p. 74, pl. iii, figs. 1-6.

Description.—Shell semiphosphatic, minute, 1.50-2.00 mm. in length, fragile, orbicular, with a scarcely pointed beak. Valves subcircular, regularly convex and marked with concentric lines of growth on the exterior surface. Ventral valve with a distinct pedicle groove and an elevated subquadrate muscular area on its interior. The dorsal valve is somewhat thickened on the cardinal margin and bears slightly elevated, trifid muscular impressions. The internal surface with radiating striae separates this species from other forms of the genus.

Occurrence.—MARTINSBURG SHALE (Corynoides bed). Chambersburg, Pennsylvania, and Williamsport, Maryland. Utica shale of New York, Canada, and the Ohio Valley.

Collections.—Maryland Geological Survey, U. S. National Museum.

Family LINGULIDAE

Genus LINGULA Bruguiere

LINGULA RICINIFORMIS Hall

Plate L, Figs. 6-8

Lingula riciniformis Hall, 1847, Pal. New York, vol. i, p. 95, pl. xxx, fig. 2.
Lingula (*Glossina*) *riciniformis* Hall and Clarke, 1892, Pal. New York, vol. viii, pt. i, pl. i, fig. 3.
Lingula riciniformis Winchell and Schuchert, 1893, Minnesota Geol. Surv. pt. iii, p. 343, fig. 24; pl. xxix, fig. 9.
Lingula riciniformis Weller, 1903, Geol. Surv. New Jersey, Pal. 3, p. 144, pl. ix, fig. 8.

Description.—Shell oval to subelliptical in outline with the two valves equally convex; an average specimen is 8 mm. long and 4 mm. wide. Anterior margin regularly rounded, lateral margins slightly convex, sub-parallel; postero-lateral margins rounded and apex rather blunt. Surface nearly smooth or marked by very fine concentric lines of growth Fine radiating striae are sometimes visible.

As pointed out by Winchell and Schuchert in 1893 this shell is of particular interest in showing the three stages of development very clearly. The first shelled condition or "protegulum" is very small; second comes a sharply defined circular stage, termed the *Obolella* stage, distinguished furthermore by its lighter color, and third arises the stage in which the shell begins to assume its specific form. Through the addition of shell substance posterior to the protegulum the apex at maturity is no longer marginal as in the *Obolella* stage, but has become submarginate.

Occurrence.—MARTINSBURG SHALE (Sinutes bed). Chambersburg, Pennsylvania, and Strasburg, Virginia. Trenton limestone of New York, Canada, Minnesota, and New Jersey.

Collections.—Maryland Geological Survey, U. S. National Museum.

LINGULA NICKLESI n. sp.

Plate LVII, Figs. 1-3

Description.—The sandstones of Lower Maysville age in the Appalachians contain specimens of a *Lingula* which upon close comparison prove to be identical with a species from the upper part of the Fairview division of the Maysville at Cincinnati, Ohio, and vicinity. This species has the subquadrangular outline of *Lingula elderi* Whitfield from the Black River group of Minnesota and Wisconsin, but its anterior end is more drawn out. It is also closely related to *L. rectilateralis* Emmons from the Utica shales of New York, but lacks the fine radiating striae of that species, is more elongate and less quadrate.

Occurrence.—MARTINSBURG SHALE (Orthorhynchula bed at the top of the Fairview division). Head of Raver's Run, three and one-half miles southwest of Saxton, Pennsylvania.

The figured specimens are from the upper part of the Fairview formation at Cincinnati, Ohio.

Collection.—U. S. National Museum.

Order NEOTREMATA

Family OBOLELLIDAE

Genus OBOLELLA Billings

OBOLELLA MINOR (Walcott)

Plate XXV, Figs. 1-4

Camarella minor Walcott, 1890, Proc. U. S. Nat. Mus. for 1889, vol. 12, pp. 36-37.

Camarella ? minor Walcott, 1891, Tenth Ann. Rept. U. S. Geol. Survey, p. 614, pl. lxxii, figs. 4, 4a-d.

Camarella minor Hall and Clarke, 1894, Nat. Hist. New York, Paleontology, vol. 8, pt. 2, p. 221.

Obolella minor Clark and Mathews, 1906, Maryland Geol. Survey, vol. 6, pt. 1, p. 252, pl. xvi, figs. 13 and 14.

Description.—"General form ovate, biconvex. Surface smooth or marked by concentric lines and varices of growth. Ventral valve subacuminate, moderately convex, with the most elevated portion at the umbo, which curves toward the small apex; the posterior or umbonal third of the valve is usually more or less tumid, a ridge of growth separating it from the anterior portion of the shell; area nearly on the plane of the margins of the valve and divided midway by narrow, deep, pedicle furrow; casts of the interior show that the area formed a shelf on each side of the pedicle furrow. Dorsal valve transversely ovate; a narrow, short area and a slight median ridge are indicated on a cast of the interior.

"This shell is small. A large ventral valve measures, length 7 mm.; width, 6 mm.; a dorsal valve, length 6 mm.; width, 6.5 mm."—Walcott.

Occurrence.—ANTIETAM SANDSTONE. Mouth of Little Antietam Creek near Eakles Mills, one mile east-southeast of Smithsburg and other localities in Washington County, Maryland.

Collections.—Maryland Geological Survey, U. S. National Museum.

Family DISCINIDAE

Genus ORBICULOIDEA D'Orbigny

ORBICULOIDEA LAMELLOSA (Hall)

Plate XLVIII, Fig. 12

Orbicula lamellosa Hall, 1847, Pal. New York, vol. i, p. 99, pl. xxx, fig. 10 (not Broderip, 1833).

Orbiculoidea lamellosa Hall and Clarke, 1892, Pal. New York, vol. viii, pt. 1, pl. 4E, fig. 12.

Orbiculoidea lamellosa Weller, 1903, Geol. Surv. New Jersey, Pal., vol. iii, p. 147, pl. ix, figs. 1, 2.

Description.—"Shell depressed-conical, nearly circular in outline, the apex of the brachial valve situated about one-third of the breadth of the shell from the margin. Surface marked by rather irregular, elevated, more or less lamellose, concentric lines, the grooves between the lines being rather wider than the ridges themselves.

"The dimensions of a nearly perfect brachial valve are: Length, 9.5 mm.; width, 8.75 mm.; convexity, 2.5 mm."—Weller, 1903.

Occurrence.—CHAMBERSBURG LIMESTONE (Christiania bed). Pennsylvania and Virginia. Trenton limestone of Middleville, etc., New York, New Jersey, and Ontario.

Collection.—U. S. National Museum.

Family ACROTRETIDAE

Genus CONOTRETA Walcott

CONOTRETA RUSTI Walcott

Plate L, Figs. 1-5

Conotreta rusti Walcott, 1890, Proc. U. S. Nat. Mus., vol. xii, p. 365, figs. 1-4.

Conotreta rusti Hall and Clarke, 1892, Pal. New York, vol. viii, pt. i, p. 104, pl. 4K, figs. 16-21.

Description.—Shell small, calcareo-corneous, circular in outline and cone-shaped in form; 2 to 3 mm. in height. Pedicle valve conical with the height greater than the length. Apex usually broken, but showing evidence of the external opening of the sipho. Extending from the apex to the posterior margin is a shallow furrow increasing in width downward. The posterior wall of the shell conforms to the curvature of the rest of the surface in small specimens, but this area becomes distinctly flattened in larger examples, as in *Acrotreta*. Surface covered with sharp concentric striae curving slightly upward as they cross the foraminal groove.

In casts of the interior a strong apical callosity marking the probable position of the foramen is produced anteriorly into a short, sharp ridge, on either side of which lie two other ridges, with evidence of a third on the lateral slopes.

The highly conical form of this calcareo-corneous shell and the numerous radiating ridges on the ventral interior readily distinguish this interesting brachiopod.

Occurrence.—MARTINSBURG SHALE (Sinuites bed). Chambersburg, Pennsylvania, and Strasburg, Virginia. Trenton limestone, Trenton Falls, New York.

Collection.—U. S. National Museum.

Family TREMATIDAE

Genus SCHIZOCRANIA Hall and Whitfield

SCHIZOCRANIA FILOSA (Hall)

Plate LII, Figs. 8, 9

Orbicula ? filosa Hall, 1847, Pal. New York, vol. i, p. 99, pl. xxx, fig. 9.
Schizocrania filosa Hall and Whitfield, 1875, Pal. Ohio, vol. ii, p. 73, pl. i, figs. 12-15.
Schizocrania filosa Weller, 1903, Geol. Surv. New Jersey, Pal., vol. iii, p. 146, pl. ix, figs. 3, 4.

Description.—"Shell orbicular or subovate, the beak of the free or brachial valve projecting slightly beyond the limits of the circle, giving a somewhat greater diameter along the median line than in a transverse direction. Pedicle or attached valve discoid, very thin, deeply and broadly notched on the posterior side; the notch occupying nearly one-quarter of the circumference of the valve on the outer margin and extending nearly to the center of the valve, its border thickened, especially at the base, which is rounded, with the center marked by a slightly projecting point, marked by strong, irregular, concentric undulations parallel to the margin, but interrupted by the border of the notch. Brachial or free valve moderately convex, most prominent near the center, its surface marked by fine, even, thread-like, radiating striae, which increase both by bifurcation and intercalation, and become stronger toward the border of the shell."—Weller, 1903.

This interesting brachiopod ranges in age from the Trenton to the Richmond, the best localities, however, being in the Trenton of New York and the Maysville of the Ohio Valley. In the Cumberland Valley the species is known only in the lower part (Corynoides bed) of the Martinsburg shale.

Occurrence.—MARTINSBURG SHALE (Corynoides bed). Williamsport, Maryland.

Collections.—Maryland Geological Survey, U. S. National Museum.

Family CRANIIDAE

Genus PHOLIDOPS Hall

PHOLIDOPS CINCINNATIENSIS Hall

Plate LIV, Figs. 23, 24

Pholidops cincinnatiensis **Hall, 1872, 24th Rept. New York State Cab. Nat. Hist., pl. vii, fig. 10.**

Pholidops cincinnatiensis **Meek, 1873, Pal. Ohio, vol. i, p. 130, pl. v, fig. 2.**

Description.—" Shell small, ovate in outline. Larger valve about one-fifth longer than wide, with height one-third to one-fourth the breadth. Apex obtuse, near half way between the middle and the larger end. Anterior end narrowly rounded, posterior end somewhat more broadly rounded, or almost sub-truncate. Surface ornamented by six or seven sub-imbricating marks of growth. Smaller valve unknown.

"Length, 0.14 inch, 0.12 inch; height of larger valve, 0.04 inch."—Meek, 1873.

Occurrence.—MARTINSBURG SHALE (Eden division). Molds and casts showing the specific characters quite plainly are found at Jordans Knob one and one-half miles northeast of Fort Loudon, Cowans Gap, five miles northeast McConnellsburg, and Tuscarora Mountain two and one-half miles southeast McConnellsburg, Pennsylvania. In Maryland the same horizon on Rickard Mountain, Washington County, has afforded specimens. Not uncommon in the Eden and Maysville strata of the Ohio Valley.

Collections.—Maryland Geological Survey, U. S. National Museum.

Order PROTREMATA

Superfamily ORTHACEA

Family BILLINGSELLIDAE

Genus EOORTHIS Walcott

EOORTHIS DESMOPLEURA (Meek)

Plate XXVII, Figs. 1-5

Orthis desmopleura Meek, 1872, Hayden's U. S. Geol. Surv. Wyoming, p. 295.
Orthis (*Plectorthis*) *desmopleura* Walcott, 1905, Proc. U. S. Nat. Mus., vol. xxviii, p. 261.
Eoorthis desmopleura Walcott, 1912, Mon. U. S. Geol. Surv., vol. li, p. 777, pl. xcvi, figs. 1, 1a-r.

Description.—"This shell has the general form and external characters of *E. wichitaensis* (Walcott). It differs in being less convex and in the details of the radiating ribs. *Eoorthis desmopleura* differs from *E. remnicha* (N. H. Winchell) in its uniformly smaller size, less convexity, and in the details of the radiating ribs. The ribs have a wide range of variation, but when from the same character of matrix they are all of the same type and the shells grade from one to the other. The ventral valves of young shells 2 to 3 mm. long are highly convex and usually appear to be a little longer than wide; if in such shells the surface striae are in sharply elevated fasiculae, the result is to all appearances a rhynchonelloid shell.

"The interior of the ventral valve shows a narrow area, broad delthyrium, spondylium almost free from the bottom of the valve, and a median septum that may have supported the front end of the spondylium. In young and strongly convex shells the spondylium is narrow and very strongly defined. The narrow area of the dorsal valve is divided by a broad delthyrium, in the center of which is a very slightly developed cardinal process."—Walcott, 1912.

Occurrence.—CONOCOCHEAGUE LIMESTONE. Near Scotland, Franklin County, Pennsylvania, and the same horizon near Funkstown, Maryland, furnish fragments apparently of this species. Upper Canadian and lowest Ordovician of Utah, New Mexico and Colorado.

Collections.—Maryland Geological Survey, U. S. National Museum.

Family ORTHIDAE

Genus HEBERTELLA Hall and Clarke

HEBERTELLA BOREALIS (Billings)

Plate XXXVIII, Figs. 9-12; Plate XLI, Fig. 17

Orthis borealis Billings, 1859, Canadian Nat. Geol., vol. iv, p. 436, fig. 14.
Orthis borealis Billings, 1863, Geol. Canada, p. 129, fig. 56, p. 167, fig. 148.
Hebertella borealis Raymond, 1911, Ann. Carnegie Mus., vol. vii, No. 2, p. 241, text figs. 13, 14.

Description.—"Shell transversely oval, width at hinge considerably less than the width below. Sides rounded, front straight or slightly rounded. There is a low, broad depression in both valves. The pedicle valve is the more convex of the two in young specimens, but in mature shells the brachial valve is slightly the larger. The cardinal area of the pedicle valve is high and incurved, with a narrow delthyrium. The surface is marked by from 20 to 30 broad, simple plications, separated by very narrow grooves."—Raymond, 1911.

Occurrence.—STONES RIVER LIMESTONE (Middle division). Near Maugansville, Maryland; Chambersburg, Pennsylvania.

CHAMBERSBURG LIMESTONE (Caryocystites bed). Fort Loudon and Blue Spring, Pennsylvania.

A not uncommon Chazyan fossil in Canada and New York. In east Tennessee the species occurs in the Lenoir (Middle Chazyan) limestone.

Collections.—Maryland Geological Survey, U. S. National Museum.

HEBERTELLA VULGARIS Raymond

Plate XXXVIII, Figs. 1-5; Plate XLI, Fig. 18

Hebertella vulgaris Raymond, 1911, Ann. Carnegie Mus., vol. vii, No. 2, p. 242, pl. xxxvi, figs. 2-5, text figs. 15-18, 22.

Description.—"Valves nearly equally convex, outline transversely oval, hinge of variable length, but always less than the greatest width. Sides and front rounded. Some specimens have a broad shallow sinus in the pedicle valve, while others have that valve evenly convex, or merely flattened toward the front. The brachial valve usually shows a narrow but not deep sinus, which extends from the beak nearly or quite to the front. The line in which the two valves meet is usually straight, but in those specimens which have a sinus in the pedicle valve and not in the brachial, the front is sinuate. Mature specimens usually have from 60 to 90 fine striae on each valve. The striae increase both by bifurcation and implantation. The cardinal area of the pedicle valve is high and slightly incurved, the delthyrium apparently open. The teeth are supported by thin lamellae, between which are the scars of the muscles. In the brachial valve there is a low median septum which expands at the posterior end, forming a platform, in the middle of which is the small linear cardinal process. In front of this platform are two pairs of deep adductor scars. The dental sockets are narrow and deep."—Raymond, 1911.

Occurrence.—STONES RIVER LIMESTONE (Middle division). Chambersburg, Pennsylvania.

CHAMBERSBURG LIMESTONE (Caryocystites bed). Fort Loudon and near Blue Spring, Pennsylvania.

An abundant fossil in the Chazyan rocks of New York, Canada, and Tennessee.

Collections.—Maryland Geological Survey, U. S. National Museum.

HEBERTELLA BELLARUGOSA (Conrad)

Plate XLI, Fig. 6; Plate XLV, Figs. 10-12

Orthis bellarugosa Conrad, 1843, Proc. Acad. Nat. Sci., Phila., vol. i, p. 333.

Orthis bellarugosa Hall, 1847, Pal., New York, vol. i, p. 118, pl. xxxii, fig. 3.

Orthis (*Hebertella ?*) *bellarugosa* Winchell and Schuchert, 1893, Geol. Minnesota, vol. iii, p. 434, pl. xxxiii, figs. 1-4.

Hebertella bellarugosa Raymond, 1911, Ann. Carnegie Mus., vol. vii, No. 2, p. 245, pl. xxxvi, figs. 8, 9, text figs. 19, 20.

Description.—" Shell usually nearly circular in outline, valves about equally convex. Surface marked by from 30 to 40 coarse striae which increase by implantation and bifurcation. The radial striae are crossed by sharp concentric lamellae, producing the rugose appearance which suggested the specific name. From 10 to 15 of the radial striae are stronger than the others, and between each pair of strong striae is a single weaker one, except in the sinus of the brachial valve, where there are two. The pedicle valve is evenly convex, somewhat flattened toward the front, but without a sinus. Hinge line less than the greatest width. Cardinal area not high, nor much incurved. The bachial valve has a narrow median sinus.

" The shells vary in outline; some are wider than long, while in others the width and length are about equal. The sides are rounded, and the front is nearly straight in some specimens and rounded in others."—Raymond, 1911.

Occurrence.—CHAMBERSBURG LIMESTONE (Caryocystites and Echinospherites beds). Pinesburg and Wilson, Maryland; Fort Loudon and Blue Spring, Pennsylvania.

The original types of this wide-spread species were obtained in the Black River rocks of Wisconsin.

Collections.—Maryland Geological Survey, U. S. National Museum.

Genus ORTHIS Dalman

ORTHIS TRICENARIA Conrad

Plate XLVII, Figs. 4-6

Orthis tricenaria Conrad, 1843, Proc. Acad. Nat. Sci. Philadelphia, vol. i, p. 333.

Orthis tricenaria Hall, 1847, Pal. New York, vol. i, p. 121, pl. xxxii, fig. 8.

Orthis tricenaria Hall and Clarke, 1892, Pal. New York, vol. viii, pt. 1, pp. 191, 193, 221, 228, pl. v, figs. 9-14.

Orthis tricenaria Weller, 1903, Geol. Surv. New Jersey, Pal., vol. iii, p. 151, pl. ix, figs. 18-21.

Description.—" Shell plano-convex, longitudinally semi-elliptical in outline; hinge-line equal to the greatest width of the shell, rarely shorter. Cardinal area well developed on each valve. Surface marked by 30 to 36 usually nearly equal, simple, subangular, radiating costae, which are crossed by exceedingly delicate, concentric lines of growth. Pedicle valve strongly convex, subangular along the median line, with the greatest elevation on the umbo. Cardinal area very high, more or less concave, striated longitudinally and transversely, divided by a very narrow delthyrium, whose apical third is occupied by a flat, concave or convex deltidium. Brachial valve nearly flat, slightly elevated at the beak, from which point the surface slopes gradually into a broad, scarcely perceptible, rarely well-defined, median sinus. Cardinal area nearly one-third as wide as that of the pedicle valve, flat, divided by a triangular delthyrium, which is as broad as long and more or less covered by a convex chilidium, the anterior margin of which is concave. The dimensions of a rather large specimen are: Length, 19 mm.; width, 20 mm.; thickness, 10.5 mm."—Weller, 1903.

A characteristic fossil of the Black River group of the Mississippi and Appalachian valleys.

Occurrence.—CHAMBERSBURG LIMESTONE (Nidulites bed). Wilson and Pinesburg, Maryland.

Collections.—Maryland Geological Survey, U. S. National Museum.

Genus PLECTORTHIS Hall and Clarke

PLECTORTHIS PLICATELLA Hall

Plate LVII, Figs. 4-7

Orthis plicatella Hall, 1847, Pal. New York, vol. i, p. 122, pl. xxxii, fig. 9.
Orthis plicatella Meek, 1873, Pal. Ohio, vol. i, p. 108, pl. viii, fig. 7.
Plectorthis plicatella Hall and Clarke, 1892, Pal. New York, vol. viii, pt. i, p. 22, pl. v, figs. 18-20.

Description.—"Broadly semioval, nearly equivalve, length and breadth about as 3 to 4; surface marked by strong radiating plicae, which are usually simple, about 20 to 28 on each valve, crossed by simple elevated concentric lines, which are more distinct in the depressions between the costae, and often obscure or obsolete upon their exposed surfaces; valves nearly equally convex, without sensible depression or elevation on either one, meeting at the edges in a straight line; cardinal line not extending beyond the width of the shell; area narrow, dorsal foramen extending to the beak."—Hall, 1847.

Occurrence.—MARTINSBURG SHALE (Orthorhynchula bed at the top of the Fairview division). Tuscarora Mountain, one and one-half miles southeast of McConnellsburg, Pennsylvania. The types of this species were obtained in the upper part of the Fairview formation at Cincinnati, Ohio.

Collections.—Maryland Geological Survey, U. S. National Museum.

PLECTORTHIS PLICATELLA Hall var.

Plate LIV, Figs. 15-16

Description.—The typical form of this species occurs in the lower part of the Maysville group at Cincinnati, Ohio, and vicinity. The upper part of the Martinsburg shale in Pennsylvania has afforded brachiopod so close to *P. plicatella* that it cannot be considered more than a variety. Unfortunately the preservation of these specimens is not good enough to allow this variety to be distinguished. A description of *Plectorthis plicatella* is given above.

Occurrence.—MARTINSBURG SHALE (Eden division). Jordans Knob, one and one-half miles northeast of Fort Loudon, Pennsylvania, has furnished the Eden form here regarded as a variety.

Collections.—Maryland Geological Survey, U. S. National Museum.

Genus DALMANELLA Hall and Clarke

DALMANELLA TESTUDINARIA (Dalman) var.

Plate L, Figs. 9, 10

Orthis testudinaria **Dalman, 1828, Kongl. Svenska Vet.-Akad. Handl., p. 115, pl. ii, fig. 4.**

Dalmanella testudinaria **Weller, 1903, Geol. Surv. New Jersey, Pal., vol. iii, p. 155, pl. x, figs. 1, 2; p. 216, pl. xvi, figs. 4, 5.**

Description.—"Adult shells subcircular and the younger ones transversely subelliptical in outline; hinge-line less than the greatest width; cardinal angles rounded, lateral and anterior margins broadly rounded, though the extreme front of the shell is sometimes straight for a short distance. Surface of both valves marked by unequal, angular, radiating costae, about 10 or 12 of the largest ones having their origin at the beak, the remainder being lateral branches from these. In some of the larger individuals as many as 60 or more costae are present along the margin of the shell. The branches from the main costae are small at first, but increase in size towards the margin of the shell, and themselves give off additional branches. In many individuals this manner of branching gives to the costae a more or less fasciculate appearance, each fascicle having one large rib in the center, with smaller ones on either side. In those specimens having the shell well preserved the bottoms of the grooves between the costae exhibit a series of fine, transverse crenulations. Pedicle valve convex, subcarinate along the median line, the lateral slopes nearly straight, the greatest convexity of the valve about one-third the distance from the beak. Cardinal area moderately concave, forming an angle of about 45° with the plane of the valve, about five or six times as high. Delthyrium a little higher than wide. Brachial valve nearly flat, with a sinus beginning close to the beak and expanding in a broad, shallow depression towards the front.

"The dimensions of an average-sized specimen are: Length, 8 mm.; width, 8.25 mm.; convexity of pedicle valve, 2.5 mm."—Weller, 1903.

The particular variety of *Dalmanella testudinaria* described above by Weller from the Trenton limestone of New Jersey is represented in the Sinuites bed at the base of the Martinsburg shale.

Occurrence.—Martinsburg Shale (Sinuites bed). The Trenton variety here figured occurs at Chambersburg, Pennsylvania, and Strasburg, Virginia. Shells identified as this species occurs in most of the Middle and Upper Ordovician strata of Europe and America.

Collections.—Maryland Geological Survey, U. S. National Museum.

Dalmanella edsoni n. sp.

Plate XLIX, Figs. 17-21

Description.—This well-marked new species is distinguished by its large size and by its sharply folded plications, arranged in bundles. The length and breadth of average specimens from southern Pennsylvania is as 3 is to 4 mm., that is, the length is 18 mm. and the breadth 24 mm. Other specimens from the same area attain as great a breadth as 35 mm. The Vermont specimens are even more robust, an average specimen here being 30 mm. long and almost 40 mm. broad. The arrangement of the plications in bundles, each bundle being marked off by a stronger plication, is also a striking specific feature. The specific name is in honor of the late George E. Edson, who discovered the species in the Trenton rocks of Vermont.

Occurrence.—MARTINSBURG SHALE (Sinuites bed). Two miles south of St. Thomas, Pennsylvania. Lower Trenton at Highgate Springs, Vermont.

Collection.—U. S. National Museum.

DALMANELLA MULTISECTA (Meek)

Plate LIV, Figs. 5, 6

Orthis emacerata var. *multisecta* (James MSS.) Meek, 1873, Pal. Ohio, vol. i, p. 112, pl. viii, fig. 3.

Orthis emacerata var. *multisecta* Miller, 1875, Cincinnati Quart. Jour. Sci., vol. ii, p. 22.

Orthis multisecta Sardeson, 1897, American Geologist, vol. xix, p. 97, pl. iv, figs. 20-23.

Dalmanella testudinaria var. *multisecta* Cumings, 1908, 32d Ann. Rept. Dept. Geol. and Nat. Res. Indiana, p. 901, pl. xxxiii, figs. 4, 4c.

Description.—"Shell small, subcircular, plano-convex, or sometimes concavo-convex, hinge line shorter than the greatest breadth of the valves; valves thin. Dorsal valve nearly flat, or having a concentric depression through the middle; mesial sinus undefined or indistinct; beak, small, not incurved; area low at the middle, and narrowing off to nothing at the lateral extremities; foramen very small and filled by the cardinal process. Interior flat; mesial ridge extending to about the middle of the shell, without any well-defined termination; scars of posterior pair of adductor muscles a little smaller than the anterior pair, from which they are separated by a very fine line, or, more generally, not distinctly separated; cardinal process very small, conical, obscurely trifid on the posterior side; brachial processes slender, prominent, and directed obliquely forward; surface granular and showing the radiating striae.

"Ventral valve convex, with elevated mesial ridge, greatest convexity just behind the middle; beak arched, projecting slightly; area moderate, narrowing laterally; foramen an equilateral triangle, partly occupied by the cardinal process of the other valve. Interior strongly concave, showing moderately prominent teeth; dental laminae extend from the base of the teeth forward, gradually becoming more indistinct as they fade away in a circular line to the mesial depression, forming a heart-shaped cavity for the muscular scars; surface granular and showing the radiating striae.

"Surface of both valves ornamented by fine radiating striae, that increase by bifurcation; lateral striae curved so that a few of them run out on the hinge line; concentric striae plainly visible with the aid of a magnifier, and sometimes visible to the unaided eye; imbricating marks of growth usual. Length of an average full-grown specimen, 0.50 inch; breadth, 0.58 inch; convexity, 0.20 inch. They vary, however, from one-fourth this size to one-half larger."—Miller, 1875.

This is probably the most abundant fossil of the Eden shale wherever exposed. In the Appalachian Valley of Pennsylvania and Maryland it occurs in the upper sandy layers of the Martinsburg.

Occurrence.—MARTINSBURG SHALE (Eden division). Jordans Knob, one and one-half miles northeast of Fort Loudon, in Pennsylvania, and the west slope of Rickard Mountain in Maryland furnish specimens.

Collections.—Maryland Geological Survey, U. S. National Museum.

DALMANELLA ELECTRA (Billings)

Plate XXXV, Fig. 6

Orthis electra Billings, 1865, Pal. Foss., vol. i, p. 79, fig. 72.
Dalmanella electra Weller, 1903, Geol. Surv. New Jersey, Pal., vol. iii, p. 125, pl. iv, fig. 13.

Description.—Shell wider than long, the usual dimensions being about 6 mm. in length and 7 mm. in width, with the hinge-line a little shorter than the greatest width, and the cardinal extremities angular. Pedicle valve moderately convex on the umbo, but more flattened towards the cardinal extremities; cardinal area narrow, concave above; beak projecting slightly beyond the cardinal margin. Surface marked by about 50 fine, subequal, radiating costae, increasing by bifurcation.

The numerous fine radiating costae distinguish this shell from the closely allied *Dalmanella wemplei* Cleland, which differs in having larger costae at regular intervals.

Occurrence.—BEEKMANTOWN LIMESTONE (Ceratopea zone). West of Hagerstown, near Halfway, and east of Williamsport, Maryland.

Canadian at Point Levis, Quebec, Newfoundland, New Brunswick, New Jersey and Pennsylvania.

Collections.—Maryland Geological Survey, U. S. National Museum.

DALMANELLA WEMPLEI Cleland

Plate XXXI, Figs. 7-12

Dalmanella (Orthis) wemplei Cleland, 1900, Bull. Amer. Pal., vol. iii, p. 129 (257), pl. xvii, figs. 10-13.

Dalmanella wemplei Weller, 1903, Geol. Surv. New Jersey, Pal., vol. iii, p. 124, pl. iv, figs. 10-12.

Dalmanella wemplei Cleland, 1903, Bull. Amer. Pal., vol. iv, p. 19.

Description.—Shell small, the average being about 5 mm. long and 6 mm. wide, subquadrangular to subcircular in outline, with the hinge-line slightly shorter than the width; cardinal extremities usually quite angular. Pedicle valve strongly convex, highest posterior to the middle; beak elevated, projecting beyond the hinge-line; cardinal area high, slightly arched. Brachial valve much less convex than the pedicle, with a mesial depression which may become a shallow sinus towards the front. Surface of each valve marked by from 10 to 16 stronger, radiating costae, alternating with from two to four finer ones.

This species differs from the closely related *Dalmanella electra* (Billings) which occurs in the higher beds of the Beekmantown, especially in its coarser striae which alternate with from two to four finer ones.

The original types were collected in the Tribes Hill limestone at Fort Hunter, New York. The species has been identified by Weller in the corresponding horizon in the Canadian part of the Kittatinny limestone at Columbia, New Jersey. Specimens fairly well preserved are not uncommon in the Stonehenge limestone, particularly the upper part, at many localities in Maryland. The outcrops around Hagerstown and Funkstown have shown some layers fairly crowded with this brachiopod.

Occurrence.—BEEKMANTOWN LIMESTONE (Stonehenge member). Numerous localities in Maryland, especially around Hagerstown and Funkstown. Tribes Hill limestone at Fort Hunter, New York, and Kittatinny limestone, Columbia, New Jersey.

Collections.—Maryland Geological Survey, U. S. National Museum.

Family RHIPIDOMELLIDAE

Genus DINORTHIS Hall and Clarke

DINORTHIS (PLAESIOMYS) PLATYS (Billings)

Plate XXXVIII, Figs. 6-8

Orthis platys Billings, 1859, Canadian Nat. and Geol., vol. iv, p. 438, fig. 15.
Dinorthis platys Schuchert, 1897, Bull. U. S. Geol. Surv., 87, p. 216.
Plaesiomys platys Raymond, 1911, Ann. Carnegie Mus., vol. vii, No. 2, p. 238, pl. xxxv, figs. 13, 14.

Description.—"Pedicle valve fairly high and convex on the umbo, flat or only slightly convex in front. Brachial valve nearly flat, usually showing a shallow sinus on the umbo. Surface marked by fairly coarse striae, which increase by implantation. There are usually three or four in the space of 2 mm. on the front of the shell. The interior of the pedicle valve shows a small muscle area under the beak, composed of two strong diductor scars, and between them two very narrow adductor scars. Delthyrium narrow. No specimen has been seen which was so preserved as to retain the deltidium. In the brachial valve there is a low median septum. Other details could not be made out."—Raymond, 1911.

Occurrence.—STONES RIVER LIMESTONE (Middle division). Maugansville, Maryland.

The types occurred in the Chazyan at Montreal, Canada. In the Lake Champlain area this fossil occurs in the Crown Point or middle division of the Chazyan. In east Tennessee it is found in the supposedly equivalent horizon—the Lenoir limestone.

Collections.—Maryland Geological Survey, U. S. National Museum.

DINORTHIS PECTINELLA (Emmons)

Plate XLV, Figs. 8, 9

Orthis pectinella Emmons, 1842, Geol. New York, Rep. 2d Dist., p. 394, fig. 2.
Dinorthis pectinella Hall and Clarke, 1892, Pal. New York, vol. viii, pt. 1, pp. 195, 222, 228, pl. v, figs. 27-33.
Orthis (*Dinorthis*) *pectinella* Winchell and Schuchert, 1893, Geol. Minnesota, vol. iii, p. 424, pl. xxxii, figs. 31-34.
Dinorthis pectinella Weller, 1903, Geol. Surv. New Jersey, Pal., vol. iii, p. 154, pl. ix, figs. 29, 30.

Description.—"Shell resupinate, transversely subelliptical in outline, wider than long, in about the proportion of four to three; cardinal line is usually less than the greatest width of the shell, the cardinal extremities rounded; surface of each valve marked by from 22 to 30 prominent, rounded, simple costae, which are equal in width to the spaces between, and are crossed by fine, closely crowded elevated, concentric lines of growth. Pedicle valve slightly convex near the beak, flattened on the sides, with a broad, shallow, ill-defined depression along the center, usually most distinct in front, but frequently nearly obsolete. Cardinal area moderately large and well defined, flat, lying nearly at right angles to the plane of the shell. Brachial valve regularly convex, most prominent in the center, flattened and slightly deflected near the cardinal extremities. Cardinal area much narrower than that of the opposite valve, lying nearly in the plane of the shell.

"The dimensions of the nearly perfect pedicle valve are: Length, 21 mm.; width, 27.5 mm."—Weller, 1903.

Occurrence.—CHAMBERSBURG LIMESTONE (Echinospherites bed). Wilson and Pinesburg, Maryland.

This species occurs in the Upper Black River and Early Trenton of New York and Canada, and the Ohio and Mississippi valleys.

Collections.—Maryland Geological Survey, U. S. National Museum.

Genus PIANODEMA Foerste

PIANODEMA SUBAEQUATA (Conrad)

Plate XLV, Figs. 1-3

Orthis subaequata Conrad, 1843, Proc. Acad. Nat. Sci. Philadelphia, vol. i, p. 333.

Dalmanella subaequata Hall and Clarke, 1892, Pal. New York, vol. viii, pt. 1, pp. 194, 207, 224, pls. 5c, figs. 6-11.

Orthis (Dalmanella) subaequata Winchell and Schuchert, 1893, Geol. Minnesota, vol. iii, p. 446, pl. xxxiii, figs. 30-36.

Dalmanella subequata Weller, 1903, Geol. Surv. New Jersey, Pal., vol. iii, p. 156, pl. x, figs. 3, 4.

Description.—"Shell subequally biconvex, usually wider than long; the hinge-line shorter than the greatest width of the shell, except sometimes in young individuals; cardinal extremities angular or rounded. Surface of each valve marked by numerous, fine, tubulose striae, which bifurcate about twice in passing from the beak to the anterior margin. Pedicle valve strongly and evenly convex, the greatest elevation posterior to the middle of the shell; near the beak and upon the umbo no medial depression exists, but near the middle of the valve a broad, shallow and indistinct sinus begins and becomes deeper toward the anterior margin. The cardinal area is well defined, broadly triangular, elevated and only moderately concave; the delthyrium, with slightly curved sides, is about twice as high as wide. Brachial valve more evenly, but a little less convex than the pedicle, the greatest elevation near the middle. Near the beak the mesial portion of the shell is usually flattened or slightly depressed, but near the middle of the shell this flattening gradually changes into a low, broad, ill-defined elevation, corresponding with the sinus of the pedicle valve. The cardinal area is narrow and concave, with a delthyrium as broad or broader than high. The dimensions of an average specimen are: Breadth, 16 mm., and length, 14 mm."—Weller, 1903.

Occurrence.—CHAMBERSBURG LIMESTONE (Echinospherites bed). Pinesburg Station, Maryland, and various localities in southern Pennsylvania. Stones River group of Tennessee and the Black River group of Minnesota, etc.

Collections.—Maryland Geological Survey, U. S. National Museum.

Superfamily STROPHOMENACEA

Family STROPHOMENIDAE

Genus STROPHOMENA Blainville

STROPHOMENA STOSEI n. sp.

Plate XXXVII, Figs. 1-4

Description.—This brachiopod, which is the most frequent fossil of the few species discovered in the Frederick limestone is known from both brachial and pedicle valves, although none show the hinge line clearly. Its general shape is that of *Strophomena sinuata* James of the Cincinnatian rocks, but *S. stosei* differs conspicuously in the occurrence of several fine radiating striae between each of the larger coarse ones. The interior of the brachial valve in each of these species seems to be quite alike and the reference of this new species of *Strophomena* to the *S. sinuata* group appears to be warranted.

The specific name is in honor of George W. Stose, of the U. S. Geological Survey, who helped collect the type specimens.

Occurrence.—FREDERICK LIMESTONE. Just east of Frederick, Maryland.

Collections.—Maryland Geological Survey, U. S. National Museum.

STROPHOMENA SCULPTURATA n. sp.

Plate XLIX, Fig. 1

Description.—Although this new species belongs to a group of brachiopods not uncommon in the faunas of eastern North America, all of these species happen to be new, so that comparison is not necessary. It is the only brachiopod in the Middle Ordovician limestone with such a highly sculptured shell and for that reason will be easily recognized. Between each of the very distinct radiating ridges there are five or six smaller radiating striae visible only under a lens. Transverse to these radiating striations are concentric, squamose ridges of growth quite similar to those obtaining in *Leptaena charlottae.* In the latter respect the group of species is related to *Leptaena,* but other features suggest *Strophomena.*

An average specimen is 10 mm. high and 13 mm. wide.

Occurrence.—MARTINSBURG SHALE (Sinuites bed). Pennsylvania. The type specimens are from one mile south of St. Thomas.

Collections.—Maryland Geological Survey, U. S. National Museum.

STROPHOMENA HALLIE (S. A. Miller)

Plate LIV, Figs. 7-9

Streptorhynchus ? hallie Miller, 1874, Cincinnati Quart. Jour. Sci., vol. i, p. 148, figs. 14-16.

Strophomena hallie Foerste, 1914, Bull. Sci. Lab. Denison Univ., vol. xvii, p. 38, pl. ii, figs. 1a-e.

Description.—" Shell sub-trigonal in outline, concavo-convex, deflected laterally, resupinate, rather thin and frail; hinge scarcely equalling the greatest breadth of the valves; length and breadth about three-fourths of an inch.

" Dorsal valve convex in the central part, flattened on the umbone and deflected laterally; surface marked by moderately coarse, radiating striae, which increase by intercalation of smaller ones; area linear, beak not distinct from the edge of the area. Interior showing cardinal process to be very small and divided into two teeth-like parts, directed a little forward and flattened on their faces; socket-ridges small, short, and oblique; mesial ridge scarcely perceptible without a magnifier, radiating striae plainly visible.

" Ventral valve moderately concave in the central and anterior regions, but slightly convex at the beak, which is perforated and projects slightly beyond the edge of the area; surface marked by radiating striae, which increase by even bifurcations; area narrow and sloping laterally; foramen closed by a rounded deltidium for the reception of the cardinal teeth of the dorsal valve. Interior showing trigonal hinge and circular cavity; marked by radiating striae."—Miller, 1874.

Occurrence.—MARTINSBURG SHALE (Eden division). Jordans Knob one and one-half miles northeast of Fort Loudon, and Tuscarora Mountain, two and one-half miles southeast of McConnellsburg, Pennsylvania. Eden shale at Cincinnati, Ohio.

Collection.—U. S. National Museum.

STROPHOMENA SINUATA James

Plate LIV, Figs. 10-14

Strophomena sinuata James, 1871, Cat. Fossils, Cincinnati group, p. 9.
Strophomena (Hemipronites) sinuata Meek, 1873, Pal. Ohio, vol. i, p. 87, pl. 15, fig. 5a-g.
Strophomena sinuata Foerste, 1912, Bull. Sci. Lab. Denison Univ., vol. xvii, p. 57, pl. i, figs. 3a-d.

Description.—" Shell semicircular, or forming rather more than a semicircle, moderately convex, with valves nearly equal, the dorsal being most convex in the central and anterior regions, and the ventral near the umbo; hinge nearly or quite equalling the greatest breadth; lateral margins forming more or less nearly right angles with the hinge line; or sometimes rounding a little to the same, and rounding regularly to the front, which forms a semicircular curve, with rarely a slight sinuosity at the middle.

" Dorsal valve, flat at the beak, which is not distinct from the cardinal margin, usually a little raised in the middle at the front, so as to form a low, broad, undefined medial prominence; cardinal area narrow and inclined backward; interior with a low, small, deeply bipartite cardinal process, from which diverge three small ridges, the two lateral of which extend obliquely outward to form the margins of the rather well-defined sockets for the reception of the teeth of the other valve, while the third ridge is central, and extends a short distance forward; muscular scars not visible in any specimen examined.

" Ventral valve moderately convex at the umbo, which is not very prominent or arched, and has a minute perforation at the apex; front with usually a broad, shallow, undefined depression; lateral regions more or less nearly flat; cardinal area well developed, tapering to the lateral extremities, flat, and inclined more or less obliquely backward; foramen closed by a prominent, triangular deltidium; interior showing small, somewhat saucer-shaped cavity, formed by the low, sharp dental laminae, extending forward from the inner side of the rather well-developed oblique cardinal teeth, and curving a little toward each other, without meeting at their inner ends; muscular scars not visible in any specimens examined.

"Surface of both valves ornamented with rather coarse radiating striae, most of which bifurcate once or oftener, while occasionally a shorter one is intercalated between two longer; crossing the whole, occasional small marks of growth, and finer but obscure, concentric striae may be seen, by the aid of a lens, on well-preserved specimens.

"Length of a rather large specimen, 0.65 inch; breadth, 0.88 inch; convexity, 0.30 inch."—Meek, 1873.

Occurrence.—MARTINSBURG SHALE (Eden division). Jordans Knob, one and one-half miles northeast of Fort Loudon, and Tuscarora Mountain, two and one-half miles southeast of McConnellsburg, Pennsylvania.

This species has hitherto been recorded only from the upper part of the Fairview formation in the Ohio Valley.

Collections.—Maryland Geological Survey, U. S. National Museum.

Genus PLECTAMBONITES Pander

PLECTAMBONITES PISUM Ruedemann

Plate XLVIII, Figs. 1-7

Plectambonites pisum Ruedemann, 1902, Bull. New York State Museum, No. 49, p. 19, pl. i, figs. 8-20.

Description.—"Shell small, semicircular in outline, with subauriculate cardinal extensions; highly concavo-convex, the convexity surpassing that of a hemisphere; toward the cardinal ears becoming depressed convex; length to width as 4 : 5; greatest width along the hinge line, which is nearly straight. Surface marked with very fine striae, which usually are interrupted by from 16 to 20 coarse striae; sometimes the fine striae become nearly obsolete, leaving the interspace between the coarse striae almost smooth; at other times the coarse striae disappear, leaving the shell uniformly and finely striated; a few concentric growth lines are also present. Pedicle valve extremely gibbous, the greatest elevation being in the central part; the unbonal part sloping abruptly; the umbo being protuberant and projecting beyond the cardinal line; anterior and lateral slopes less abrupt, near the margins turning suddenly into a flatter border. Cardinal area moderately elevated, concave, delthyrium large, of equal width and length; no deltidium observed. Teeth small, supported by strong, diverging dental lamellae, which continue in outward direction into the much elevated margin of the diductor muscles; this margin extends about one-fourth the length of the valve, and then returns under an acute angle including a very deep pyriform muscle pit. The muscle margins are separated by a distinct septum, which extends to near the anterior margin; from the anterior part of the muscular impressions extend strongly marked vascular trunks which are tri- or quadripartite and inclose between them a narrow elongate depressed area. Brachial valve concave in the middle part, closely following the curvature of the pedicle valve with a well-defined ridge all around the lateral and anterior margin. Cardinal area as high as that of the pedicle valve, and also slightly concave, retrorse, with a large chilidium, somewhat concave in the middle. Cardinal process single and erect and, by the coalescence with the divergent, short, crural plates, appearing distinctly trilobate at the posterior end, similarly to *P. sericeus,* with the difference, however, that the posterior ends of the crural plates are not closely appressed to the cardinal process, but separate again a little, forming processes almost as prominent as and parallel to the cardinal process. Adductor scars shallow, broadly triangular, extending not quite to the middle of the shell, slightly divergent, inner margins formed by two ridges, branching from the crural processes and extending to near the anterior margin; outer somewhat indented margin of the muscular impressions greatly elevated as in *P. gibbosus* Winchell and Schuchert.

"Dimensions: Length, 8.5 mm.; width, 10.2 mm.; height, 5.5 mm."—Ruedemann, 1902.

Occurrence.—CHAMBERSBURG LIMESTONE (Christiania bed). Pennsylvania, Maryland, and Virginia.

Rysedorph conglomerate at base of Trenton, New York.

Collections.—Maryland Geological Survey, U. S. National Museum.

PLECTAMBONITES RUGOSUS (Meek)

Plate LIV, Figs. 31-33

Leptaena sericea var. *rugosa* Meek, 1873, Pal. Ohio. vol. i, pt. 2, pl. v, figs. 3f-h.

Plectambonites rugosa Foerste, 1912, Bull. Sci. Lab. Denison University, vol. xvii, p. 123, pl. i, figs. 7a-c; pl. x, figs. 7a-d.

Description.—The form of *Plectambonites* found so abundantly in the Eden shales of the Cincinnati area was long ago separated by Meek as a variety of the ubiquitous species *P. sericea.* "The term *rugosa* was given not on account of the oblique wrinkles along the hinge-line, but on account of the roughened surface of the general exterior surface of the valves, especially anteriorly. This roughened surface appears due to the presence of numerous very thin overlapping films of shell material. These films appear to consist of the same extremely fine, silky, fibrous material as that forming the compact body of the valves. Sometimes they are traversed by the same radiating striae as those seen on that part of the exterior surface of the valves where the films are not present. The films may be more or less discrete from one another, but in some specimens they are built up into a solid mass, resulting in a thickening of the valves exteriorly. At the exterior margin of the pedicle valve, this thickening may reach a total of fully 2 mm., and frequently the anterior, more or less vertical slope of this thickening is crossed by lines evidently corresponding to the extensions of the radiating striae. The thickening usually is confined to the anterior half or third of the valves. It may result in a succession of concentric bands, the one nearest the anterior margin being the most conspicuous. At other times, the thickening increases evenly, without any concentric banding, but, most frequently it is more or less irregular, the films being more or less warped or broken into shreds."—Foerste, 1912.

Occurrence.—MARTINSBURG SHALE (Eden division). Jordans Knob, one and one-half miles northeast of Fort Loudon, Pennsylvania, and in the same horizon on Rickard Mountain, Maryland. Eden shale of the Ohio Valley.

Collections.—Maryland Geological Survey, U. S. National Museum.

Genus CHRISTIANIA Hall and Clarke

CHRISTIANIA TRENTONENSIS Ruedemann

Plate XLVIII, Figs. 16-18

Christiania trentonensis Ruedemann, 1902, Bull. New York State Mus., No. 49, p. 21, pl. ii, figs. 2-6.

Description.—" Shell small, convexo-concave, somewhat variable in shape, rotundo-quadrate to rotundo-rectangular; sides sub-parallel or slightly converging to the cardinal line; front rounded. Hinge line straight, only slightly shorter than the greatest width of the valve in the middle part; cardinal extremities obtusely angular, having the appearance of flattened ears. Pedicle valve uniformly and strongly convex; umbo slightly projecting and very narrow; beak obscure. Cardinal area narrow (?); interior of pedicle valve not observed. Brachial valve strongly concave, beak hardly projecting beyond the long, straight hinge line. Cardinal extremities strongly developed, flat; area very small, cardinal process small, bipartite on its anterior face; the lobes being denticulate anteriorly with from three to five small denticles on each side. Crural plates very long and slightly divergent; the lower portion produced on each side as a strongly elevated wall with perpendicular sides extending in the original direction of the crural plates close to the ante-lateral angle, where it recurves and returns, parallel to the median axis and nearly in a straight line as a still more prominent wall merging into the base of the cardinal process. The elongate, symmetric, sub-rectangular spaces thus formed are each divided transversely by a vertical ridge about one-third of the length of the valve from the cardinal line. The long narrow space between the inner muscular walls is also bounded anteriorly by a low, rounded, curving ridge and divided in the median line of the shell by a low, rounded, longitudinal ridge. The anterior half of the surface of the long anterior adductors is very rugose and radially striated.

" The surface is covered with concentric lines of growth and radiating quite widely separated, filiform striae with smooth, flat, interspaces."—Ruedemann, 1902.

Occurrence.—CHAMBERSBURG LIMESTONE (Christiania bed). Appalachian Valley of Pennsylvania, Maryland, and Virginia.

Rysedorph conglomerate at base of Trenton, New York.

Collections.—Maryland Geological Survey, U. S. National Museum.

CHRISTIANIA LAMELLOSA n. sp.

Plate XLIX, Figs. 3-10

Description.—The strongly lamellose surface of this brachiopod is sufficient reason for discriminating it from all other described species of the genus. The general outline of the shell is not unlike several small shells of the Chambersburg and early Trenton rocks referred to both *Christiania* and *Plectambonites,* but the interior of the valve shows the characteristic markings of the former genus. The pedicle valve is strongly convex and bears the concentric lamellae almost to the beak. The brachial valve is as strongly concave, with a smooth surface. The average shell is 9 mm. high and about 10 mm. wide.

Occurrence.—MARTINSBURG SHALE (Sinuites bed). Southern Pennsylvania; also abundant at the same horizon in northern Virginia, the types being from Strasburg.

Collections.—Maryland Geological Survey, U. S. National Museum.

Genus LEPTAENA Dalman

LEPTAENA CHARLOTTAE Winchell and Schuchert

Plate XLI, Figs. 11-13

Leptaena charlottae Winchell and Schuchert, 1892, Amer. Geol., vol. ix, p. 288.

Leptaena charlottae Winchell and Schuchert, 1893, Geol. Minnesota, vol. iii, p. 410, pl. xxxii, figs. 1-5.

Strophomena halli Sardeson, 1892, Bull. Minnesota Acad. Nat. Sci., vol. iii, p. 334, pl. iv, figs. 36, 38.

Description.—"Shell small, transversely semioval, plano-convex, geniculate, with the sides slightly convex and converging to the broadly rounded front, or drawn out tongue shaped; hinge-line as long as, or somewhat shorter than, the greatest width of the shell. Surface marked by fine, closely crowded, alternating striae, as in *Rafinesquina alternata,* crossed by exceedingly delicate concentric lines and over the central flat disc of each valve by more or less continuous zigzag undulations or wrinkles.

"Ventral valve depressed-convex over the greater portion of the shell and more or less suddenly bent downward or geniculated along the margin, especially anteriorly. Cardinal area wide, broadly triangular, with a convex deltidium, wider than long, apically perforated by a rather large pedicle opening, posteriorly excavated and completely occupied by the chilidium of the other valve. Crenulated hinge teeth prominent and supported by short dental plates, which are attached to the elevated outer margin of the small, transversely oval muscular area. Within this area, in the center of the mesial thickening, are placed the short and narrow adductors, surrounded by the large diductors, and outside these, at the base of the dental plates, are the distinct scars of the small adjustors. Surface marked by delicate, crowded papillae, strongest in front of the muscular area, and in the thin shells by the wrinkling of the outer surface.

"Dorsal valve nearly flat, with the anterior margin more or less reflexed downward. Cardinal area narrow, about one-third that of the other valve, with a broad and strongly convex chilidium. Dental sockets deep; crural plates slender, very bilobed, cordate cardinal process; in front of this is a short, low septum separating the inconspicuous septa. Just inside the outer margin of the valve is situated a prominent, rounded ridge of the same nature as that in *L. rhomboidalis.*"—Winchell and Schuchert, 1893.

Leptaena charlottae differs conspicuously from all other American species of the genus in its zigzag, concentric surface corrugations.

Occurrence.—CHAMBERSBURG LIMESTONE (Caryocystites bed). Fort Loudon and Blue Spring, Franklin County, Pennsylvania.

The type specimens were described from the Decorah shales division of the Black River at Minneapolis and St. Paul, Minnesota.

Collections.—Maryland Geological Survey, U. S. National Museum.

LEPTAENA GIBBOSA (James)

Plate LIV, Fig. 25

Strophomena gibbosa James, 1874, Cincinnati Quart. Jour. Sci., vol. i, p. 333.
Leptaena gibbosa Foerste, 1909, Bull. Sci. Lab. Denison Univ., vol. xiv, p. 316.
Leptaena gibbosa Foerste, 1912, Idem., vol. xvii, p. 116, pl. i, figs. 5a-c.

Description.—"Shell fragile, semi-oval; cardinal line extended to or a little beyond the width of the shell farther forward, deflected at the extremities; lateral and front margins regularly rounded. Ventral valve slightly convex in the umbonal region, but at about one-third or one-half the distance from the beak, toward the front and lateral margins, it curves suddenly upward, then rounds off, and is deflected as suddenly the other way to the front and sides, forming a high rounded ridge, giving to the shell a decidedly gibbous form; this hump extends to about 1/8th of an inch of the cardinal line on each side, where the shell is rather depressed from the umbonal slopes outwards to the deflected extremities immediately in front of the cardinal line; cardinal area linear; beak rather prominent, projecting, minutely perforated; six to eight slight wrinkles on the umbonal region. Surface covered by fine radiating striae, increased by interstitial additions, somewhat variable in size on the front slope, but quite uniform on the umbone and to the lateral margins; crossed by fine concentric striae. Interior not observed.

"Dorsal valve (exterior) gently concave to about the middle, where it makes a sudden curve, conforming to the shape of the other valve; the two valves are so closely drawn together as to leave scarcely any visceral space; beak very little elevated above the cardinal line; area no more than a rather sharp edge of the hinge; radiating striae, as far as observed same as on the ventral valve. Interior nearly flat, or slightly convex to the base of the ridge, in front and laterally to within about one-quarter or one-eighth of an inch of the cardinal line, where there is a flat depression extending to the lateral margins; the curve to the front from the top of this ridge is abrupt, corresponding to the exterior; cardinal process bifid, erect, rather prominent, curving slightly anteriorly, crenulated posteriorly and sloping in the same direction; socket ridges short, crenulated, oblique; rounded, low, wavy elevations just beyond the points and in front of the socket ridges; a small but rather deep pit immediately in front of the cardinal process, from which extends a low mesial ridge to about the middle of the shell forwards, where it fades out; the concentric wrinkles of the exterior show through slightly, and the radiating striae plainly, with small, but distinct, radiating rows of papillae, which are rather distant from each other, to the ridge, but crowded together on the front slope and toward the lateral margins; no muscular scars observed.

"Width of a specimen of medium size, measuring from the points of the hinge-line, 1⅛ inches; length about three-fourths of an inch."—James, 1874.

Occurrence.—MARTINSBURG SHALE (Eden division). Jordans Knob, one and one-half miles northeast of Fort Loudon, Pennsylvania. Eden shale of the Ohio Valley.

Collections.—Maryland Geological Survey, U. S. National Museum.

LEPTAENA TENUISTRIATA Sowerby var.

Plate XLIX, Fig. 2

Leptaena tenuistriata Sowerby, 1839, in Murchison's Sil. Syst., vol. ii, p. 636, pl. xxii, fig. 2a.

Leptaena tenuistriata Foerste, 1910, Bull. Sci. Lab. Denison Univ., vol. xvi, p. 45, pl. v, fig. 9.

Description.—The particular form of *Leptaena* found in the Sinuites bed of southern Pennsylvania is in general aspect quite like specimens from a similar lower Trenton horizon in Tennessee identified by Foerste as *L. tenuistriata* Sowerby. Direct comparison with typical British specimens is necessary before the identity of the American form can be determined with certainty. In the meantime it is believed best to record the Sinuites zone species as a variety.

Occurrence.—MARTINSBURG SHALE (Sinuites bed). One mile south of St. Thomas and other localities in southern Pennsylvania.

Collection.—U. S. National Museum.

Genus RAFINESQUINA Hall and Clarke

RAFINESQUINA CHAMPLAINENSIS Raymond

Plate XLI, Figs. 8, 9

Rafinesquina champlainensis Raymond, 1902, Bull. Amer. Pal., vol. iii, p. 37, pl. xviii, figs. 5, 6.

Rafinesquina champlainensis Raymond, 1911, Ann. Carnegie Mus., vol. vii, p. 233, figs. 6-9.

Description.—"Shell large, ventricose, almost hemispheric. Length and width nearly equal. Hinge line usually a little longer than the width below, and the cardinal extremities are produced into broad, rounded ears. The pedicle valve is strongly and evenly convex, the highest point being about the middle of the valve. The brachial valve is flat on the umbo and concave in front, following the curvature of the opposite valve. Cardinal area on the pedicle valve rather wide. Delthyrium covered by a broad convex deltidium. Area of brachial valve linear. The surface is marked by very numerous fine radiating striae, every third or fourth one of which is stronger than the ones between. The striae increase by implantation. In the partially exfoliated state in which the specimens are usually found, the striae appear nearly equal and the shell structure fibrous."—Raymond, 1902.

Occurrence.—CHAMBERSBURG LIMESTONE (Caryocystites bed). Fort Loudon and Blue Spring, Franklin County, Pennsylvania.

In the type localities in the Lake Champlain area, this species occurs in the Middle Chazy (Crown Point) limestone. It has been identified in the stratigraphically equivalent Lenoir limestone of east Tennessee and Virginia.

Collection.—U. S. National Museum.

RAFINESQUINA MINNESOTENSIS (Winchell)

Plate XLV, Fig. 4

Strophomena deltoidea Owen (not Conrad), 1844, Geol. Expl. Iowa, Wisconsin and Illinois, pl. xvi, fig. 8; pl. xvii, fig. 6.

Strophomena minnesotensis N. H. Winchell, 1881, Ninth Ann. Rept. Geol. Nat. Hist. Surv. Minnesota, p. 120.

Rafinesquina minnesotensis Hall and Clarke, 1892, Pal. New York, vol. viii, pt. 1, pl. 31, figs. 25-29.

Rafinesquina minnesotensis Winchell and Schuchert, 1893, Geol. Minnesota, vol. iii, p. 401, pl. xxxi, figs. 25-29.

Description.—" Shell semi-oblong or semi-oval, with the cardinal angle about 90, or less than 90; diameter from six to nine lines transversely, and from four and a half to eight lines perpendicularly; the ventral valve convex, sometimes more suddenly deflected after passing the visceral area; dorsal valve gently concave, but reflexed more rapidly about the margin; the exterior of the convex, ventral valve marked by fine, radiating striae, every third, fourth or fifth one being larger than the intervening ones; interior of the convex (ventral) valve, which is best known from its frequent casts, shows a large muscular impression somewhat bilobate in front and larger in proportion to the size of the valve; scars of adductor muscles closely approximate, small and in many casts of this valve undistinguishable; behind they are separated (on the casts) by a short mesial ridge, which between them becomes a narrow mesial furrow and then a deep furrow, terminating at the sinus between the outer larger scars; the outer larger scars (diductors) are radiately striated from the beak (at the base of the dental lamellae small adjustors are occasionally indicated); their margins are strongly marked (on the cast) along their posterior sides by distinct grooves formed by the dental plates, which diverge at once from the foramen at an angle of 100-1200, running nearly straight to the outer margins of the muscular scar, when they curve slightly towards the front; the anterior and lateral margins of the general muscular impression are slightly marked on the casts; outside of the muscular scar is a shallow marginal impressed line which is most evident at the cardinal angles as it converges toward the beak; the interior edge of the cardinal line is carinate from the teeth to the cardinal angles; the details of the markings in the apex of the beak are seen on the valve itself to consist of two short, distinct, diverging ridges extending not much beyond the hinge teeth (enclosing the adductor scars), between the anterior ends of which rises a short mesial ridge of about the same size and length, with faint linear ridges parallel with it on each side, which extend a little further forward than the mesial ridge. The mesial ridge first gives place to a flat, unmarked interval, when it again rises more conspicuously, but narrower and sharper, extending nearly to the sinus separating the lobes of the outer muscular scar. The cardinal area of the convex valve slopes from the hinge-line obliquely backward, instead of being in plane with the lateral edges, thus differing from *R. alternata.* From three to five undulations of the shell transverse to the cardinal line are seen often between the umbo and the cardinal angles, the heavier ones being near the cardinal angles. The cardinal process is bifid and prominent, the two parts being short, smooth, dentate protruberances that stand prominently exposed about parallel with the plane of the cardinal area.

"The interior of the dorsal valve is very different from that of the dorsal valve of *R. alternata.* The general visceral disc is nearly flat, surrounded by a suddenly flexed margin, inside of which is a shallow impressed broad line, most evident round the front; inside the cardinal angles are a few scattered, radiately interrupted, short ridges or elevations (genital markings), but these do not prevail along the side nor in front, the surface there being smooth or finely granulated instead; in the center of the valve are five smooth, abrupt, digitately spreading ridges, the middle one of which is a little larger and longer than the others; these rise more abruptly at their anterior extremities than behind, but none of them reach the beak, or even the umbonal region, though the exterior pair of lateral ones are placed further back than the others, converging at an angle of about 700 (and often pass through the large pair of adductor scars). Socket (crural) ridges very short and widely divergent; behind them are small, doubly grooved sockets. The beak of the ventral valve is often perforated by a minute, circular, pedicle opening."—Winchell and Schuchert, 1893.

Occurrence.—CHAMBERSBURG LIMESTONE (Echinosphærites bed). Wilson and Pinesburg Station, Maryland. A characteristic Black River species of the Mississippi Valley.

Collections.—Maryland Geological Survey, U. S. National Museum.

RAFINESQUINA MINNESOTENSIS INQUASSA (Sardeson)

Plate XLV, Figs. 5, 6

Strophomena inquassa Sardeson, 1892, Bull. Minnesota Acad. Nat. Sci., vol. iii, p. 334, pl. v, figs. 22-24.

Rafinesquina minnesotensis var. *inquassa* Winchell and Schuchert, 1893, Geol. Minnesota, vol. iii, p. 403, pl. xxxi, figs. 27, 28.

Description.—The brachiopod to which this varietal name has been applied differs from *R. minnesotensis* in its larger and more convex shell with a wide ventral hinge area. Externally this shell also has a considerable resemblance to *R. alternata,* but the interiors of each exhibit considerable difference, the two ridges on each side of the median septum in the present variety being reduced to one in *R. alternata.*

Occurrence.—CHAMBERSBURG LIMESTONE (Echinospherites bed). Southern Pennsylvania and at Pinesburg Station and Wilson, Maryland.

Collections.—Maryland Geological Survey, U. S. National Museum.

RAFINESQUINA SQUAMULA (James)

Plate LIV, Figs. 3-4; Plate LVIII, Fig. 4

Strophomena squamula James, 1874, Cincinnati Quart. Jour. Sci., vol. i, p. 335.

Rafinesquina squamula Foerste, 1914, Bull. Sci. Lab. Denison Univ., vol. xvii, p. 264.

Description.—" Shell small, thin, semi-oval in outline, broader than long; hinge-line varying from a little more to a little less than the greatest breadth of the shell farther forward.

" Dorsal valve slightly convex or nearly flat; cardinal line straight; cardinal area linear; a slight depression immediately forward of the beak. Surface covered with fine, rounded radiating striae of nearly uniform size, increased toward the free margin by bifurcation.

" Ventral valve slightly convex; beak and hinge-line slightly projecting; cardinal area narrow, a little the widest in the middle; foramen triangular and nearly closed by the cardinal process of the other valve; a strong mesial rib extending from beak to the front; surface covered by fine, rounded, radiating striae, which bifurcate once or twice before reaching the free margins; the striae starting at and near the beak more prominent than the branching ones; crossed by very fine concentric lines, visible only under a good magnifier, and even then in some cases quite obscure. Visceral space very little, the valves being so closely drawn together, translucent. Interior not observed. Breadth of a full-sized specimen, 5/8 inch; length, 1.2 inch."—Foerste, 1914.

Although hitherto unfigured the species has long been known as an interesting shell of the Cincinnati area where it occurs at several horizons in the Eden shale and in the Fairview formation of the Maysville group. The above description was based upon the type specimens and the examples illustrated were identified by the author of the species.

Occurrence.—MARTINSBURG SHALE (Eden division). Jordans Knob, one and one-half miles northeast of Fort Loudon, Pennsylvania, and in sandstone fragments on Rickard Mountain, Washington County, Maryland.

The Orthorhynchula bed at the top of the Fairview division of the Martinsburg shale, just under the Oswego sandstone, one and one-half miles southeast of McConnellsburg Pennsylvania, has furnished numerous specimens.

Collections.—Maryland Geological Survey, U. S. National Museum.

RAFINESQUINA ALTERNATA (Emmons)

Plate LVII, Fig. 8

Strophomena alternata Emmons, 1842, Geol. New York, Rept. 2d Dist., p. 395, fig. 3.

Leptaena alternata Hall, 1847, Pal. New York, vol. i, pp. 102, 286, pl. xxxi, fig. 1; pl. xxxiA, fig. 1; pl. lxxix, fig. 2.

Rafinesquina alternata Hall and Clarke, 1892, Pal. New York, vol. viii, pt. 1, p. 282, pl. viii, figs. 6-11, 27, 28; pt. 2, 1895, pl. lxxxiv, figs. 17, 18.

Description.—"Broadly semioval; length and breadth about as 12 to 15; hinge line, in perfect specimens, a little longer than the width of the shell, slightly reflected at the extremities, which sometimes become short, acute ears; cardinal area narrow, the callosity of the ventral valve nearly filling the triangular foramen of the dorsal valve; beak uniformly perforated with a minute circular opening; dorsal valve depressed convex, sometimes more convex in the middle, suddenly deflected near the margin and flattened towards the cardinal line; ventral valve concave, gradually or sometimes suddenly inflected towards the basal margin; surface marked by fine rounded radiating striae, which alternate at unequal intervals with coarser ones; striae increasing in number towards the margin of the shell, crossed by fine elevated concentric lines and a few imbricating lines of growth."—Hall, 1847.

This very abundant brachiopod has such a long range that it is of little value for detailed stratigraphic purposes, although it is true that the varieties or mutations of the species which occur at various horizons hold their characters fairly well if minute discriminations are made. The illustrations represent the common Maysville form of the species occurring in the Pulaski shale of New York. The same form occurs at the corresponding horizon in Pennsylvania and Maryland.

Occurrence.—MARTINSBURG SHALE (Fairview division). Tuscarora Mountain, one and one-half miles southwest of McConnellsburg, Pennsylvania.

Collections.—Maryland Geological Survey, U. S. National Museum.

Genus TRIPLECIA Hall

TRIPLECIA (CLIFTONIA) SIMULATRIX n. sp.

Plate XLIX, Figs. 11-13

Description.—The strata of the Chambersburg limestone succeeding the Lowville division and the Sinuites bed at the base of the Martinsburg shale, contain a radially plicated brachiopod which is so similar to small examples of *Platystrophia* that its references to that genus would seem proper. However, upon close examination this new species is found to have the characteristic bifurcated cardinal process of *Triplecia* and to lack the surface granulations of *Platystrophia*. The open delthyrium of *Platystrophia* is also absent, but the deltidium of the Strophomenidae is present.

This species belongs to the genus or subgenus *Cliftonia* established by Foerste for the plicated forms of *Triplecia,* which was well described as *Oxoplecia* by Miss Alice Wilson. *Triplecia* (*Cliftonia*) *simulatrix* is related to *Oxoplecia calhouni* Wilson, from the base of the Collingwood (Trenton) shale of Ottawa, Canada, but differs in its coarser plication, this feature being most marked on the sides of the shell.

Occurrence.—MARTINSBURG SHALE (Sinuites bed). One mile south of St. Thomas, Pennsylvania, and at Strasburg, Virginia. The species occurs also in the Echinospherites, Nidulites, and Christiania beds of the Chambersburg limestone in Pennsylvania, Maryland, and Virginia.

Collections.—Maryland Geological Survey, U. S. National Museum.

Superfamily PENTAMERACEA

Family SYNTROPHIIDAE

Genus SYNTROPHIA Hall and Clarke

SYNTROPHIA LATERALIS (Whitfield)

Plate XXXIII, Figs. 4, 5

Triplesia lateralis Whitfield, 1886, Bull. Amer. Mus. Nat. Hist., p. 303, pl. xxiv, figs. 9-11.

Syntrophia lateralis Hall and Clarke, 1892, Pal. New York, vol. viii, pt. 1, p. 270; ibid., vol. viii, pt. 2, p. 216, pl. lxii, figs. 1-10.

Syntrophia lateralis Weller, 1903, Geol. Surv. New Jersey, Pal., vol. iii, p. 126, pl. iv, figs. 14, 15.

Syntrophia lateralis Walcott, 1912, Mon. U. S. Geol. Surv., vol. li, p. 802, text fig. 11, p. 299; pl. cii, figs. 6, 6a-g.

Description.—Shell averaging 7.5 mm. in length and 11 mm. wide, subelliptical, with the hinge-line about two-thirds the greatest width and the cardinal extremities rounded. Pedicle valve somewhat convex, prominent on the umbo, but a little flattened near the cardinal angles; beak slightly incurved and rather blunt, projecting beyond the cardinal margin; mesial sinus broad, shallow, and ill-defined, not extending to the beak. Surface with fine, concentric lines of growth.

Occurrence.—BEEKMANTOWN LIMESTONE (Cryptozoon steeli zone). At various localities around Williamsport and Hagerstown, Maryland.

Collections.—Maryland Geological Survey, U. S. National Museum.

Family CLITAMBONITIDAE

Genus SCENIDIUM Hall

SCENIDIUM ANTHONENSE Sardeson

Plate XLVII, Figs. 1-3

Scenidium anthonensis Sardeson, 1892, Bull. Minnesota Acad. Nat. Sci., vol. iii, p. 333, pl. iv, fig. 7.

Scenidium halli Hall and Clarke, 1892, Pal. New York, vol. viii, pt. 1, p. 242, pl. viiA, figs. 33-39.

Scenidium anthonensis Winchell and Schuchert, 1893, Geol. Minnesota, vol. iii, p. 381, pl. xxx, figs. 20-23.

Scenidium anthonensis Weller, 1903, Geol. Surv. New Jersey, Pal., iii, p. 157, pl. x, figs. 5-7.

Description.—" Shell small, subsemi-circular in outline, the greatest width along the hinge-line. Each valve marked by from 20 to 26 simple, rounded plications. Pedicle valve subpyramidal, the beak erect; cardinal area large, flat, broadly triangular, with a large delthyrium. Along the median line a slight elevation or ill-defined fold is developed. In the interior of the apical portion of the valve is a small spondylium. Brachial valve depressed, convex, with a slight mesial sinus. The dimensions of an average specimen are: Length, 2.5 mm., and breadth, 5 mm."—Weller, 1903.

Occurrence.—CHAMBERSBURG LIMESTONE (Nidulites bed). Wilson and Pinesburg Station, Maryland.

Black River group of Minnesota, Iowa and New Jersey.

Collections.—Maryland Geological Survey, U. S. National Museum.

SCENIDIUM ? MEROPE (Billings)

Plate L, Figs. 14-16

Orthis merope Billings, 1865, Geol. Surv. Canada, Pal. Fossils, vol. i, p. 139, fig. 116.

Scenidium ? merope Hall and Clarke, ? 1892, Pal. New York, vol. viii, pt. 1, p. 242, pl. viiA, figs. 31, 32.

Description.—Shell small, subpyramidal, somewhat semi-circular, with a width to the hinge-line of 6 mm. and a length of 3 mm.; cardinal angles acute, from 60° to 70°; exterior surface marked with 25 to 30 strong radiating striae. Ventral valve elevated, subpyramidal, most elevated at the beak, thence sloping nearly uniformly to the sides and margin; area large, triangular, at right angles to the plane of the margin; foramen large, extending to the beak. Dorsal valve nearly flat, with an obscure mesial sinus.

This interesting little brachiopod is somewhat similar to several small striated forms, and a restudy of the types is necessary before its true generic characters can be determined. The shell from Cincinnati, Ohio, figured by Hall and Clarke in 1892, is very probably of a distinct species.

Occurrence.—MARTINSBURG SHALE (Sinuites bed). Chambersburg, Pennsylvania. Trenton limestone at Ottawa, Canada.

Collection.—U. S. National Museum.

Family PORAMBONITIDAE

Genus PARASTROPHIA Hall and Clarke

PARASTROPHIA HEMIPLICATA Hall

Plate XLVIII, Figs. 8-11

Atrypa hemiplicata Hall, 1847, Pal. New York, vol. i, p. 144, pl. xxxiii, fig. x.

Anastrophia ? hemiplicata Winchell and Schuchert, 1893, Geol. Minnesota, vol. iii, p. 382, pl. xxx, fig. 29-31.

Parastrophia hemiplicata Hall and Clarke, 1893, Pal. New York, vol. viii, pt. 2, p. 221, pl. lxiii, figs. 1-3.

Parastrophia hemiplicata Weller, 1903, Geol. Surv. New Jersey, Pal., vol. iii, p. 158, pl. x, figs. 11-14.

Parastrophia hemiplicata Wilson, 1914, Canada Geol. Surv. Mus. Bull. No. 2, pp. 1-10, pl. iv, figs. 1-34.

Description.—" Shell subglobose, subpentagonal in outline, wider than long, the thickness frequently equal to the length. Cardinal line short, with sometimes the appearance of a small area on the pedicle valve. Each valve marked by from 8 to 12 simple, subangular, radiating plications, which reach from one-third to one-half the distance from the margin to the beak, leaving the older portion of each valve smooth. Besides the radiating plications, the entire surface is marked by fine, concentric, subimbricating lines of growth, which are more conspicuous near the margin of the shell. Pedicle valve depressed-convex, with an abrupt, broad, but not deep sinus, which originates about one-third of the distance from the beak to the anterior margin and is produced as a lingual extension in front at nearly a right angle to the plane of the valve; it is marked by from three to five radiating plications. The beak is small, closely incurved; delthyrium small and triangular. Brachial valve strongly convex or gibbous, with a broad mesial fold commencing one-third of the distance from the beak to the anterior margin, which is marked by from four to six radiating plications.

"The dimensions of a perfect individual are: Length, 13 mm.; width, 16.5 mm.; thickness, 12.5 mm."—Weller, 1903.

Occurrence.—CHAMBERSBURG LIMESTONE (Christiania bed). Southern Pennsylvania. Trenton limestone of New York, New Jersey, etc.

Collections.—Maryland Geological Survey, U. S. National Museum.

Order TELOTREMATA

Superfamily RHYNCHONELLACEA

Family RHYNCHONELLIDAE

Genus CAMAROTOECHIA Hall and Clarke

CAMAROTOECHIA PLENA (Hall)

Plate XLI, Figs. 14-16

Atrypa plena Hall, 1847, Pal. New York, vol. i, p. 21, pl. iv, figs. 7.
Camarotoechia plena Raymond, 1911, Ann. Carnegie Mus., vol. vii, p. 221, pl. xxxiii, figs. 7-18.

Description.—"The adult shells are subtriangular to subcircular in outline, with a wide, shallow ventral sinus and a somewhat elevated dorsal fold. Surface marked by from 17 to 24 strong plications, four to seven of which are in the sinus and five to eight on the fold. The plications are crossed by zigzag lines of growth, which are sometimes stronger and sometimes weaker on partially exfoliated specimens than of specimens with perfect shells. The dorsal beak is strongly incurved, and the umbo bears a slight median depression. The beak of the pedicle valve is only slightly incurved, and does not rest against the brachial valve. The delthyrium is open throughout life. None of the specimens in the collection show the deltidial plates.

"Casts of the interior of the brachial valve show a low septum which extends about one-third the length of the shell. This septum divides at its posterior end as in the typical species of *Camarotoechia,* but there is no cardinal process as in *Rhynchotrema.*"—Raymond, 1911.

One of the most abundant and characteristic Upper Chazyan (Valcour) fossils of the Lake Champlain region in New York and in Canada.

Occurrence.—CHAMBERSBURG LIMESTONE (Caryocystites bed). In the strip of outcrop from Fort Loudon to Blue Spring, Franklin County, Pennsylvania.

Collections.—Maryland Geological Survey, U. S. National Museum.

Genus ORTHORHYNCHULA Hall and Clarke

ORTHORHYNCHULA LINNEYI (James)

Plate LVII, Figs. 9-12

Orthis ? linneyi James, 1881, Paleontologist, vol. v, p. 41.
Orthorhynchula linneyi Hall and Clarke, 1893, Pal. New York, vol. viii, pt. 2, p. 181, pl. lvi, figs. 10-13, 19.

Description.—"Shells rhynchonelloid in contour; hinge-line short, straight, extending for about one-third the transverse diameter of the valves. A true cardinal area is present on both valves, that of the pedicle-valve being considerably the broader, erect, often incurved. Each valve also possesses a distinct triangular delthyrium, that of the pedicle-valve, according to the evidence at hand, never being in any degree closed by deltidial plates. External surface strongly and simply plicated, the median fold and sinus being well developed. On the interior, the pedicle-valve possesses blunt teeth which rest upon the laterally thickened walls of the valve and are not supported by lamellae. Between, and slightly in front of these lies a short, subquadrate muscular scar. The brachial valve possesses a linear cardinal process, on either side of which are two discrete crural plates, sharply concave on the upper surface and diverging anteriorly for a considerable distance. Shell-substance fibrous, impunctate."—Hall and Clarke, 1893.

Although occurring at two distinct geological horizons this interesting brachiopod, when considered with the associated fossils, is highly characteristic of each horizon. The species is so well developed at the top of the Fairview formation of the Maysville group that the name Orthorhynchula bed has been applied to these strata. In this bed the species often grow to an unusual size, some examples being an inch or more in length.

Occurrence.—MARTINSBURG SHALE (Fairview division). Tuscarora Mountain, one and one-half miles southeast of McConnellsburg, Pennsylvania. Upper Trenton of Kentucky and Tennessee, Lower Maysville of the Ohio Valley, Virginia, Maryland, and Pennsylvania.

Collections.—Maryland Geological Survey, U. S. National Museum.

Genus ZYGOSPIRA Hall

ZYGOSPIRA RECURVIROSTRIS (Hall)

Plate XLII, Figs. 9-12

Atrypa recurvirostris Hall, 1847, Pal. New York, vol. i, p. 140, pl. xxxiii, fig. 5.

Zygospira recurvirostris Winchell and Schuchert, 1893, Geol. Minnesota, vol. iii, p. 466, pl. xxxiv, figs. 38-41.

Zygospira recurvirostris Hall and Clarke, 1895, Pal. New York, vol. viii, pt. 2, pl. liv, figs. 1-6.

Zygospira recurvirostris Weller, 1903, Geol. Surv. New Jersey, Pal., vol. iii, p. 161, pl. x, figs. 23-26.

Description.—"Shell small, subcircular or longitudinally subovate in outline, subglobular; surface of both valves marked by 24 to 28 rounded or subangular, radiating plications, which are crossed by fine, concentric lines of growth. Pedicle valve gibbous, with its greatest elevation near the center, subcarinate near the beak, the keel becoming broader toward the front and forming a rather well-defined, more or less flat-topped median fold; beak small and pointed, incurved over the beak of the brachial valve. Brachial valve less convex than the other, marked by a rather broad, shallow, rounded median sinus, which corresponds with the fold of the pedicle valve and which reaches nearly to the beak. The dimensions of an average specimen are: Length, 6 mm.; width, 6 mm.; thickness, 4 mm."—Weller, 1903.

An abundant species in its various forms, in the Black River and Trenton rocks of New York and Canada and the Ohio and Mississippi valleys.

Occurrence.—CHAMBERSBURG LIMESTONE (Tetradium cellulosum bed). Railroad cut two miles southwest of Marion and at Fort Loudon, Franklin County, Pennsylvania, where the Lowville form occurs in some abundance.

Collections.—Maryland Geological Survey, U. S. National Museum.

ZYGOSPIRA EXIGUA (Hall)

Plate XLVIII, Figs. 19, 20

Atrypa exigua Hall, 1847, Pal. New York, vol. i, p. 141, pl. xxxiii, fig. 6.
Protozyga exigua Hall and Clarke, 1893, Pal. New York, vol. viii, pt. 2, p. 149, figs. 137, 138, pl. liv, figs. 47, 48.

Description.—" Plano-convex; length and breadth about equal; cardinal line considerably extended; dorsal valve elevated in a ridge along the middle, depressed at the sides, and slightly inflected towards the cardinal extremities; beak small, straight, much extended beyond the cardinal line; ventral valve considerably shorter than the dorsal, depressed-convex, with a broad depression along the center, reaching half way from the base to the beak; beak small, and close pressed into the foramen beneath the beak of the opposite valve; surface scarcely marked with fine concentric lines, and a few indistinct longitudinal rays near the margin.

" In the largest specimen which I have seen, there are evidences, under a magnifier, of small radii commencing below the center of the valve. Since, however, they are not perceptible to the naked eye, they are of minor importance, unless it should be found that this is the young of a species which changes with growth. The specimens yet seen, however, are minute, and it may properly be doubted whether the species attains a size beyond the largest figures given. The valves are often close pressed, and deflected at the margin."—Hall, 1847.

Occurrence.—CHAMBERSBURG LIMESTONE (Christiania bed). Greencastle and other localities in southern Pennsylvania. Trenton limestone of New York.

Collection.—U. S. National Museum.

ZYGOSPIRA MODESTA (Hall)

Plate LIV, Figs. 20-22; Plate LVII, Figs. 13-16

Atrypa modesta (Say) Hall, 1847, Pal. New York, vol. i, p. 141, pl. xv, fig. 15.
Zygospira modesta Meek, 1873, Pal. Ohio, vol. i, p. 125, pl. ii, fig. 4.
Zygospira modesta Winchell and Schuchert, 1893, Geol. Minnesota, vol. iii, p. 465, pl. xxxiv, figs. 42-44.
Zygospira modesta Hall and Clarke, 1893, Pal. New York, vol. viii, pt. 2, p. 155, figs. 146-149; pl. liv, figs. 7-10, 12.

Description.—" Shell small, rather depressed, nearly plano-convex, suborbicular, or straightened and converging to the beaks at an obtuse angle; lateral margins more or less rounded; front rounded, or sometimes a little straightened, or very slightly sinuous at the middle.

" Dorsal valve with a rather shallow, undefined mesial sinus of moderate breadth at the front, but becoming rapidly narrower, and less impressed posteriorly, so as often to die out before reaching the umbo; surface on each side of the sinus gently convex centrally, and sloping gradually to the lateral margins; beak but slightly prominent and incurved.

" Ventral valve, with a low mesial ridge, corresponding to the sinus of the other valve, excepting that it is generally most prominent near the middle, and somewhat depressed anteriorly; while on each side of the ridge the slopes are distinctly compressed; beak small, abruptly pointed, projecting beyond that of the other valve, and rather distinctly arched; but not so closely incurved as to conceal the small fissure, which seems to be closed below by a deltidium, that leaves a minute aperture above, just under, or extending to, the apex; margin on each side of beak carinated, so as to give the appearance of a kind of false cardinal area.

"Surface of each valve ornamented by about 16 to 18 small, simple, radiating plications, of which about three to five near the front of the dorsal valve occupy the mesial sinus, the middle one being usually a little the largest; while on the ventral valve about four of the largest occupy the mesial prominence, the furrow between the middle two being generally a little larger and deeper than the others; marks of growth undefined, or extremely minute and obscure. Length of a mature, moderately large specimen, 0.26 inch; breadth, 0.30 inch; convexity, 0.15 inch."—Meek, 1873.

An abundant Cincinnatian fossil at many localities in the United States and Canada. In Maryland and Pennsylvania the species occurs in the upper part (Eden) of the Martinsburg shale and in the succeeding Fairview formation.

Occurrence.—MARTINSBURG SHALE (Eden Division). Rickard Mountain and Fairview Mountain, Washington County, Maryland.

Collections.—Maryland Geological Survey, U. S. National Museum.

ZYGOSPIRA ? ERRATICA (Hall)

Plate LVII, Figs. 17-23

Orthis ? erratica Hall, 1847, Pal. New York, vol. i, p. 288, pl. lxxix, fig. 5.
Catazyga erratica Hall and Clarke, 1893, Pal. New York, vol. viii, pt. 2, p. 158, pl. liv, figs. 17-23.

Description.—"Subhemispherical, orbicular; dorsal valve very convex, with the mesial portion abruptly elevated, flat above; ventral valve convex at the sides, depressed in the middle, and considerably elevated in front; surface marked by fine simple uniform striae."—Hall, 1847.

This species is readily distinguished from *Zygospira modesta* with which it is associated, by its larger size, greater convexity, and especially by the numerous fine striae. A characteristic fossil of the Pulaski shales of New York and Canada.

Occurrence.—MARTINSBURG SHALE (Fairview division). Tuscarora Mountain, one and one-half miles southeast of McConnellsburg, Pennsylvania.

Collections.—Maryland Geological Survey, U. S. National Museum.

VERMES

Order TUBICOLA

Genus CORNULITES Schlotheim

CORNULITES FLEXUOSUS (Hall)

Plate LVI, Fig. 18

Tentaculites ? flexuosa Hall, 1847, Pal. New York, vol. i, p. 92, pl. xxix, figs. 6a-d, p. 284, pl. lxxviii, figs. 2a, b.
Cornulites flexuosus Hall, 1888, Pal. New York, vol. vii, Supp. 1; p. 18, pl. cxv, figs. 41, 42.

Description.—"Tubes single or aggregate, adhering, more or less curved at the tip or along the whole length; surface marked by strong annulations somewhat irregular; interior distinctly septate; septa with the concave sides upwards."—Hall, 1847.

Occurrence.—MARTINSBURG SHALE (Eden division). Jordans Knob, one and one-half miles northeast of Fort Loudon, Pennsylvania, and Tuscarora Mountain, two and one-half miles southeast of McConnellsburg, Pennsylvania.

Collections.—Maryland Geological Survey, U. S. National Museum.

WORM BURROWS (?)

Genus SCOLITHUS Haldemann

SCOLITHUS LINEARIS (Haldemann)

Plate XXV, Fig. 9

Fucoides ? linearis Haldemann, 1840, Supp. Monograph Limniades, p. 3.
Scolithus linearis Hall, 1847, Pal. New York, vol. i, p. 2, pl. i, figs. 1a-1c.
Scolithus linearis Walcott, 1890, 10th Ann. Rep. U. S. Geol. Surv., p. 603, pl. lxiii, figs. 1, 1a-c.

Description.—The pencil-like fillings of the worm burrows to which the above name is applied have a wide distribution in the arenaceous Cambrian rocks of Eastern North America. The species is determined in large part by its geological position and by the diameter of the tubes. *Scolithus linearis* forms free cylindrical or subcylindrical, unbranched, vermiform tubes with their surface usually smooth, but sometimes apparently striated. Their form is rigidly straight and they range in length from several inches to a foot or more. The diameter varies between one-eighth to one-half an inch.

These tubes preserve their distinctness under almost all conditions and they often stand out quite clearly in the rock.

Occurrence.—HARPERS SHALE AND ANTIETAM SANDSTONE. In Maryland this species has been identified at Eakles Mills and other localities, particularly in the drift blocks along the west front of the Blue Ridge. Widely distributed in the Cambrian of Pennsylvania, New York, Virginia, Canada, etc.

Collections.—Maryland Geological Survey, U. S. National Museum.

MOLLUSCA

CLASS PELECYPODA

Order PRIONODESMACEA

Family CTENODONTIDAE

Genus CTENODONTA Salter

CTENODONTA GIBBERULA Salter

Plate XLII, Figs. 18-20

Ctenodonta gibberula Salter, 1857, Canadian Org. Rem. Dec. I, p. 38, pl. viii, fig. 6.

Tellinomya ventricosa Meek and Worthen, 1868, Geol. Surv. Illinois, vol. iii, p. 307, pl. ii, figs. 7a-c.

Ctenodonta gibberula Ulrich, 1894, Geol. Minnesota, Pal., vol. iii, pt. 2, p. 587, pl. xlii, fig. 37, text figs. 44f-g, p. 599.

Description.—"Shell rhombic subovate, ventricose, the height, length and thickness, respectively, as seven, ten, and six, with large incurved beaks, situated a little behind the mid-length; antero-dorsal and ventral margins subparallel, the posterior end obliquely truncate above the narrow and sharply rounded lower part; anterior end broadly rounded and continuing into the basal margin; the latter is straight or very gently sinuate and ascends from the prominently rounded anterior part; posterior umbonal ridge inconspicuous in a lateral view, rather sharply defined, however, in a dorsal view by a narrow furrow which outlines a wide lanceolate flattened area, equally divided by the hinge line, and in the upper part of which (immediately behind the beaks) the ligament is attached to distinct fulcra; anterior dorsal slope abruptly rounded; entire anterior half of valves strongly ventricose, while between this part and the posterior umbonal ridge a slight sulcus crosses from near the beak to the base. Surface marked by rather distinct, closely arranged, subequal concentric striae of growth, tending to irregularity in the basal parts of old shells.

"Impressions of adductor muscles extremely deep, the anterior pair larger than the posterior. A small, though distinct, pedal muscle scar is always present on the upper part of the strong ridge which forms the inner boundary of the anterior adductor (in casts it lies at the bottom of the deep cavity produced by this ridge), but the corresponding posterior scar is rarely distinguishable. Hinge plate very narrow at the beaks, but widening rapidly on each side, the anterior half somewhat the stronger and slightly concave along its inner margin, both terminating abruptly at the muscular scars; denticles 12 behind and 10 or 11 in front, those near the beaks very small, all interlocking deeply, especially those of the anterior set, which are also somewhat larger than the posterior. The shell is very thick and the rostral filling so considerable that in casts of the interior the beaks appear obtuse and widely separated."—Ulrich, 1894.

A characteristic Black River species of Canada, New York, and the Ohio and Mississippi valleys..

Occurrence.—CHAMBERSBURG LIMESTONE (Tetradium cellulosum bed). Fort Loudon, Franklin County, Pennsylvania.

Collections.—Maryland Geological Survey, U. S. National Museum.

CTENODONTA OBLIQUA Hall

Plate LIV, Figs. 17-19

Nucula obliqua Hall, 1845, Amer. Jour. Sci., vol. xliii, p. 292.
Tellinomya ? obliqua Meek, 1873, Pal. Ohio, vol. i, p. 139, pl. xi, figs. 11a-c.
Ctenodonta obliqua Ulrich, 1894, Geol. Minnesota, vol. iii, pt. 2, p. 604, pl. xlii, figs. 83-87.

Description.—" Shell very small, compressed, subcircular, approaching subquadrangular; height and breadth about equal; anterior margin short and rounding or less rounded; beaks elevated, nearer the anterior margin; dorsal margin sloping from the beaks, the anterior slope being the more abrupt, and the margin behind the beaks straighter, more compressed and sharper; surface smooth; internal casts showing the muscular impressions to be comparatively rather distinct. Hinge unknown. Length, 0.06 inch; height slightly less; convexity, 0.03 inch."—Meek, 1873.

As indicated above, the hinge of this small pelecypod is unknown, as no specimens have ever been found preserving the shell structure. Like *Cyclora minuta* and other dwarfed gastropods and pelecypods, the species occurs only as phosphatized casts or as molds in the rock. Such casts of *C. obliqua,* however, occasionally show a denticulated margin along the hinge line such as would be left by the denticles of a species of *Ctenodonta.*

This abundant small pelecypod was described from specimens found at Cincinnati, Ohio, but it ranges in age from the Trenton to and through the Richmond and occurs in many states.

Occurrence.—MARTINSBURG SHALE (Eden division). Jordans Knob, one and one-half miles northeast of Fort London, Pennsylvania.

Collections.—Maryland Geological Survey, U. S. National Museum.

CTENODONTA FILISTRIATA Ulrich

Plate LIV, Figs. 26-29

Ctenodonta filistriata **Ulrich, 1894, Geol. Minnesota, vol. iii, pt. 2, p. 599, figs. 44a-e.**

Description.—This species has usually been identified with the Trenton species *Ctenodonta levata* Hall, but it may be distinguished from this and similar forms by the delicate, crowded, thread-like concentric lines which cover the entire surface. Twelve to twenty of these lines may be counted in a space 1 mm. wide. This surface ornamentation in connection with the subovate forms of the shell and the rows of denticles on the hinge, causes the species to be easily recognized.

Occurrence.—MARTINSBURG SHALE (Eden division). Jordans Knob, one and one-half miles northeast of Fort Loudon, Pennsylvania. Eden shale at Cincinnati, Ohio.

Collection.—U. S. National Museum.

Family LEDIDAE

Genus CLIDOPHORUS Hall

CLIDOPHORUS PLANULATUS (Conrad)

Plate LIV, Fig. 37

Nuculites planulata Conrad, 1841, 5th Ann. Rept. New York Geol. Surv., p. 50.

Cleidophorus planulatus Hall, 1847, Pal. New York, vol. i, p. 300, pl. lxxxii, figs. 9a-e.

Description.—" Shell transversely elliptical oblong, height about half the length of the shell, with the beak approximately a third of the length of the shell from the anterior end. Umbonal ridge low, distinctly defined along its cardinal border where it makes an angle of 162 to 165 degrees with the longitudinal axis of the shell. Above this umbonal ridge, the posterior cardinal slope of the shell is flattened and subalate. The posterior part of the hinge-line extends from the beak for a distance equalling about two-fifths the length of the shell, and then makes an angle of about 150 degrees with the posterior margin of the shell. The margin is rather strongly rounded at both the posterior and anterior ends of the shell, the maximum curvature of the anterior margin, however, being nearer the hinge-line. The basal margin is moderately and evenly convex. The clavicular adductor support anterior to the beak forms an angle of about 80 degrees with the longitudinal axis of the shell; it is comparatively straight and extends downward to about the middle height of the shell; it is sharp and narrow, appearing on the cast of the interior of the shell as a sharp incision not depressing the immediately adjoining part of the shell. The convexity of the shell is moderate, that of a shell 9 mm. in height being about 1.6 mm. Specimens 20 mm. in length occur."—Foerste, 1914.

Occurrence.—Martinsburg Shale (Eden division). Rickard Mountain, Washington County, Maryland. Eden shale and Maysville group of New York and Ohio.

Collection.—U. S. National Museum.

Family CYRTODONTIDAE

Genus ISCHYRODONTA Ulrich

Ischyrodonta unionoides (Meek)

Plate LVIII, Figs. 2, 3

Anodontopsis ? unionoides Meek, 1871, Amer. Jour. Sci., vol. ii, p. 299.
Anodontopsis (*Modiolopsis ?*) *unionoides* Meek, 1873, Pal. Ohio, vol. i, p. 141, pl. xii, figs. 2a, b.
Ischyrodonta unionoides Ulrich, 1893, Geol. Surv. Ohio, vol. vii, p. 677, pl. liv, figs. 1-3.
Ischyrodonta curta Foerste, 1914, Bull. Sci. Lab. Denison Univ., vol. xvii, p. 298, pl. iii, fig. 14.

Description.—" Shell of medium size, subovate, a little the highest posteriorly, compressed, convex, thickest slightly above and in advance of the middle. Anterior margin regularly but rather narrowly rounded; base forming a broad semielliptic curve; posterior margin broadly rounded, very slightly oblique; dorsal outline more or less strongly arcuate, passing gradually into the ends. Beaks small, compressed, projecting very little beyond the hinge margin, placed between one-fourth and one-fifth of the length of the valves behind the anterior extremity; umbonal ridge scarcely distinguishable. Surface showing only a few distinct subimbricating marks of growth.

" Hinge comparatively weak for the genus, with one oblique cardinal tooth in the right valve and two (?) in the left. The ridge-like internal ligament support leaves a linear depression within the dorsal edge extending posteriorly from the beak for a distance equaling about one-third of the length of the shell. Anterior adductor and pedal muscle attachments having the characters usual for the genus, except that they are, with respect to the beaks, more anterior in position for the reason that the anterior end is uncommonly long."—Ulrich, 1893.

Occurrence.—MARTINSBURG SHALE. (Top of the Fairview Orthorhynchula bed) just under the Oswego sandstone on Tuscarora Mountain, one and one-half miles southeast of McConnellsburg, Pennsylvania. Top of the Fairview or base of the McMillan formation at Cincinnati, Ohio. Pulaski shales of New York and Canada.

Collections.—Maryland Geological Survey, U. S. National Museum.

Family AMBONYCHIIDAE

Genus BYSSONYCHIA Ulrich

BYSSONYCHIA VERA (Ulrich)

Plate LIV, Figs. 34-36

Byssonychia vera Ulrich, 1893, Geol. Surv. Ohio, vol. vii, p. 629, figs. a-c.
Ambonychia cincinnatiensis Miller and Faber, 1894, Jour. Cincinnati Soc. Nat. Hist., vol. xvii, p. 24, pl. i, figs. 8-10.

Description.—This species is quite similar to *Byssonychia radiata* (Hall), the type of the genus, and in fact is frequently identified with it, but *B. vera* differs in its smaller size, finer striae (there being about 50 to from 37 to 40 in the typical form of that species), shorter hinge line, more evenly convex valves, and shorter byssal opening.

Occurrence.—MARTINSBURG SHALE (Eden division). Southern Pennsylvania, and in the sandstone debris of Rickard Mountain, Maryland. Eden shale of the Ohio Valley.

Collections.—Maryland Geological Survey, U. S. National Museum.

BYSSONYCHIA RADIATA (Hall)

Plate LVII, Fig. 26

Ambonychia radiata Hall, 1847, Pal. New York, vol. i, p. 292, pl. lxxx, figs. 4a-l.
Ambonychia radiata Hall and Whitfield, 1875, Geol. Surv. Ohio, Pal., vol. ii, p. 79, pl. ii, fig. 2.
Byssonychia radiata Ulrich, 1897, Geol. Minnesota, vol. iii, pt. 2, p. 477, fig. 35VI.
Byssonychia radiata Foerste, 1914, Bull. Sci. Lab. Denison Univ., vol. xvii, p. 273, pl. iii, figs. 12a-c.

Description.—" Shell small to medium sized, varying in outline from subquadrangular, with a rounded base, to acutely ovate, according to the degree of obliquity of the body of the shell to the direction of the hinge-line. Surface of the shell ventricose, and often subcarinate on the umbones and towards the beaks, gradually and somewhat regularly sloping to the basal margin, becoming attenuate and compressed toward the postero-cardinal region, and abruptly truncate and even impressed on the anterior side. Beaks acutely pointed, strongly incurved, terminal and projecting above the line of the hinge; posterior end at right angles to the hinge straight or rounded, or sometimes sloping obliquely backwards to the postero-basal margin; base sharply rounded. Anterior border of the valves excavated below the beaks, forming a rather large byssal opening, which is usually about half as wide as long when the valves are united.

"Surface of the valves marked by strong, radiating ribs, which are simple throughout, strongest on the body of the shell, and becoming finer on the postero-cardinal region. On the upper portion of the shell the ribs are flattened on the top, and often grooved in the center, giving them a strongly duplicate character, but becoming smooth below, the spaces between as narrow, or much narrower, than the width of the rib. The ribs are crossed by fine, concentric, imbricating lines of growth, which undulate as they cross the elevation."—Hall and Whitfield, 1875.

Occurrence.—MARTINSBURG SHALE (Fairview division). Tuscarora Mountain, one and one-half miles southeast of McConnellsburg, Pennsylvania. Maysville group of the Ohio Valley and Canada.

Collections.—Maryland Geological Survey, U. S. National Museum.

BYSSONYCHIA PRAECURSA Ulrich

Plate LVII, Figs. 28, 29

Byssonychia praecursa Ulrich, 1893, Geol. Surv. Ohio, vol. vii, p. 633, pl. xlv, figs. 1, 2.

Description.—In outline and number of costae this species is quite similar to *Byssonychia radiata* with which it is associated, but it is less oblique, the hinge is longer, and the central part of the valve is somewhat narrower. The marked difference between the two, however, lies in the flattening of the anterior side in *B. praecursa*.

Occurrence.—MARTINSBURG SHALE (Fairview division). Tuscarora Mountain, one and one-half miles southeast of McConnellsburg, Pennsylvania. A characteristic fossil of the Pulaski shale of New York and of the corresponding horizon (Fairview division of the Maysville group) in the Ohio Valley.

Collection.—U. S. National Museum.

Genus ALLONYCHIA Ulrich

ALLONYCHIA OVATA Ulrich

Plate LVII, Fig. 27

Allonychia ovata Ulrich, 1893, Geol. Surv. Ohio, vol. vii, p. 642, pl. xlviii, figs. 4-6.

Description.—Shell large, 55 mm. in length and 36 mm. wide, subovate but almost erect, strongly convex. Hinge line short not alated posteriorly with the beaks large, incurved and not terminal. Surface marked with 40 to 45 radially arranged costae. Hinge line short, edentulous, with a high ligamental area.

A fairly well preserved cast in sandstone from Tuscarora Mountain, Pennsylvania, exhibited all the characters of this well-marked species.

Occurrence.—MARTINSBURG SHALE (Fairview division). Tuscarora Mountain, one and one-half miles southeast of McConnellsburg, Pennsylvania. Upper part of Fairview formation at Covington, Kentucky.

Collection.—U. S. National Museum.

Family AVICULIDAE

Genus PTERINEA Goldfuss

PTERINEA (CARITODENS) DEMISSA (Conrad)

Plate LVII, Fig. 24

Avicula demissa Conrad, 1842, Jour. Acad. Nat. Sci. Philadelphia, vol. viii, p. 242, pl. xiii, figs. 3.

Avicula demissa Hall, 1847, Pal. New York, vol. i, p. 292, pl. lxxxix, fig. 2a, b.

Pterinea demissa Hall and Whitfield, 1875, Geol. Surv. Ohio, Pal., vol. ii, p. 78, pl. ii, fig. 1.

Caritodens demissa Foerste, 1914, Bull. Sci. Lab. Denison Univ., vol. xvii, p. 269, pl. i, figs. 10, pl. 3, fig. 11.

Description.—"Shell subrhomboidal in outline, with the basal margin rounded; hinge-line much longer than the body of the shell; anterior wing extended into a rather long, acute point, when perfect, forming nearly one-third of the length of the hinge, measured from the point of the beak; posterior wing large, rather obtusely pointed, and extending as far as the body of the shell below; body of the shell oblique, a line drawn from the beak to the center of the .base forming an angle with the posterior hinge-line of about 65 or 70 degrees; posterior margin of the shell broadly and roundly, but not deeply, excavated between the posterior wing and the postero-basal extremity of the shell; basal margin rather sharply rounded; anterior margin obliquely sloping from the hinge-line, being nearly parallel with the body of the shell; very slightly excavated below the anterior alation. Left valve strongly convex when not compressed, prominent and rounded in the center, but flattened and slightly concave toward the alations; beak small, extending but little above the hinge-line; flattened or depressed convex on the umbo. Right valve concave, the concavity not exceeding one-half of the convexity of the opposite valve, and usually somewhat shorter on the basal portion.

"Surface of the convex valve marked by regular, concentric, lamellose lines, the edges of which are sharply elevated when well preserved, giving an exceedingly roughened character to the surface. In the degree of this latter feature, as also in the relative distance of the lines, there is considerable variation in different individuals. Surface of the concave valve distinctly lamellose, but the precise features have not been very clearly determined, as no very good specimens of this valve have been examined." —Hall and Whitfield, 1875.

A detailed description of this species, particularly of the shell structure, was given by Foerste in 1914, but the above-quoted description applies better to the specimens as found in the Cumberland Valley of Maryland and Pennsylvania.

Occurrence.—MARTINSBURG SHALE (Fairview division). Tuscarora Mountain, one and one-half miles southeast of McConnellsburg, Pennsylvania. Not uncommon in the Maysville and Richmond groups of the Ohio Valley, New York, and Canada.

Collections.—Maryland Geological Survey, U. S. National Museum.

Family LYRODESMIDAE

Genus LYRODESMA Conrad

LYRODESMA CONRADI Ulrich

Plate LIV, Fig. 30

Lyrodesma conradi Ulrich, 1893, Geol. Surv. Ohio, vol. vii, p. 684, pl. xlvii, fig. 9.

Description.—" Shell a little oblique, transversely subovate, somewhat the highest across the middle of the posterior end; length 15 to 22 mm., height 11.5 to 15 mm., thickness about half the height; just beneath the middle of the slightly oblique posterior margin, the outline is a little produced and more narrowly rounded than elsewhere. Valves moderately convex, the posterior umbonal ridge rounded, not a prominent feature, the beaks small, situated just within the anterior third of the length. Surface marked by very fine, closely arranged, sharp concentric lines, crossed on the posterior cardinal slope by about ten radiating striae. Hinge with seven teeth of the usual type in each valve. Adductor scars distinct, the posterior one rather small and situated a very short distance beneath the submarginal pedal muscle impression. Pallial line with a small though undeniable posterior sinus. A peculiar feature of internal casts is the broad and shallow furrow shown in the figure just in front of the umbonal ridge."—Ulrich, 1893.

Occurrence.—MARTINSBURG SHALE (Eden division). Jordans Knob, one and one-half miles northeast of Fort Loudon, Pennsylvania. Eden shale at Cincinnati, Ohio.

Collection.—U. S. National Museum.

Family MODIOLOPSIDAE

Genus MODIOLOPSIS Hall

MODIOLOPSIS MODIOLARIS (Conrad)

Plate LVIII, Fig. 12

Pterinea modiolaris Conrad, 1838, 2d Ann. Rept. Geol. Surv. New York, p. 118.

Modiolopsis modiolaris Hall, 1847, Pal. New York, vol. i, p. 294, pl. 81, figs. 1a-g; pl. lxxxii, fig. 1.

Modiolopsis modiolaris Foerste, 1914, Bull. Sci. Lab. Denison Univ., vol. xvii, p. 281, pl. iii, fig. 1; pl. v, figs. 1, 2.

Description.—" Shell obliquely oblong. The cardinal margin posterior to the beak nearly straight, rounding gradually into the oblique posterior margin. Anterior to the beak, the cardinal margin is deflected downward, and then rounds into the strongly curved anterior margin of the shell. Basal margin straight along that part of the shell which lies directly opposite the straight cardinal margin; rising gradually toward the curved anterior margin, and more rapidly towards the posterior margin, which is most curved at the posterior extremity of the umbonal ridge. Umbonal ridge most strongly defined on the cardinal side and within about 10 or 15 mm. from the beak, almost disappearing into the general convexity of the shell posteriorly. Mesial sinus practically obsolete, although occasional specimens show a very faint indication of the same accompanied by a scarcely perceptible concavity of the basal outline. General convexity of the shell small. Concentric striations best defined anteriorly, along that part of the shell which is anterior to the oblique umbonal ridge. Anterior adductor depressions large and distinctly defined, although usually very shallow, owing to the thinness of the shell. The interior of one of the valves is faintly striated posteriorly, below the umbonal ridge, in a direction parallel to a line drawn from the posterior termination of the umbonal ridge to a point half way between the beak and the upper anterior margin of the shell."—Foerste, 1914.

Numerous references have been made to this species in the literature and it has undoubtedly been misidentified many times. The only serious study of this pelecypod is that in 1914 by Foerste whose description is quoted above. *Modiolopsis modiolaris* as restricted by Foerste is a guide fossil of the Pulaski shale in New York and in the corresponding horizons southward in the Appalachians and west to the Ohio Valley.

Occurrence.—MARTINSBURG SHALE (Fairview division). Tuscarora Mountain, one and one-half miles southeast of McConnellsburg, Pennsylvania.

Collections.—Maryland Geological Survey, U. S. National Museum.

Genus MODIOLODON Ulrich

MODIOLODON TRUNCATUS (Hall)

Plate LVII, Fig. 25

Modiolopsis truncatus Hall, 1847, Pal. New York, vol. i, p. 296, pl. lxxxi, figs. 3a, b.

Modiolopsis truncatus Hall and Whitfield, 1875, Geol. Surv. Ohio, Pal., vol. ii, p. 86, pl. ii, fig. 13.

Modiolodon truncatus Ulrich, 1893, Geol. Surv. Ohio, vol. vii, p. 656, pl. li, figs. 9, 10.

Description.—" Shell below the medium size; shortly ovate in outline, the widest part being about one-third of the entire length from the posterior end. Valves compressed, or depressed convex, most prominent near the center. Beaks small and closely compressed, scarcely projecting beyond the line of the hinge. Anterior margin rather shortly rounded, the extremity extending but little beyond the beaks; basal margin gently and regularly curving; posterior end more broadly rounded than the anterior and most abruptly at the postero-basal portion; above, it slopes more gradually backwards to the extremity of the hinge line, with which it unites without forming any perceptible angle.

" Surface of the valves marked by irregular, rather strong, concentric lines of growth.

" The internal casts—the condition in which the species is usually found in the softer parts of the formation—show a large, elongate posterior muscular scar, situated a little within the postero-cardinal margin, and parallel with it; also a smaller lunate anterior scar, and an entire pallial line."—Hall and Whitfield, 1875.

Occurrence.—MARTINSBURG SHALE (Fairview division). Tuscarora Mountain, one and one-half miles southeast of McConnellsburg, Pennsylvania. Pulaski shale near Rome, New York.

Collection.—U. S. National Museum.

Genus ORTHODESMA Hall and Whitfield

ORTHODESMA NASUTUM (Conrad)

Plate LVIII, Fig. 1

Cypricardites nasuta Conrad, 1841, 5th Ann. Rept. New York Geol. Surv., p. 52.

Modiolopsis nasutus Hall, 1847, Pal. New York, vol. i, p. 159, pl. xxxv, fig. 7, p. 296, pl. lxxxi, fig. 2.

Orthodesma nasutum Foerste, 1914, Bull. Sci. Lab. Denison Univ., vol. xvii, p. 286, pl. iii, fig. 5; pl. 5, fig. 3.

Description.—This well-marked species is easily distinguished from all associated pelecypods by its narrow, subelliptical form and its anterior extremity drawn out into a narrow, quite extended nasute form. The cardinal margin of the shell is distinctly straight posterior to the beak, but anterior to it the margin drops so that at its greatest departure it is at least 3 mm. lower. In its anterior portion the shell is depressed and this, in connection with the outline, adds to the nasute appearance. Posterior to the beak the shell is more convex with the areas of greatest convexity near the cardinal margin. The surface is marked by indistinct concentric striations which are plainest along the basal margin of the anterior part.

The type specimens were secured from the Pulaski shale division of the Lorraine at Lorraine, near Rome, etc., New York.

Occurrence.—MARTINSBURG SHALE (Fairview division). Tuscarora Mountain, one and one-half miles southeast of McConnellsburg, Pennsylvania.

Collection.—U. S. National Museum.

CLASS GASTROPODA

Order ASPIDOBRANCHIA

Family PLEUROTOMARIIDAE

Genus PLEUROTOMARIA Defrance

PLEUROTOMARIA ? CANADENSIS Billings

Plate XXXVI, Figs. 4, 5

Pleurotomaria canadensis Billings, 1865, Pal. Fossils, vol. i, Geol. Surv. Canada, p. 230, figs. 214, a, b.

Description.—Shell large, lenticular 35 to 60 mm. in diameter, consisting of six somewhat slender whorls rising into a depressed conical spire. Inner two-thirds of whorls gently convex; suture distinct. Margin of whorls sometimes acute and turned upwards, sometimes with a rounded band. Just within the margin is a wider concave band. Umbilicus wide, one-half to two-thirds the shell diameter, with margin subangular, and the inner slope of the whorls generally flat. A slight concave band just beneath the margin on the under side of the whorls. Aperture transversely ovate or rhomboidal with the outer and inner angles acute. Surface with fine, sharp, unequal striae, usually with shallow undulations 2 to 4 mm. wide conforming to the coarse of the striae; all curving backwards to the margin and reaching it at an acute angle.

Occurrence.—BEEKMANTOWN LIMESTONE (Ceratopea zone). Near McConnellsburg and other localities in southern Pennsylvania and east of Williamsport and near Halfway, Maryland.

Collection.—U. S. National Museum.

PLEUROTOMARIA ? GREGARIA Billings

Plate XXXV, Figs. 1-3

Pleurotomaria gregaria Billings, 1859, Canadian Nat. Geol., vol. iv, pp. 355, 358, figs. 8h-k.

Description.—Shell small, 8 mm. long and 5 mm. wide; spire conical with an apical angle of about 45°; three or four whorls. A narrow spiral band is present. On the body whorl, the band is somewhat above the middle of the volution, but in the upper whorls it is situated on the lower outer side at about one-fourth the height. An obscure carina on the body whorl, just above the spiral band, and another close to the suture is present on mature examples; the intervening space is flat or slightly concave. Below the band is a third carina, scarcely visible, and below this the whorl is rounded ventricose. There is a small umbilicus. Surface minutely striated.

This is an interesting and well-marked species, but until a complete revision of Beekmantown gastropods is made, its generic position must remain very uncertain.

Occurrence.—BEEKMANTOWN LIMESTONE (Turritoma zone). Stoufferstown, Pennsylvania, and east of Huyett, Maryland.

Collection.—U. S. National Museum.

PLEUROTOMARIA ? FLORIDENSIS Cleland

Plate XXXI, Fig. 6

Pleurotomaria floridensis Cleland, 1900, Bull. Amer. Pal., vol. iii, p. 125 (253), pl. xv, fig. 12.

Description.—Shell quite small, 3 mm. wide at the base and 4 mm. high, consisting of five slightly rounded volutions, conical, with an apical angle of 44° and a minute umbilicus.

Imperfect casts and cross-sections in the rock of a small conical shell found occasionally in the Stonehenge limestone of Maryland seem to be representatives of this interesting species which hitherto has been noted only in the corresponding horizon in New York. The reference of this species to *Pleurotomaria* is known to be incorrect, but in the present state of our knowledge of Canadian gastropods it is useless to attempt more accurate generic determination. The specimens found in Maryland are not well enough preserved for a critical study of their generic characters.

Occurrence.—BEEKMANTOWN LIMESTONE (Stonehenge member). Vicinity of Hagerstown, Maryland. Tribes Hill limestone of New York.

Collection.—U. S. National Museum.

Genus HORMOTOMA Salter

HORMOTOMA ARTEMESIA (Billings)

Plate XXXVI, Figs. 8, 9

Murchisonia artemesia Billings, 1865, Pal. Fossils, vol. i, Geol. Surv. Canada, p. 345, fig. 332.

Description.—Shell elongate, varying from 50 to 75 mm. in length, slender, consisting of 10 to 12 depressed convex whorls with a strong, rounded spiral band. In casts the whorls are depressed ventricose, flattened in the middle and abruptly rounded in the deep suture. Casts of the exterior show a strong, rounded band along the median line of the whorls about 2 mm. wide on the large whorls. Surface with fine, sharp striae curving backwards to the band.

The elongate, slender form of this shell and the band along the median line of the whorls are sufficient characters to discriminate it from other associated forms of gastropods.

Occurrence.—BEEKMANTOWN LIMESTONE (Ceratopea zone). Appalachian Valley in Pennsylvania, Maryland, and Virginia. Natural sections and poorly preserved casts of this species occur in the exposures east of Williamsport and in the vicinity of Halfway, Maryland.

Collections.—Maryland Geological Survey, U. S. National Museum.

HORMOTOMA GRACILIS (Hall)

Plate LV, Figs. 7, 8

Murchisonia gracilis Hall, 1847, Pal. New York, vol. i, p. 181, pl. xxxix, figs. 4a-c; p. 303, pl. lxxxiii, figs. 1a-b.

Hormotoma gracilis Ulrich and Scofield, 1897, Geol. Minnesota, vol. iii, pt. 2, p. 1015, pl. lxx, figs. 18-21.

Description (typical form).—" Height 20 to 33 mm., apical angle very constantly about 18°. Shell small, slender; volutions about 14 in a length of 30 mm.; rounded generally with a slight angulation, on which lies the band, a little beneath the middle; band seldom preserved, when perfect, rather narrow, smooth, flat or faintly concave and margined on each side by a delicate raised line; suture simple, deep; lines of growth fine, bending strongly backward from the suture to the band, and beneath this curving very strongly forward again, the whole indicating a deeply notched mouth; aperture a little higher than wide, rounded except below where it is somewhat produced; inner lip reflected, forming a slightly twisted and thickened columella."—Ulrich and Scofield, 1897.

Widely distributed in the United States and Canada in rocks ranging from the Trenton to and through the Richmond.

Occurrence.—MARTINSBURG SHALE (Eden division). Fort Loudon, Pennsylvania, and the west slope of Rickard Mountain, Washington County, Maryland.

Collections.—Maryland Geological Survey, U. S. National Museum.

Hormotoma gracilens (Whitfield)

Plate XXXV, Figs. 4, 5

Murchisonia gracilens Whitfield, 1889, Bull. Amer. Mus. Nat. Hist., vol. ii, p. 53, pl. viii, figs. 14, 15.

Description.—Shell rather small, possibly reaching 25 mm. in length, and very slender with the apical angle not more than 16 to 18 degrees, consisting of numerous whorls, six of which occur in the upper part of the spire of a small individual in 6 mm. Volutions ventricose, smooth or with but a very slight angularity near the middle of the exposed portion; sutures deep and strongly marked. Columella and aperture unknown.

This species is probably the Canadian representative of the abundant Middle and Upper Ordovician *Hormotoma gracilis* Hall which it greatly resembles. The earlier species, however, is a trifle more slender.

Occurrence.—Beekmantown Limestone (Turritoma zone). Stoufferstown, Pennsylvania, and near Huyett, Maryland.

Collections.—Maryland Geological Survey, U. S. National Museum.

Genus TURRITOMA Ulrich

Turritoma acrea (Billings)

Plate XXXV, Fig. 11

Murchisonia acrea Billings, 1865, Pal. Foss., vol. i, Geol. Surv. Canada, p. 232, text fig. 216.

Description.—Shell rather small and slender, about 25 mm. long and 7 mm. at its widest portion, resembling a *Turritella;* apical angle 15° to 20°; whorls 12 to 15 in number, flat or subconcave, each with the lower edge angularly rounded and projecting slightly over the one below; surface above this projection flat or gently concave; and sloping to the suture, near which is a slight convexity. Surface characters unknown.

This shell is easily recognized even in poor specimens by its considerable resemblance to a small species of *Turritella.* Its characters are so distinctive that Ulrich selected it as the type of his genus *Turritoma.*

Occurrence.—BEEKMANTOWN LIMESTONE (Turritoma zone). Stouf-ferstown, Pennsylvania, and east of Huyett, Maryland. Canadian (Division G of the Quebec group), Port aux Choix, Newfoundland.

Collection.—U. S. National Museum.

Genus LOPHOSPIRA Whitfield

LOPHOSPIRA BICINCTA (Hall)

Plate XXXIX, Figs. 1-5

Murchisonia bicincta Hall, 1847 (not McCoy, 1844), Pal. New York, vol. i, p. 177, pl. xxxviii, figs. 5a-f (?5g and 5h).

Lophospira bicincta Ulrich and Scofield, 1897, Geol. Minnesota, Pal., vol. iii, pt. 2, p. 964, pl. lxxii, figs. 1-5.

Description.—"Hight 15 to 30 mm.; apical angle 59° to 63°, usually about 60°. Volutions five or six, subangular; last one ventricose below, tricarinate, the upper ones bicarinate, the lower carina being hidden by the suture; central or peripheral angle margined on either side by a sharp elevated line, with a narrow groove between, the angle, therefore, being composed of three lines of which the central one is a little stronger and more prominent than the lateral ones; lower carina thin, abruptly raised, the space between it and the peripheral angle scarcely concave and almost perpendicular; upper carina sharp, rather strong, removed a little more than a third of the biconcave upper slope of the volution from the suture; aperture somewhat obliquely subelliptical, higher than wide, narrow below, subangular at the lower inner corner; inner lip but little thickened, slightly twisted, never completely covering the minute umbilicus; outer lip very slightly sinuate. Surface marked by fine, sharp, subequal striae, curving backward very gently from the suture to the peripheral band; beneath the latter they pass in a vertical direction to the lower carina which scarcely interrupts their course to the umbilicus, near which only a slight backward curve is noticeable. On the most perfect specimen seen all the transverse lines present the appearance of being minutely papillose or toothed, while the central line of the peripheral band is crossed by straight lines, of which there are nearly twice as many in a given space as of those coming from above and below.

"The most marked and important feature of this species is the exceeding shallowness of the sinus or notch in the outer lip. The essential characters of *L. bicincta,* as here identified and restricted, are (1) the ventricose whorls, (2) the sharp and regular lines of growth, and (3) the exceedingly shallow sinus in the outer lip and vertical direction of the surface striae from the peripheral band downward."—Ulrich and Scofield, 1897.

Occurrence.—STONES RIVER LIMESTONE. Old quarry at Chambersburg, Pennsylvania, and south into Maryland. The original types are from the Trenton of New York, but the species is said to range from the Stones River to the Richmond.

Collections.—Maryland Geological Survey, U. S. National Museum.

LOPHOSPIRA (RUEDEMANNIA) LIRATA (Ulrich)

Plate LV, Figs. 5, 6

Lophospira (? Seelya) lirata Ulrich, 1897, Geol. Minnesota, vol. iii, pt. 2, p. 998, pl. lxxii, figs. 56-59.

Ruedemannia lirata Foerste, 1914, Bull. Sci. Lab. Denison Univ., vol. xvii, p. 312.

Description.—"Hight 15 to 24 mm., apical angles 65° to 70°, the angle of the first three whorls usually a little wider. Volutions about five and a half, ventricose, the carinae not greatly interfering with the general roundness of their outlines. Peripheral band median, appearing lower on the whorls of the spire, very slightly prominent, trilineate; the lines of equal strength and elevation or the median one is a little weaker and not as sharply defined as the margined ones. About midway between the band and the suture lines a small ridge or carina divides the upper slope into two flat or slightly concave spaces. Nearly the same distance beneath the lower margin of the band in the typical form of the species we meet with the first and strongest of about eight revolving ribs. . . . . Umbilicus exceedingly small, sometimes closed by a slight overlap of the inner lip. Aperture subovate, rounded below and rather straight at the inner side. Lines of growth sharp, thread-like, regular, either fine and equal on all parts of a whorl or they may be farther apart with interpolations on the upper slope. The lunulae of the band are fine and regularly curved."—Ulrich, 1897.

Occurrence.—MARTINSBURG SHALE (Eden division). Jordans Knob, one and one-half miles northeast of Fort Loudon; Tuscarora Mountain, two and one-half miles southeast of McConnellsburg; and Cowan Gap, five miles northeast of McConnellsburg, Pennsylvania. Fragmentary casts of this species were noted in the sandstone debris of the Upper Martinsburg on the west slope of Rickard Mountain, Washington County, Maryland.

Collection.—U. S. National Museum.

Genus LIOSPIRA Ulrich and Scofield

LIOSPIRA MICULA (Hall)

Plate LVIII, Figs. 7-9; Plate LV, Figs. 25, 26

Pleurotomaria micula **Hall, 1862, Geol. Rept. Wisconsin, p. 55, fig. 1.**
Liospira micula **Ulrich and Scofield, 1897, Geol. Minnesota, vol. iii, pt. 2, p. 994, pl. lxviii, figs. 24-29.**

Description.—Shell discoidal and small, rarely exceeding 16 mm. in diameter and usually 11 or 12 mm., with the umbilicus filled by a reflexed callosity of the inner lip. Externally this filling is concave, smooth and distinct from the finely striated under side of the volutions. The shell has four volutions with such shallow sutures that the spire forms an almost even slope from its apex to the periphery. Surface marked with fine lines of growth and in the best preserved specimens with very delicate revolving lines. On the under side the lines of growth are broadly curved with the greatest curvature on the inner half. The band is obliquely placed on the periphery and most visible on the upper side.

This is one of the long ranging gastropods, specimens apparently the same as the types, which come from the Richmond (Maquoketa) of Wisconsin, being found in all the formations from the Trenton to and through the Richmond.

The usual specimens found are seldom well preserved and it is possible that with better material differences may be noted in examples from the various horizons.

Occurrence.—MARTINSBURG SHALE (Eden and Fairview divisions). Jordans Knob, one and one-half miles northeast of Fort Loudon, Pennsylvania, and the west slope of Rickard Mountain, Washington County, Maryland, have afforded poorly preserved specimens.

Collection.—U. S. National Museum.

Family EUOMPHALIDAE Dekoninck

Genus MACLURITES Lesueur

MACLURITES AFFINIS (Billings)

Plate XXXIII, Figs. 8, 9

Maclurea affinis Billings, 1865, Pal. Fossils, vol. i, Geol. Surv. Canada, p. 238, text figs. 224a, b.

Maclurea affinis Whitfield, 1897, Bull. Amer. Mus. Nat. Hist., vol. ix, p. 180, pl. iv, figs. 8, 9.

Description.—Shell 35 to 50 mm. in width and 12 to 16 mm. in height with a flat spire of four or five slender whorls, uniformly convex on the upper side, and with deeply impressed sutures. Umbilicus about three-fifths the width of the shell, with the edge, as shown in a vertical section, acute; the inner sides of the whorls, in the umbilicus, convex. Surface unknown.

Occurrence.—BEEKMANTOWN LIMESTONE (Cryptozoon steeli zone). Vicinity of Hagerstown and Williamsport, Maryland. Canadian of Newfoundland and Vermont.

Collection.—U. S. National Museum.

MACLURITES MAGNUS Lesueur

Plate XXXIX, Figs. 12-15

Maclurites magna Lesueur, 1818, Jour. Acad. Nat. Sci. Philadelphia, vol. i, p. 312, pl. xiii, figs. 1-3.

Maclurea magna Hall, 1847, Pal. New York, vol. i, p. 26, pl. v, figs. 1a-e; pl. v, (bis), figs. 1a-c.

Maclurites magnus Raymond, 1908, Ann. Carnegie Mus., vol. iv, p. 199, pl. l, figs. 1, 2; pl. li, figs. 1, 2; pl. lii, figs. 1-4.

Description.—"Sinistrorsal, discoidal, depressed turbinate; breadth more than twice as great as the height; spire flat, a slightly depressed line at the sutures; whorls about six, gradually increasing from the apex, ventricose, flattened above, obtusely angular on the outer edge; surface marked by fine striae, which upon close examination, are found to be produced by the imbricating edges of lamellae; striae undulating, bending backwards from the suture and forward in passing over the edge of the shell; aperture obtusely trigonal, depressed above, slightly expanded beyond the dimensions of the whorl just behind it; axis hollow, umbilicus broad and deep, extending to the top of the spire."—Hall.

Associated with the large shell of this *Maclurites* is an operculum which undoubtedly belongs to the species. It is large, heavy, and horn-shaped and has the nucleus twisted to the right. In the inner right-hand corner of the operculum, as may be noted in fig. 15, of pl. XXXIX, there is a long process projecting downward into the shell and forming a place for attachment of muscles.

Occurrence.—STONES RIVER LIMESTONE (Middle division). Many localities in southern Pennsylvania; Pinesburg, etc., Maryland. An abundant and characteristic fossil of the Middle Chazyan from Montreal. Canada, to east Tennessee, the original types coming from the Lake Champlain area. In Tennessee the species is so abundant in the Lenoir limestone that this formation has been termed the *Maclurea* limestone.

Collections.—Maryland Geological Survey, U. S. National Museum.

MACLURITES SORDIDUS (Hall)

Plate XXXVI, Figs. 1-3

Maclurea sordida Hall, 1847, Nat. Hist. New York, Pal., vol. i, p. 10, pl. iii, figs. 2, 2a.

Description.—Shell subdiscoidal; consisting of two to two and a half slightly disconnected whorls rapidly increasing in diameter, strongly rounded on the upper side with deeply sunken apex, flattened on the lower side, and the peripheral edge rather sharply rounded. Aperture semicircular. Shell thick, the surface usually with only faint lines of growth, but sometimes strong, transverse striae, with more distant undulations. The transverse lines of growth curve forward on the lower flattened surface and backward on the rounded upper surface.

Occurrence.—BEEKMANTOWN LIMESTONE (Ceratopea zone). Casts and section of the shall may be observed at this horizon west of Hagerstown, and also in several exposures east of Williamsport, Maryland. Beekmantown of New York and Vermont.

Collection.—U. S. National Museum.

MACLURITES OCEANUS (Billings)

Plate XXXV, Figs. 7, 8

Maclurea oceana Billings, 1865, Pal. Fossils, vol. i, Geol. Surv. Canada, p. 237, text fig. 223a, b.

Description.—Shell varying from 25 mm. to 100 mm. in diameter, consisting of four or five, rather slender whorls with an umbilicus measuring about half the whole width in the small specimens. Spire flat; the outer edge narrowly rounded; the suture deeply impressed in the usual specimens, casts of the interior, but compressed and thread-like when the shell is preserved. Outer side of the body-whorl gently convex, and sloping to the edge of the umbilicus at an angle of from 60° to 70° with the plane of the flat side of the shell. Aperture a little less than half the whole width of the shell in height. Edge of umbilicus acutely rounded; inner side of the whorls in the umbilicus gently convex, and somewhat sloping with the edge exposed to the apex. Surface unknown, but most probably finely striated.

Occurrence.—BEEKMANTOWN LIMESTONE (Turritoma zone). Natural sections of this shell were noted in the exposures along the National Highway east of Huyett, Maryland. Canadian of Newfoundland.

Collection.—U. S. National Museum.

Genus CERATOPEA Ulrich

CERATOPEA KEITHI Ulrich

Plate XXXVI, Fig. 15

Operculum *of ? Maclurea* Bassler, 1909, Bull. Geol. Surv. Virginia, vol. iia, pl. xx, fig. 3.

Ceratopea keithi Ulrich, 1911, Bull. Geol. Soc. Amer., vol. xxii, No. 3, p. 665.

Description.—The above name has been employed for an unusual type of operculum supposed to belong to some spiral shell like *Maclurea.* The particular gastropod possessing such a thick closure to the shell is unknown. Possibly the shell was of such a nature that it was easily destroyed, but the opercula occur often in considerable numbers. Several distinct types of these opercula are known, but each holds its own particular form and marks a definite stratigraphic horizon. The one to which the name *Ceratopea keithi* has been given, marks a zone in the Middle Beckmantown throughout the Appalachian Valley, and as specimens are usually common, this species is regarded as such an exceptionally valuable guide fossil that the name *Ceratopea* zone has been applied to the strata containing it. The various aspects of the species are illustrated in enough detail on pl. XXXVI to make its identification certain.

Occurrence.—BEEKMANTOWN LIMESTONE (Ceratopea zone). Several localities northeast and southwest of Halfway, Maryland, afford silicified specimens of this fossil. A common and characteristic fossil of the Middle Beekmantown in the Appalachian Valley from Pennsylvania to Alabama.

Collections.—Maryland Geological Survey, U. S. National Museum.

Genus HELICOTOMA Salter

HELICOTOMA PLANULATOIDES Ulrich

Plate XLII, Figs. 13-15

Helicotoma planulatoides **Ulrich, 1897, Geol. Minnesota, Pal., vol. iii, pt. 2, p. 1034, pl. lxxiv, figs. 28-30.**

Description.—This species is closely related to the widespread Black River species *Helicotoma planulata* Salter, but differs in that it has only about four whorls instead of five and each descends slightly below the level of the preceding. The umbilicus is somewhat narrower than in *H. planulata* and revolving lines are totally absent. Specimens range in width from 15 to 25 mm.

Occurrence.—CHAMBERSBURG LIMESTONE (Tetradium cellulosum bed). Fort Loudon, Franklin County, Pennsylvania. Lowville limestone of Kentucky and Tennessee.

Collection.—U. S. National Museum.

HELICOTOMA VERTICALIS Ulrich

Plate XLII, Figs. 16, 17

Helicotoma verticalis Ulrich, 1897, Geol. Minnesota, Pal., vol. iii, pt. 2, p. 1035, pl. lxii, fig. 69; pl. lxxiv, figs. 18 and 19.

Description.—This shell, although known only from casts of the interior, is so well characterized by the rectangular form of the outer and upper surfaces of the whorls that it should be easily recognized. The whorls are not more than four in number, enlarge rapidly, are strongly convex below and leave a deep and relatively narrow umbilicus. On the under side the cast resembles the shell of *Helicotoma planulatoides* quite closely, but otherwise the two species are quite different, as the outer side of the whorls in the latter are concave and inclined inward above instead of convex or flat and vertical.

Occurrence.—CHAMBERSBURG LIMESTONE (Tetradium cellulosum bed). Fort Loudon, Franklin County, Pennsylvania. Lowville limestone of Kentucky.

Collection.—U. S. National Museum.

Genus ECCYLIOPTERUS Remele

ECCYLIOPTERUS DISJUNCTUS (Billings)

Plate XXXV, Figs. 9, 10

Ophileta ? disjuncta Billings, 1865, Pal. Foss., vol. i, Geol. Surv. Canada, p. 344, text fig. 331a, b.

Description.—Shell about 25 mm. in diameter, consisting of two or three whorls slightly separated from each other and with a strongly elevated, sharp carina. Spire deeply concave; carina located one-third the width from the outer margin. Within the carina there is first a shallow concave band, and then a concave slope into the suture; without it is a little defined concavity, below which the periphery is uniformly convex. The whorls on the under side vary from uniformly to depressed convex, sometimes becoming flat near the aperture along the median line. Depth and width of whorls about equal, greatest amount of separation of whorls about 4 mm. Surface with rather strong, scale-like striae.

Occurrence.—BEEKMANTOWN LIMESTONE (Turritoma zone). Stoufferstown, Pennsylvania, and in exposures along the National Highway, east of Huyett, Maryland. Beekmantown limestone of Canada.

Collection.—U. S. National Museum.

ECCYLIOPTERUS TRIANGULUS (Whitfield)

Plate XXXIII, Figs. 6, 7

Ecculiomphalus triangulus **Whitfield, 1890, Bull. Amer. Mus. Nat. Hist., vol. iii, p. 29, pl. i, figs. 5-9.**

Eccyliopterus triangulus **Ulrich and Scofield, 1897, Geol. Minnesota, Pal., vol. iii, pt. 2, pl. lxxiv, figs. 5, 6; pl. lxii, fig. 73.**

Description.—Shell less than two inches in diameter and consisting of from one to one and a half volutions, loosely coiled and not in contact at any point. Tube increasing rather rapidly in dimensions, triangular in section, flattened on three-fourths of its upper surface and rapidly rounded to the inner angle. Peripheral angle acute and the outer surface sloping rapidly inward to the rounded basal angle. Shell substance very thin, the surface characters unknown, except indistinct wavy lines crossing the shell and receding toward the acute angle. The apical portion is usually entirely filled with calcareous matter as the shell gets larger, thus shortening the inner coil of the casts.

Occurrence.—BEEKMANTOWN LIMESTONE (Cryptozoon steeli zone). Three-fourths mile east of Charlton, Maryland, and at the same horizon in Pennsylvania. The types are from this formation in Vermont.

Collection.—U. S. National Museum.

Genus OPHILETA Vanuxem

OPHILETA COMPLANATA Vanuxem

Plate XXXI, Figs. 2-5

Ophileta complanata **Vanuxem, 1842, Nat. Hist. New York, Geol., vol. iii, p. 36, fig. 2.**

Ophileta complanata **Cleland, 1903, Bull. Amer. Pal., vol. iv, p. 15 (41).**

Pleurotomaria hunterensis **Cleland, 1900, Bull. Amer. Pal., vol. iii, p. 124 (252), pl. xvii, figs. 1, 2, 7, 8.**

Pleurotomaria hunterensis **Cleland, 1903, Bull. Amer. Pal., vol. iv, p. 16, pl. iv, figs. 1, 2.**

Description.—Shell conical, varying from 10 mm. to 40 mm. in width, consisting of six or more volutions elevated into a spire and with an umbilicus about one-half as wide as the entire diameter. Upper surface of shell nearly flat with a faint groove near the edge; under surface slightly angulate. Aperture irregularly rhomboidal.

Under the name of *Ophileta complanata* a number of distinct species of Canadian gastropods has been classed in the past half century and it has only been by the study of specimens from the type localities in the Mohawk Valley that the real characters of the species have been identified. Vanuxem's very imperfect description is as follows:

"[*O. complanata*] consists of many convolutions resembling a single coil of cord formed on a flat surface, the diameter of the coil being usually about an inch. From analogy of formation it evidently pertains to the same genus with *O. levata.* It is more rare than *O. levata,* but is occasionally met with in the same localities on the Mohawk."

The type specimen of *O. complanata* appears to be lost, but as noted by Cleland, there is little doubt that the species described by him as *Pleurotomaria hunterensis* has usually been identified as *O. complanata* in the Mohawk Valley. Both names undoubtedly refer to the same species, especially since the occurrence of each is identical. Although Vanuxem's description and figure are not sufficient for present-day purposes, it seems best to recognize his name on account of the generic term *Ophileta.* If the genotype *O. complanata* should not be recognized the widely quoted genus *Ophileta* too would have to be dropped. The synonymy is further complicated by the fact that Weller has based his genus *Polygyrata* on a species from New Jersey apparently closely related to *Ophileta complanata.* With regard to the numerous other references to supposed *O. complanata,* this is neither the time nor the place to discuss them. Only a monographic faunal study of the entire Canadian can clear up this complicated subject.

Occurrence.—BEEKMANTOWN LIMESTONE (Stonehenge member). Vicinity of Hagerstown and Funkstown, Maryland.

The type localities are in the Mohawk Valley of New York, Little Falls, Canajoharie, Tribes Hill, Ft. Hunter, etc., where the species occurs in the Tribes Hill division of the Canadian.

Collections.—Maryland Geological Survey, U. S. National Museum.

OPHILETA LEVATA Vanuxem

Plate XXXI, Figs. 18, 19

Ophileta levata Vanuxem, 1842, Nat. Hist. New York, Geol., vol. iii, p. 36, fig. 1.
Ophileta levata Cleland, 1903, Bull. Amer. Pal., vol. iv, p. 16.
Ophileta discus Cleland, 1900, Bull. Amer. Pal., vol. iii, p. 124 (252), pl. xv, figs. 5, 6.

Description.—Shell discoidal, 10 mm. or less in diameter, consisting of four or more whorls rising into a slightly elevated spire, and concave on the lower side where the umbilicus is wide and shows all of the whorls. Margin of whorls sharp and somewhat elevated; upper side of whorl flat, lower side rounded.

The identification of the specimens here referred to *Ophileta levata* is due to Cleland who by a comparison of type specimens of each has shown that his *Ophileta discus* and Vanuxem's *O. levata* are based on the same species. As in the case of *Ophileta complanata,* Vanuxem's description and figure of *O. levata* are of little value.

Occurrence.—BEEKMANTOWN LIMESTONE (Stonehenge member). Vicinity of Hagerstown and Funkstown, Maryland.

Abundant in the Tribes Hill limestone of the Canadian at Canajoharie, Tribes Hill, Fort Hunter and other localities in the Mohawk Valley of New York.

Collection.—U. S. National Museum.

OPHILETA COMPACTA Salter

Plate XXXIII, Figs. 1-3; Plate XXXIV, Fig. 2

Ophileta compacta Salter, 1859, Quart. Jour. Geol. Soc. London, vol. xv, p. 378, pl. xiii, fig. 12.
Ophileta complanata Whitfield, 1889, Bull. Amer. Mus. Nat. Hist., vol. ii, p. 48, pl. vii, figs. 18-25.

Description.—Shells discoidal, coiled in the same plane; flat or slightly concave below, more concave above. Periphery flattened obliquely, the lower edge of the volution being the largest, and rounded to the base, while the upper angle is sharply carinate. Upper surface of each volution obliquely sloping to the volution within it, giving the depressed spire. Aperture trapezoidal. Substances of the shell thick, the surface transversely striated on the top and below, with frequent strongly marked undulations on the flattened side and back of the volution.

The above description is based upon fairly well preserved examples of this species from the Beekmantown of the Champlain Valley, described and illustrated by Whitfield as *Ophileta complanata*. Typical *Ophileta complanata* is quite a different shell, as can be noted by a comparison of the figures on plates XXXI and XXXIII.

Occurrence.—BEEKMANTOWN LIMESTONE (Cryptozoon steeli zone). Poor casts in the rock or in the form of natural sections. Hagerstown, etc., Maryland and various localities in Pennsylvania.

Collection.—U. S. National Museum.

Genus ECCYLIOMPHALUS Portlock

ECCYLIOMPHALUS MULTISEPTARIUS Cleland

Plate XXXI, Figs. 20, 21; Plate XXXIV, Figs. 3, 4

Ecculiomphalus multiseptarius Cleland, 1900, Bull. Amer. Pal., vol. iii, p. 123 (251), pl. xv, figs. 1-4.

Ecculiomphalus multiseptarius Cleland, 1903, Bull. Amer. Pal., vol. iv, p. 17.

Description.—The shell of this species is discoid and consists of two or more loosely coiled, slender volutions which gradually expand until the outer portion is 6 mm. in diameter in a specimen of 20 mm. width. In transverse section the outer coil of the shell is subovate and slightly carinated on the outer edge.

The specific name refers to the partitions shown in natural section of the shell which give it the aspect of a cephalopod, but the curvature and the irregularity of these partitions will distinguish them from septa. Such partitions are known in other species of the genus and indeed form a generic character. They are especially well developed in the present species.

Occurrence.—BEEKMANTOWN LIMESTONE (Stonehenge member). Rare in both the lower and upper divisions of the Stonehenge member at several localities in the vicinity of Hagerstown, Maryland. Natural sections of this shell can be seen in the lower Stonehenge quarries and especially in the fences along the National Highway, one-fourth to one-half mile south of Funkstown, Maryland.

Not uncommon in the Tribes Hill formation of the Canadian near Fort Hunter, New York.

Collection.—U. S. National Museum.

ECCYLIOMPHALUS TRENTONENSIS (Conrad)

Plate L, Figs. 19, 20

Cyrtolites trentonensis Conrad, 1842, Jour. Acad. Nat. Sci., Philadelphia, vol. viii, p. 270, pl. xvii, fig. 4.

Cyrtolites trentonensis Hall, 1847, Pal. New York, vol. i, p. 189, pl. xla, figs. 3a-d.

Eccyliomphalus trentonensis Weller, 1903, Geol. Surv. New Jersey, Pal., vol. iii, p. 184, pl. xii, figs. 20, 21.

Description.—Shell consisting of less than one volution, increasing gradually in size from the apex, coiled in one plane. Cross-section angularly subovate. Ventral side of the shell convex from the periphery to the inner margin; the periphery rather sharply rounded; about midway between it and the inner margin, on the dorsal side of the shell, is an angular, subcarinate ridge, the space between this ridge and the peripheral angulation being nearly flat; from the dorsal ridge to the inner margin of the shell the surface is convex. The surface is marked by rather obscure and irregular lines of growth, which, on the dorsal side, slope backward to the dorsal ridge, thus indicating the presence of an angular sinus in the aperture at that point. The most complete specimen observed has a length of about 35 mm. around the periphery of the shell from apex to aperture."—Weller, 1903.

Occurrence.—MARTINSBURG SHALE (Sinuites bed). Carlisle, Chambersburg and two miles south of St. Thomas, Pennsylvania. The Lower Trenton rocks of New York and New Jersey likewise have furnished specimens.

Collection.—U. S. National Museum.

Family RAPHISTOMIDAE

Genus RAPHISTOMA Hall

RAPHISTOMA ? OBTUSUM Cleland

Plate XXXI, Figs. 15-17

Raphistoma obtusa Cleland, 1900, Bull. Amer. Pal., vol. iii, p. 125 (253), pl. xv, figs. 7-9.

Description.—Shell averaging 10 mm. in width, convex above, much compressed and consisting of three volutions, forming an apical angle of 130°. Umbilicus about one-third the shell diameter, with angular margins. Upper surface of volutions compressed, outer edge acute, and inner edge rounded.

The compressed form, angular margin, and few volutions of this shell will distinguish it from associated species.

Occurrence.—BEEKMANTOWN LIMESTONE (Stonehenge member). Several localities around Hagerstown and Funkstown, Maryland. Tribes Hill limestone of New York.

Collection.—U. S. National Museum.

RAPHISTOMA ? COLUMBIANUM Weller

Plate XXXI, Figs. 22, 23

Raphistoma columbiana Weller, 1903, Geol. Surv. New Jersey, Pal., vol. iii, p. 128, pl. iv, figs. 3-5.

Description.—Shell nearly smooth, consisting of about three and one-half volutions, flat above and rounded below, which form a slightly elevated spire and have a small umbilicus below. Outer edge of shell sharply rounded and slightly elevated above. The outer volution has a broad, ill-defined sulcus just below and paralleling the periphery. The type specimen measures 13 mm. in diameter and 6.5 mm. in height.

Occurrence.—BEEKMANTOWN LIMESTONE (Stonehenge member). Hagerstown, Maryland. The types are from the Kittatinny limestone of New Jersey.

Collection.—U. S. National Museum.

Genus RAPHISTOMINA Ulrich and Scofield

RAPHISTOMINA LAURENTINA (Billings)

Plate XXXVI, Figs. 6, 7

Pleurotomaria laurentina Billings, 1859, Canadian Nat. Geol., vol. iv, p. 354, fig. 6.

Description.—Shell 25 to 50 mm. in diameter, lenticular with depressed spire consisting of five or six whorls slightly convex on their upper sides, but with a shallow concave band just within their outer margin. Lower side of body whorl somewhat concave just beneath the margin, then moderately convex to the umbilicus within which it is rather narrowly rounded. Umbilicus deep and about one-fourth the diameter of the shell. The cast of the interior exhibits an acutely rounded margin, which, owing to the concave band above, appears to be turned a little upward, or to have a narrow ridge all around on its upper side. Aperture subrhomboidal, somewhat indented by the adjacent whorl.

The Appalachian Valley specimens are poorly preserved, but agree in all essential details with the figures of the Canadian specimens published by Billings.

Occurrence.—BEEKMANTOWN LIMESTONE (Ceratopea zone). Stouferstown, Pennsylvania, and east of Williamsport, Maryland.

Collection.—U. S. National Museum.

Genus OMOSPIRA Ulrich

OMOSPIRA ALEXANDRA (Billings)

Plate XLIII, Figs. 16, 17

Murchisonia alexandra Billings, 1865, Geol. Surv. Canada, Pal. Fossils, vol. i, p. 172.

Omospira alexandra Ulrich and Scofield, 1897, Geol. Minnesota, vol. iii, pt. 2, p. 946, pl. lxx, figs. 66, 67.

Description.—"Shell rather large, turbinate, acutely conical; apical angle from 45° to 50°; whorls about six, strongly ventricose, with a flat band in the upper third. The aperture appears to be large and ovate;

the inner lip is thin and folded over so as to conceal the minute umbilicus. Surface finely striated. Length about 30 lines; width of body whorl 15 lines.

This species is about the size and somewhat of the shape of *M. bellicincta*. The principal difference is in the form of the upper part of the whorl. The lower two-thirds or three-fourths of the whorl is nearly uniformly convex, but the upper third descends abruptly to the deep suture. The band is quite flat, and being situated on the upper sloping part, gives to the whorl a truncated appearance. The lower edge of the band is defined by a small acute carina, seldom visible in specimens which are worn."—Billings, 1865.

Occurrence.—CHAMBERSBURG LIMESTONE (Tetradium cellulosum bed). Fort Loudon, Franklin County, Pennsylvania. Lowville limestone of Canada and Kentucky.

Collection.—U. S. National Museum.

Family BUCANIIDAE

Genus BUCANIA Hall

BUCANIA SULCATINA (Emmons)

Plate XXXIX, Figs. 6-8

Bellerophon sulcatinus Emmons, 1842, Geol. Nat. Hist. New York, vol. ii, p. 312, text fig. 4.

Bucania sulcatina Hall, 1847, Pal. New York, vol. i, p. 32, pl. vi, figs. 10, 10a; pl. xxxiii, fig. 4d.

Bucania champlainensis Whitfield, 1897, Bull. Amer. Mus. Nat. Hist., vol. ix, p. 181, pl. iv, figs. 14-16.

Bucania sulcatina Raymond, 1908, Ann. Carnegie Mus., vol. iv, p. 194, pl. xlix, figs. 15-17; pl. l, figs. 3, 4; pl. lv, figs. 13, 14.

Description.—"Shell large, coiled in one plane, umbilicated on both surfaces, all the whorls visible. The whorls are broad, somewhat angular at the sides, the last whorl moderately expanded at the mouth. Shell on the whorls thin, but on the lip it becomes very thick and sometimes corrugated. The surface is ornamented by coarse wavy revolving striae which are crossed by transverse lines of growth.

"These lines turn backward in crossing the middle of the shell and then forward again on either side. Along the center of the shell runs a narrow carina or slit band which is open for a short distance on the last whorl. The lip shows a broad, deep notch on the outer edge, and at the base of this notch is a further slit. On most specimens this carina is a flat or depressed band, but on a few, especially on young specimens and on the outer whorl of adults, the carina is elevated."—Raymond, 1908.

This well-known Chazyan fossil is easily recognized by the shape of the shell with a slit band, and especially by its characteristic reticulate surface markings.

Occurrence.—STONES RIVER LIMESTONE (Middle division). Examples have been collected at the old quarry at Chambersburg, Pennsylvania, and south along this band of outcrop into Maryland. Chazyan of the Lake Champlain area and Tennessee.

Collections.—Maryland Geological Survey, U. S. National Museum.

Genus TETRANOTA Ulrich and Scofield

TETRANOTA OBSOLETA Ulrich

Plate LV, Figs. 22-24

Tetranota obsoleta Ulrich and Scofield, 1897, Geol. Minnesota, vol. iii, pt. 2, p. 880, pl. lxv, figs. 19-23.

Description.—This species differs from other members of the genus, and especially from the genotype *Tetranota bidorsata,* in the fact that the revolving ridges are much less developed, particularly on the last volution. The central lateral pair is quite obsolete except on the inner volutions and even the central pair merely maintains the same strength relatively that it held in earlier stages. Interior casts of the mature shell exhibit a broad, comparatively low, and more or less distinctly grooved central ridge, beyond which the surface is first shallowly excavated and then gently convex to the lateral boundaries of the volutions which again are not angular but rounded. The exterior of the shell appears the same except that the ridges bordering the slit band seem thinner and sharper.

Another point of difference from *T. bidorsata* is that the umbilicus is smaller and less abrupt and the volutions more rounded on each side and therefore elongate, reniform in cross-section. In the Eden shales, specimens of this species average 20 mm. in height.

Occurrence.—MARTINSBURG SHALE (Eden division). Jordans Knob, one and one-half miles northeast of Fort Loudon; Tuscarora Mountain, two and one-half miles southeast of McConnellsburg; and Cowan Gap, five miles northeast of McConnellsburg.

Collection.—U. S. National Museum.

Family CYRTOLITIDAE

Genus CYRTOLITINA Ulrich

CYRTOLITINA NITIDULA (Ulrich)

Plate L, Figs. 17-18

Cyrtolites nitidulus Ulrich, 1879, Jour. Cincinnati Soc. Nat. Hist., vol. ii, p. 12, pl. vii, figs. 7, 7a.

Cyrtolitina nitidula Ulrich, 1897, Geol. Minnesota, Pal., vol. iii, pt. 2, p. 866, pl. lxii, figs. 53-55.

Description.—" Shell small, 6 to 8 mm. in diameter; volutions about two, rapidly increasing in size, the outer embracing quite a half of the inner; dorsum blunt, thick, flattened in casts; sides gently convex to the edge of the umbilicus into which they descend at first rather abruptly, then gently, the ventral part spreading saddle-like over the inner volution. Aperture subcordate, notched below; outer lip rather broadly and deeply emarginated. Umbilicus about 3.5 mm. wide in a specimen 8 mm. in diameter, narrowly rounded at the edge. Surface of casts with distinct, subregular, retrally curved, transverse striae, averaging about five in 2 mm. on the sides and back. The striae continue over and are quite distinct and curved on the flattened dorsum or slit-band. On the latter some very fine revolving lines, about four in 1 mm., occur on the sides of the volutions. Greatest diameter of a large specimen 8.3 mm.; width of aperture 5.0 mm.; height of same 5.0 mm."—Ulrich, 1897.

The form of the volutions, the slit-band, and the striate, almost lamellose, surface markings characterize this interesting shell which has hitherto been known only from the Trenton rocks of the Ohio Valley.

Occurrence.—MARTINSBURG SHALE (Sinuites bed). Chambersburg, Pennsylvania. Trenton at Covington, Kentucky.

Collection.—U. S. National Museum.

Genus MICROCERAS Hall

MICROCERAS INORNATUM (Hall)

Plate L, Figs. 21, 22

Microceras inornatus Hall, 1845, Amer. Jour. Sci. and Arts, vol. xlviii, p. 294.

Cyrtolites (Microceras) inornatus Meek, 1873, Geol. Surv. Ohio, Pal., vol. i, p. 147, pl. xiii, figs. 4a, b.

Cyrtolites subcompressus Meek, 1873, Geol. Surv. Ohio, Pal., vol. i, p. 147 (under *C. inornatus*).

Description.—Shell minute, the largest diameter being 1.25 mm. or less, consisting of two rapidly diminishing volutions which form a spire equally depressed on either side and obtusely carinated or angular upon the back. The carina is most conspicuous near the aperture and gradually becomes obsolete. The aperture is somewhat quadrangular and the surface is smooth.

This shell occurs almost invariably in association with several species of *Cyclora,* similar minute or dwarfed gastropods of larger species such as *Cyclonema* or *Lophospina.* In themselves these shells are of little value as horizon markers and it is only in association with other species that they are useful.

Waagen supposed the species of *Microceras* to represent "embryonic volutions of bellerophontes," but they are more likely dwarfed varieties or embryonic stages of some carinated genus such as *Cyrtolites.*

Occurrence.—MARTINSBURG SHALE (Sinuites bed). Chambersburg, Pennsylvania. Mohawkian and Cincinnatian rocks of the Ohio Valley, etc.

Collections.—Maryland Geological Survey, U. S. National Museum.

Family SINUITIDAE

Genus SINUITES Koken

SINUITES CANCELLATUS (Hall)

Plate LV, Figs. 12-21; Plate L, Figs. 37-39

Bellerophon bilobatus Emmons (not Sowerby), 1842, Geol. New York, vol. ii, p. 392, fig. 6.

Bellerophon cancellatus Hall, 1847, Pal. New York, vol. i, p. 307, pl. lxxxiii, figs. 10a-c.

Protowarthia cancellata Ulrich and Scofield, 1897, Minnesota Geol. Survey, Pal., vol. iii, pt. 2, p. 872, pl. lxiii, figs. 1-14.

Protowarthia cancellata Weller, 1903, Geol. Surv. New Jersey, Pal., vol. iii, p. 175, pl. xii, figs. 3-5.

Description.—" Shell of medium size, subglobose, close coiled, with no umbilicus when the shell is preserved, but with a small one in the casts. In immature specimens the dorsum of the outer volution is rather sharply rounded, but with increasing age it becomes more broadly rounded, losing entirely the obscure carination of the younger shells. Sinus shallow, rounded; the lateral margins of the aperture on either side of the sinus regularly and rather gently convex. Aperture wider than high, subsemicircular in outline. On the larger internal casts one or more rather broad and shallow, rounded, transverse, wrinkle-like depressions are frequently present near the aperture and parallel with the apertural margin.

" The dimensions of a large specimen are: Maximum diameter, 21 mm.; width of aperture, 18 mm."—Weller, 1903.

A wide-spread species of the United States and Canada ranging from the Trenton to and through the Richmond. In Pennsylvania and Maryland the species occurs at practically all the outcrops of the fossiliferous Sinuites bed and Eden divisions of the Martinsburg shale.

Occurrence.—MARTINSBURG SHALE. The slopes of Rickard Mountain in Maryland have furnished casts of the species.

Collections.—Maryland Geological Survey, U. S. National Museum.

SINUITES GRANISTRIATUS (Ulrich)

Plate LV, Figs. 9-11; Plate L, Figs. 40, 41

Protowarthia granistriata Ulrich, 1897, Minnesota Geol. Survey, Pal., vol. iii, pt. 2, p. 870, pl. lxiii, figs. 28-30.

Description.—" Shell scarcely reaching the medium size, closely coiled, leaving no umbilicus; center of dorsum raised into a low broad ridge, defined on each side by an obscure wide furrow; with age the outer boundaries of the latter increase gradually in distinctness, the back of the outer half of the last volution in the largest specimens presenting a flattened appearance; but the central ridge, though decreasing somewhat in hight, continues to the aperture. In casts of the interior there is a small umbilicus, while the central ridge is nearly as on the shell itself. Aperture transverse, about twice as wide as high, the width generally equalling the hight of the shell; sinus wide, only moderately deep, the margin of the lobes bending rather sharply where the apertural margin is intersected by the faintly raised boundaries of the flattened dorsum. Except in the umbilical regions the test is thin. Out of nearly 30 specimens, only two preserve anything of the external layer. These show that it is marked by fine lines of growth and by very delicate revolving lines. All of the other testiferous examples preserve only the inner and middle layers, the latter appearing in every case quite smooth. Most of the specimens preserve what may be called a fourth layer. This seems to have been deposited by the inner mantle over the inner volutions, including the smaller half of the outer, while on each side it extends around the callous filling of the umbilicus. The whole of this layer is finely granulose, except the lateral extensions, and these are covered by wavy revolving striae. Hight of an average shell, 19 mm.; width of aperture, 19 mm.; median hight of same, 9.3 mm.; width of inner volution, 6 mm.; depth of sinus, 5 mm.; width of same, about 10 mm."—Ulrich, 1897.

This shell is related to the preceding *Sinuites cancellatus,* but the latter species has a deeper sinus, a rounder back and no dorsal ridge nor obscure furrows. When well preserved, the difference in surface markings is also a distinguishing character.

The types are from the Eden shale of the Ohio Valley. In the Appalachian Valley the species is known from the corresponding horizon in southern Pennsylvania, the upper part (Eden) of the Martinsburg shale, and also from the Sinuites bed.

Occurrence.—MARTINSBURG SHALE. Jordans Knob, one and one-half miles northeast of Fort Loudon; Chambersburg; two miles south of St. Thomas, Pennsylvania; Rickard Mountain, Maryland.

Collection.—U. S. National Museum.

Family TROCHONEMATIDAE

Genus STROPHOSTYLUS Hall

STROPHOSTYLUS TEXTILIS Ulrich and Scofield

Plate L, Figs. 31-36

Strophostylus textilis Ulrich and Scofield, 1897, Minnesota Geol. Survey, Pal., vol. iii, pt. 2, p. 1064, pl. lxxxii, figs. 49-54.

Description.—" Shell rather small, 12 to 25 mm. high, 11 to 20 mm. wide, obliquely conical; apical angle 60° to 70°; whorls, in casts, three or four, in entire shells, six or seven, increasing quite regularly in size from the acute apex, almost uniformly rounded, often with several widely separated, deep, oblique constrictions; suture deep; aperture subovate, oblique; inner lip appearing thin in a ventral view, but when a part of the outer wall is removed it is seen that it forms a moderately thick columella with a spiral fold beginning near the lower angle. In young examples neither the fold nor a spiral furrow just above it is very distinct, while in some cases the whole inner lip appears to be simple and thin as in *Holopea.* Surface beautifully cancellated by subequal, fine, sharp, revolving and obliquely transverse lines, the network growing strong enough on the last whorl to be distinctly visible to the naked eye."—Ulrich and Scofield, 1897.

The graceful form and beautiful markings of this shell are features which aid in its ready recognition.

Occurrence.—MARTINSBURG SHALE (Sinuites bed). Chambersburg, Pennsylvania. Black River and Trenton of Minnesota, Missouri and Kentucky.

Collection.—U. S. National Museum.

Genus CYCLORA Hall

CYCLORA MINUTA Hall

Plate L, Figs. 23-26; Plate LII, Figs. 10-12

Cyclora minuta Hall, 1845, Amer. Jour. Sci. and Arts, vol. xlviii, p. 294.
Holopea nana Meek, 1871, Proc. Acad. Nat. Sci. Phila., p. 172.
Cyclora minuta Meek, 1873, Geol. Surv. Ohio, Pal., vol. i, p. 152, pl. xiii, figs. 7a-e.

Description.—Shell small, averaging 1.00 mm. in height, smooth, consisting of about three volutions which rapidly expand toward the mouth and form a moderately elevated spire. The upper two whorls are quite small and the shell is formed in large part by the third whorl. The aperture is round and well defined.

This interesting minute species occurs literally by the million at certain Middle and Upper Ordovician horizons where usually all the associated shells are similar dwarfed or embryonic forms. *Cyclora minuta* possibly represents the very young stages of *Cyclonema* or *Strophostylus*, althougn its black corneous shell substance is quite different from either of these genera. Probably a closer assumption would be to consider them as embryonic forms of *Holopea*. The latter genus, however, is sparsely represented by individuals in the rocks in which Cyclora abounds.

Common at many horizons and localities of the Mohawkian and Cincinnatian in the United States and Canada. In the Cumberland Valley, however, it has been found only in the lower portions of the Martinsburg shale, particularly in the Sinuites zone at the base.

Occurrence.—MARTINSBURG SHALE (Sinuites and Corynoides beds). Chambersburg, Pennsylvania; Williamsport, Maryland and Strasburg, Virginia.

Collections.—Maryland Geological Survey, U. S. National Museum.

CYCLORA PARVULA (Hall)

Plate L, Figs. 28-30

Turbo ? parvulus Hall, 1845, Amer. Jour. Sci. and Arts, vol. xlviii, p. 294.
Cyclora ? parvula Meek, 1893, Geol. Surv. Ohio, Pal., vol. i, p. 154.

Description.—" Spire elevated, volutions about four, smooth; first whorl angulated upon the center towards the aperture; outer edge of the aperture projecting downwards. Height of shell 1/15 of an inch."—Hall, 1845.

Although this species has not been figured heretofore and its description was quite meager, there is no difficulty in distinguishing it from other forms of *Cyclora* because of the angulation of the first whorl towards the aperture. The other species of *Cyclora* have rounded whorls and may represent the young of such genera as *Cyclonema* or *Hormotoma*. The angulated whorl of *Cyclora parvula* would suggest its relationship to *Lophospira* or some similar genus.

Common in association with *Cyclora minuta* Hall in the Mohawkian and Cincinnatian rocks at Cincinnati, Ohio, and many other localities.

Occurrence.—MARTINSBURG SHALE (Sinuites bed). Chambersburg, Pennsylvania, and Strasburg, Virginia.

Collections.—Maryland Geological Survey, U. S. National Museum.

CYCLORA HOFFMANNI Miller

Plate L, Fig. 27

Cyclora hoffmanni Miller, 1874, Cincinnati Quart. Jour. Sci., vol. 1, p. 313, fig. 33.

Description.—Shell minute, the average length being about 1.50 mm., consisting of an elongated spire made up of five or six volutions which are round and increase gradually in size. Whorls quite convex, with a deep suture; aperture nearly circular, directed slightly downward; surface smooth.

This neat, elongate little species is usually found associated with *Cyclora minuta* and *Microceras inornatum,* and like them has little stratigraphic value. In the Appalachians, however, these species are known only in the Trenton portion of the Martinsburg shale.

Occurrence.—MARTINSBURG SHALE (Sinuites bed). Chambersburg, Pennsylvania, and Strasburg, Virginia.

Collections.—Maryland Geological Survey, U. S. National Museum.

Order OPISTHOBRANCHIA

Suborder PTEROPODA

Family HYOLITHIDAE

Genus HYOLITHES Eichwald

HYOLITHES COMMUNIS Billings

Plate XXV, Figs. 5-8

Hyolithes communis Billings, 1872, Canadian Nat., n. s., vol. vi, p. 214.
Hyolithes communis Walcott, 1886, Bull. U. S. Geol. Surv., No. 30, p. 136, pl. xiv, figs. 3, 3a-c.
Hyolithes communis Walcott, 1890, 10th Ann. Rep. U. S. Geol. Surv., p. 620, fig. 65, pl. lxxvii, figs. 3, 3a-g.

Description.—" This species attains a length of about 18 lines, although the majority of the specimens are from 10 to 15 lines in length. The ventral [dorsal] side is flat (or only slightly convex) for about two-thirds the width, and then rounded up to the sides. The latter are uniformly convex. The dorsum [ventrum], although depressed convex, is never distinctly flattened, as is the ventral [dorsal] side. The lower lip projects forward for a distance equal to about one-fourth or one-third the depth of the shell. In a specimen whose width is three lines, the depth is two lines and a half.

" The operculum is nearly circular, gently but irregularly convex externally and concave within. The ventral [dorsal] limb is seen on the outside as an obscurely triangular, slightly elevated space; the apex of the triangle being situated nearly in the center of the operculum. The base of the triangle forms the ventral [dorsal] margin. This limb occupies about one-third of the whole superficies of the external surface. The remainder, constituting the dorsal [ventral] limb, is nearly flat, slightly elevated from the margin towards the center. On each side of the apex of the ventral [dorsal] limb there is a slight depression running from the nucleus out to the edge. On the inside there is an obscure ridge corresponding to each one of the external depressions. It is most prominent where it reaches the edge. These two ridges meet at the center and divide the whole of the inner surface of the operculum into two nearly equal proportions.

"The surface of the operculum is concentrically striated. The shell itself in some of the specimens is covered with fine longitudinal striae, from five to ten in the width of a line. The shell varies in thickness in different individuals. In some it is thin and composed of a single layer, but in others it is much thickened by concentric laminae, and thus approaches the structure of a *Salterella.* There are also fine engirdling striae, and sometimes obscure subimbricating rings of growth."—Billings, 1872.

The above description with the emendation as to the ventral and dorsal sides given by Walcott, will serve for the recognition of the poor fragments found in the Maryland strata.

Occurrence.—ANTIETAM SANDSTONE. Eakles Mills, Maryland, and the same horizon in Pennsylvania.

Collections.—Maryland Geological Survey, U. S. National Museum.

Suborder CONULARIIDA

Family TORELLELLIDAE Holm

Genus SALTERELLA Billings

SALTERELLA sp.

Description.—Certain layers in the lower part of the Tomstown limestone have exhibited molds of small, hollow, slender shells with a striated surface. These show that the shell is composed of several hollow cones placed one within the other as in the genus *Salterella.* These remains are too imperfect for description or illustration, but they are interesting on account of their occurrence in the Tomstown limestone where fossils are exceedingly scarce.

Occurrence.—TOMSTOWN LIMESTONE. Several localities east and southeast of Waynesboro, Pennsylvania.

Collection.—U. S. National Museum.

Genus COLEOLUS Hall

COLEOLUS IOWENSIS James

Plate XLIX, Figs. 22, 23

Coleolus iowensis James, 1890, Amer. Geol., vol. v, p. 355.

Description.—This species has never been illustrated, but it has been known for many years as a very abundant fossil in the Maquoketa shale of Richmond age in Illinois and Iowa. It occurs here in great numbers associated with *Cyclora minuta* and similar small gastropod shells, as well as such minute pelecypods as *Ctenodonta obliqua* and *Clidophorus.* The shell layer is seldom preserved, the species occurring almost invariably as phosphatized casts of the interior. The surface markings of the outer shell are occasionally preserved as molds of the exterior in which it may be noted that the shell surface is smooth or sometimes very minutely annulated. The shell itself is an elongate, gradually tapering, straight or slightly curved cone, 15 to 20 mm. long and a millimeter in diameter at its widest portion. The diameter and length of different examples of the species vary considerably, indeed quite frequently these fossils occur only as broken fragments.

Occurrence.—MARTINSBURG SHALE (Sinuites bed). Chambersburg, Pennsylvania.

Abundant in the Mohawkian and Cincinnatian rocks of Iowa, Illinois, and many other states, the types coming from the Maquoketa shale division of the Richmond group of Iowa.

Collections.—Maryland Geological Survey, U. S. National Museum.

Family CONULARIIDAE

Genus CONULARIA Miller

CONULARIA TRENTONENSIS Hall

Plate L, Fig. 42

Conularia trentonensis Hall, 1847, Nat. Hist. New York, Pal., vol. i, p. 222, pl. lix, figs. 4a-f.

Conularia trentonensis Weller, 1903, Geol. Surv. New Jersey, Pal., vol. iii, p. 188, pl. iii, figs. 7, 8.

Description.—" Shell of medium size, pyramidal in form, quadrangular in cross-section, the sides diverging from the apex at an angle of about

25°. The sides slightly convex, the angles furrowed. Each side marked by a series of angular, transverse costae, which are directed obliquely forward toward the aperture from each lateral margin forming a rounded angle of about 130° at the median line; from two to four of these costae occupy the space of 1 mm., being closer together and finer near the apex of the shell and becoming progressively coarser towards the aperture. The furrows between the costae are wider than the ridges, rounded in the bottom, and are crossed at right angles by fine raised bars joining adjacent costae, which are somewhat closer together than the costae themselves and not quite as high.

"The dimensions of a specimen which is somewhat incomplete at the apex are: Length, 38 mm.; diameter at aperture, 18 mm."—Weller, 1903.

Occurrence.—MARTINSBURG SHALE (Sinuites bed). Five miles southwest of Chambersburg, Pennsylvania, and at Strasburg, Virginia. Trenton limestone of New York.

Collection.—U. S. National Museum.

CLASS CEPHALOPODA

Subclass TETRABRANCHIATA

Order NAUTILOIDEA

Suborder HOLOCHOANITES

Family ENDOCERATIDAE

Genus CAMEROCERAS Conrad

CAMEROCERAS sp.

Plate XXXVII, Fig. 10

Description.—The thin slabs of Frederick limestone not infrequently exhibit subcylindrical bodies now composed of crystalline matter, which are supposed to represent the endosiphuncle of some species of *Cameroceras.* With no other evidence it is impossible to identify the species of this cephalopod.

Occurrence.—FREDERICK LIMESTONE. Frederick, Maryland, and neighboring localities.

Collection.—U. S. National Museum.

Suborder ORTHOCHOANITES

Family ORTHOCERATIDAE

Genus ORTHOCERAS Breynius

ORTHOCERAS PRIMIGENIUM Vanuxem

Plate XXXII, Fig. 5

Orthoceras primigenium Vanuxem, 1842, Geol. New York, 3d Dist., p. 36, fig. 4.

Orthoceras primigenium Whitfield, 1889, Bull. Amer. Mus. Nat. Hist., vol. ii, No. 2, p. 56, pl. x, fig. 1.

Orthoceras primigenium Cleland, 1903, Bull. Amer. Pal., vol. iv, p. 14, pl. iii, figs. 8, 9.

Description.—In spite of 15 or more references to this cephalopod, the species cannot yet be said to have been sufficiently described for accurate determination. Really this name has been employed for any gradually tapering, straight cephalopod of the Canadian in which the septa are thin, deeply concave, and closely arranged. In the present case the same procedure has been followed, for the identification of this species in Maryland has been based upon longitudinal sections in the rock showing no other characters than those just mentioned. However, it is believed that this identification will be found correct when specimens from the New York type localities are restudied, since Vanuxem's type came from the Tribes Hill limestone and the Maryland examples are from the corresponding formation in that state.

Occurrence.—BEEKMANTOWN LIMESTONE (Stonehenge member). Hagerstown, Maryland, and vicinity.

Collections.—Maryland Geological Survey, U. S. National Museum.

ORTHOCERAS ARCUOLIRATUM Hall

Plate XLVIII, Fig. 22

Orthoceras arcuoliratum Hall, 1847, Pal. New York, vol. i, p. 198, pl. xlii, figs. 7a-c.

Description.—" Slender, very gradually tapering to an acute point; surface marked by strong and extremely arching or undulating annulations, and obscurely, by fine longitudinal striae; annulations about equalling the spaces between them; outer chamber and aperture unknown; section circular; siphuncle central.

" The distinguishing features of this species are its slender form and extremely arched annulations, which, in half the circumference, ascend twice the width of the space between each annulation. All the other annulated species have the ridges less arched upon the back."—Hall, 1847.

Occurrence.—CHAMBERSBURG LIMESTONE (Greencastle bed). Greencastle, Pennsylvania. Trenton limestone of New York.

Collection.—U. S. National Museum.

ORTHOCERAS JUNCEUM Hall

Plate LI, Figs. 4-7

Orthoceras junceum Hall, 1847, Pal. New York, vol. i, p. 204, pl. xlvii, figs. 3a-f.

Orthoceras junceum Clarke, 1897, Minnesota Geol. and Nat. Hist. Surv., Pal., vol. iii, pt. 2, p. 790.

Description.—" Slender, tereta-cylindrical, tapering very gradually; septa thin, distant from one-fourth to one-third the diameter; outer chamber deep; siphuncle small, central; section circular; surface finely striated transversely, but without longitudinal striae."—Hall, 1847.

This rather frequently quoted species has received no further study since Hall's original description in 1847 and it is probable that many misidentifications of it have been made. However, fragments of an *Orthoceras* from the basal Martinsburg shale of southern Pennsylvania agree so well with typical specimens of *O. junceum* from the type locality that it is believed the present identification is correct.

Occurrence.—MARTINSBURG SHALE (Sinuites bed). Chambersburg, Pennsylvania. Trenton limestone of New York.

Collection.—U. S. National Museum.

ORTHOCERAS TRANSVERSUM Miller

Plate LV, Fig. 27

Orthoceras transversum Miller, 1875, Cincinnati Quart. Jour. Sci., vol. ii, p. 129.

Orthoceras transversum Miller, 1889, North Amer. Geol. Pal., p. 452, text fig. 755.

Description.—"Shell medium size, rather rapidly enlarging; septa strongly arched and distant about one-fourth or one-fifth the diameter of the shell; siphuncle excentric, its form not observed; outer shell thin and marked by strong transverse lines, distant from 1-100th to 4-100ths of an inch in a specimen having a diameter at the large end of three-fourths of an inch. The distance between these lines seems to increase as the diameter of the shell increases, but their distance apart is not uniform in different specimens of the same size. About four or five of these transverse lines will mark the distance between the septa, though they do not seem to have any connection with the arrangement of the latter"—Miller, 1875.

The well-marked transverse lines of this species cause its recognition to be quite easy.

Occurrence.—MARTINSBURG SHALE (Eden division). Jordans Knob, one and one-half miles northeast of Fort Loudon, Pennsylvania; and Rickard Mountain, Washington County, Maryland. Eden shale at Cincinnati, Ohio.

Collection.—U. S. National Museum.

ORTHOCERAS LAMELLOSUM Hall

Plate LVIII, Figs. 5, 6

Orthoceras lamellosum Hall, 1847, Pal. New York, vol. i, p. 312, pl. lxxxvi, figs. 2a-e.

Description.—Shell slender and gradually tapering; septa distant from each other one-fifth to one-fourth of an inch and having a convexity about equal to their distance apart; siphuncle slightly excentric; surface apparently lamellose or subimbricate.

This seems to be a well-defined species since the specimens from southern Pennsylvania show no apparent deviation from Hall's figures. Unfortunately these specimens are no better preserved than the types and it is impossible to add anything to the above description except to record the occurrence in new localities.

Occurrence.—MARTINSBURG SHALE (Fairview division). Tuscarora Mountain, one and one-half miles east of McConnellsburg, Pennsylvania. Pulaski shale of New York.

Collection.—U. S. National Museum.

Family CYCLOCERATIDAE

Genus SPYROCERAS Hyatt

SPYROCERAS BILINEATUM (Hall)

Plate LI, Figs. 1-3

Orthoceras bilineatum Hall, 1847, Pal. New York, vol. i, p. 35, pl. vii, figs. 4, 4a.

Orthoceras bilineatum Clarke, 1897, Geol. Minnesota, vol. iii, pt. 2, p. 786, pl. xlvii, figs. 20, 21; pl. liv, figs. 6, 7.

Description.—Shell comparatively small, gradually expanding, subcircular in cross-section. Surface smooth over the apical region; concentric annulations then develop, very obscure at first, but increasing in strength, until they become strong, oblique, or undulating ridges which are broad and most conspicuous near the aperture. Like these annulations the interspaces, which are somewhat wider, also become broader toward the body-chamber. An average complete shell probably has a length of about 150 mm. with an apertural diameter of not more than 20 mm.

Surface ornamented by coarse and fine vertical, elevated lines, crossed by extremely fine horizontal lines. Slight nodes or projections mark the crossing of the two sets of lines. The smooth portion of the shell near the apex exhibits the vertical lines in two simple series. With growth the lines increase in number and the alternation in size of the striae becomes less pronounced. The horizontal striae are quite delicate and often not visible at all.

The sipho is small and nearly central. The septa are rather shallow, the sutures transverse, averaging 2.50 mm. apart and with no definite relation to the annulations. The latter sometimes being oblique are crossed by the sutures which, however, may occur within a furrow.

Occurrence.—MARTINSBURG SHALE (Sinuites bed). Chambersburg, Pennsylvania. Black River and Trenton of New York and Canada.

Collection.—U. S. National Museum.

Family TROCHOLITIDAE

Genus TROCHOLITES Conrad

TROCHOLITES INTERNISTRIATUS (Whitfield)

Plate XXXV, Fig. 14

Lituites internistriatus Whitfield, 1886, Bull. Amer. Mus. Nat. Hist., vol. i, p. 332, pl. xxix, figs. 5-8.

Trocholites internistriatus Ruedemann, 1906, Bull. New York State Mus., 90, p. 479, pl. xxiv, fig. 2, text fig. 38.

Description.—Shell of rather small size, being about 50 mm. in diameter, and consisting of between two and three volutions. Volutions very slightly compressed laterally, but nearly circular in general outline, with a rounded dorsal margin. Outer surface of volutions obliquely annulated with the annulations best developed on the sides and rounded on the surface; in each case separated by concave interspaces of equal width. The annulations are directed strongly backward from the suture on the side of the shell, where they gradually die out and then become obsolete or nearly so on the dorsum. Shell substance thick, the surface on the undulations and between marked by strong, almost lamellose striae, following the direction of the undulations on the sides of the shell, forming a deep retral sinus on the dorsum indicating a deep sinus in the dorsal lip of the aperture. Interior of the shell as indicated in exfoliated specimens marked throughout by very fine, transverse, thread-like striae, directed almost across the tube and numbering about 30 in the space of 2.5 mm. Septa about 2.5 mm. apart near the base of the outer chamber and apparently rather deeply concave. Siphon near the inner margin of the tube and comparatively large.

The few examples of this fine cephalopod discovered in Maryland do not preserve all the surface features mentioned above, but they agree in size and general outline.

Occurrence.—BEEKMANTOWN LIMESTONE (Turritoma zone). Stoufferstown, Pennsylvania, and east of Huyett, Maryland. Fort Cassin, Vermont.

Collection.—U. S. National Museum.

TROCHOLITES AMMONIUS Conrad

Plate L, Fig. 43

Trocholites ammonius Conrad, 1838, 2d Ann. Rept. New York Geol. Surv., p. 119.

Trocholites ammonius Hall, 1847, Pal. New York, vol. i, p. 192, pl. xlA, figs. 4a-k.

Description.—"Discoidal; volutions in the same plane, about four, rounded, slightly concave on the ventral side, gradually enlarging in size towards the aperture, which is slightly expanded; surface marked by lamellose irregular and oblique transverse striae or ridges, between and upon which are finer lamellose striae, covering the outer surface, and giving it a peculiar textural or netted appearance; striae meeting in an arch upon the back; septa direct, or slightly undulated on the dorsal side; outer chamber large; siphuncle ventral."—Hall, 1847.

Only a small and imperfect example of this beautiful coiled cephalopod has been noted in the Trenton fauna at the base of the Martinsburg shale. So far as it goes this specimen agrees with the well-known *Trocholites ammonius* of the New York Trenton.

Occurrence.—MARTINSBURG SHALE (Sinuites bed). Chambersburg, Pennsylvania. Trenton limestone of New York and Kentucky.

Collection.—U. S. National Museum.

Suborder CYRTOCHOANITES

Family ACTINOCERATIDAE

Genus GONIOCERAS Hall

GONIOCERAS CHAZIENSE Ruedemann

Plate XLI, Fig. 19

Gonioceras chaziense **Ruedemann, 1906, New York State Mus. Bull., 90, p. 494, pl. xxxvi, figs. 3, 4.**

Description.—" The natural section exposes the septa, which are closely arranged, there being 10 of them counted within the space of 20 mm.; each septum rises within the body of the shell to about the height of five cameras, forming broad and low saddles in the lateral flanges, and becoming slightly deflected backward towards the outer margin of the flanges. Their central portions are much thickened by secondary deposits. The outer conch, which according to Hall is also in the other species of *Gonioceras* excessively thin, is not preserved; the greatest width of the phragmocone, as indicated by the septa, is a little over 70 mm. The phragmocone appears to have been at least as rapidly expanding as that of *G. anceps.* The siphuncle is very large (its diameter 7 mm.), strongly nummuloidal, filled with organic deposits which leave open but a narrow endosiphotube. From the latter radiate horizontal tubuli as in the other congeners. We have not been able to ascertain the transverse section of the conch and the surface is unknown."—Ruedemann, 1906.

Occurrence.—CHAMBERSBURG LIMESTONE (Caryocystites bed). Fort Loudon, Franklin County, Pennsylvania. Middle Chazyan of New York.

Collection.—U. S. National Museum.

Family OOCERATIDAE

Genus OOCERAS Hyatt

OOCERAS KIRBYI (Whitfield)

Plate XXXII, Figs. 19, 20

Cyrtoceras kirbyi **Whitfield, 1889, Bull. Amer. Mus. Nat. Hist., vol. ii, p. 57, pl. x, figs. 4-7.**

Cyrtoceras kirbyi? **Cleland, 1900, Bull. Amer. Pal., vol. iii, p. 131 (259), pl. xvii, figs. 3, 4.**

Description.—Shell strongly curved and laterally compressed, increasing moderately in dimension with the length. Cross-section ovate, somewhat more than three-fifths as wide as long, with the widest part within the median line and the narrowest at the dorsum, which is narrowly rounded. Septa deeply concave, somewhat numerous and closely spaced, 12 of the chambers near the outer part on the dorsal edge occurring in 25 mm. Siphon small and in contact with the shell at the dorsal margin. Living chamber comparatively long and apparently not constricted near the aperture. Surface of the shell without ornamentation and moderately thick.

Occurrence.—BEEKMANTOWN LIMESTONE (Stonehenge member). South of Funkstown, Maryland. Tribes Hill limestone of New York.

Collection.—U. S. National Museum.

Genus CYRTOCERAS Goldfuss

CYRTOCERAS GRACILE Cleland

Plate XXXII, Figs. 3, 4

Cyrtoceras sp. Cleland, 1900, Bull. Amer. Pal., vol. iii, p. 19, pl. xvii, figs. 5, 6.

Cyrtoceras gracilis Cleland, 1903, Bull. Amer. Pal., vol. iv, p. 13, pl. iii, fig. 11.

Cyrtoceras sp. Weller, 1903, Pal. New Jersey, vol. iii, p. 131, pl. v, figs. 7, 8.

Description.—Shell small, 12 mm. long and 8 mm. in diameter, slender, arcuate, oval in transverse section. Siphuncle small and placed near the ventral edge. Septa smooth, slightly concave, close together, with five to six occurring in 4 mm.

The shape and small size of this cephalopod and the closely arranged septa will distinguish it from other Canadian species.

The species was based upon specimens from the Tribes Hill limestone at Fort Hunter, Tribes Hill, and Canajoharie, New York. The same or a very similar species occurs in the Canadian portion of the Kittatinny limestone at Columbia, New Jersey.

In Maryland, natural longitudinal and cross-sections of apparently the same species have been noted on the weathered surface of the lower Stonehenge limestone.

Occurrence.—BEEKMANTOWN LIMESTONE (Stonehenge member). One-half mile south of Funkstown, and near Hagerstown.

Collection.—U. S. National Museum.

CYRTOCERAS BEEKMANENSE Whitfield

Plate XXXII, Figs. 1, 2

Cyrtoceras beekmanensis Whitfield, 1889, Bull. Amer. Mus. Nat. Hist., vol. ii, p. 57, pl. x, figs. 2, 3.

Description.—Shell as usually observed, from 75 to 100 mm. in length and less than 25 mm. wide, little curved, the amount of curvature not amounting to more than 3 mm. in a length of 75 mm.; laterally compressed so that the lateral diameter is somewhat less than the dorso-ventral; slightly oval in cross-section. Septa numerous, 14 chambers occurring in 25 mm., little curved and of shallow depth. Outer chamber of shell long. Siphon unknown. Surface of shell apparently smooth.

Occurrence.—BEEKMANTOWN LIMESTONE (Stonehenge member). National Highway, one-half mile south of Funkstown, Maryland.

Collection.—U. S. National Museum.

CYRTOCERAS CAMURUM Hall

Plate XLVIII, Fig. 21

Crytoceras camurum Hall, 1847, Pal. New York, vol. i, p. 196, pl. xlii, fig. 6.
Cyrtoceras camurum Clarke, 1897, Geol. Minnesota, 3, pt. 2, p. 805, pl. lx, figs. 5, 6.

Description.—Fragments of a curved cephalopod occurring in the strata just above the typical Christiania bed in the vicinity of Greencastle, Pennsylvania, are so similar to the New York lower Trenton species described as *Cyrtoceras camurum* by Hall that they are believed to be the same. In neither area have complete specimens been found, so that it is still impossible to give a full description of the species.

Occurrence.—CHAMBERSBURG LIMESTONE (Greencastle bed). Greencastle, Pennsylvania. The type locality is the Trenton limestone at Middleville, New York, but this species has also been identified in the Black River rocks of Wisconsin.

Collection.—U. S. National Museum.

Genus CYRTOCERINA Billings

CYRTOCERINA MERCURIUS Billings

Plate XXXV, Fig. 13

Cyrtocerina mercurius Billings, 1865, Pal. Foss., vol. 1, Geol. Surv. Canada, p. 194, text fig. 179.

Description.—Shell short, strongly curved and tapering abruptly; elliptical in section, the dorso-ventral diameter being one-third or one-fourth greater than the lateral. Measured on the surface of the ventral side near the living chamber the septa are about 1 mm. apart, but on the dorsal side near the apex they are probably closer together. Siphuncle in contact with the shell on its dorsal side.

The dorsal position of the siphuncle, the close arrangement of the septa, and the strongly curved, abruptly tapering features are characters to aid in the recognition of this shell, although the species cannot be considered to be fully described as yet.

Occurrence.—BEEKMANTOWN LIMESTONE (Turritoma zone). Stouf-ferstown, Pennsylvania, and east of Huyett, Maryland.

Collection.—U. S. National Museum.

Family ONCOCERATIDAE

Genus CYCLOSTOMICERAS Hyatt

CYCLOSTOMICERAS CASSINENSE (Whitfield)?

Plate XXXII, Figs. 6, 7

Gomphoceras cassinense Whitfield, 1886, Bull. Amer. Mus. Nat. Hist., vol. 1, p. 322, pl. xxix, figs. 1-3.

Cyclostomiceras cassinense Ruedemann, 1906, New York State Mus. Bull., No. 90, p. 50, fig. 56; pl. xxxvii, figs. 1-3; pl. xxxviii, figs. 5, 6.

Description.—This species has been carefully described by Ruedemann to whose work of 1906 the student is referred for details and illustrations. The entire shell attains a size of about 100 mm. and a greatest width of 40 mm. The rate of growth is quite rapid, the living chamber is large, forming nearly half of the shell, the septa are shallow, and the siphuncle is large. Sections in the rock seen at several Maryland outcrops exhibit a cephalopod with the same rate of growth and other characters just mentioned, but better material is necessary before the determination can be made with certainty.

Occurrence.—BEEKMANTOWN LIMESTONE (Stonehenge member). Near Funkstown, Maryland. Cassin beds at Fort Cassin, Vermont.

Collection.—U. S. National Museum.

ARTHROPODA

CLASS CRUSTACEA

Subclass TRILOBITA

Order HYPOPARIA

Family HARPEDIDAE

Genus EOHARPES Raymond

EOHARPES OTTAWAENSIS (Billings)

Plate LI, Fig. 11

Harpes ottawaensis Billings, 1865, Pal. Foss., vol. i, Geol. Surv. Canada, p. 182, text fig. 165.

Harpina ottawaensis Weller, 1903, Geol. Surv. New Jersey, Pal., vol. iii, p. 191, pl. xiv, figs. 1, 2.

Harpina ottawaensis Raymond, 1905, Annals Carnegie Mus., vol. iii, p. 331, pl. x, fig. 2.

Eoharpes ottawaensis Ruedemann, 1912, New York State Mus., Bull. No. 162, p. 116, pl. ix, fig. 1.

Description.—"Head strongly convex, with a wide, punctured border which extends backward to about the thirteenth segment of the thorax. If a line be drawn across touching the posterior edge of the neck segment, the contour in front of that line is nearly a perfect semicircle. Glabella regularly conical, its length about five-ninths that of the head; posterior furrows distinct, entering at about one-half the distance from the ocular ridge to the posterior margin of the neck segment, thence running obliquely inward and backwards at an angle of about 45°, apparently not quite one-third the width; two anterior furrows on each side, represented by obscure pits; neck furrow narrow; neck segment convex, strongly elevated on the fixed cheeks. The eyes (ocelli) are small and situated on a line drawn across the glabella at the anterior fourth; ocular ridge well defined, smooth, prolonged, with a backward curve outside of the eye. Thorax a little more than half the width of the head; the axis strongly convex and gradually tapering backwards; side lobes flat; plurae with a wide groove along the middle, a small portion of their outer extremities turned backward. Surface of thorax, glabella and a subreniform space on each side of the base of the glabella smooth; the border with circular punctures about 0.2 mm. in width; the punctures large and more distant at the inner edge of the border; on the elevated part of the cheeks they have a subreticulated arrangement."—Billings, 1865.

This splendid species of which a nearly complete example has been described as above by Billings, is represented in the Trenton fauna at the base of the Martinsburg shale by fragments only, which, however, agree fairly well with the corresponding parts of the specimen figured by Billings and here reproduced on pl. LI.

Occurrence.—MARTINSBURG SHALE (Sinuites bed). Chambersburg, Pennsylvania. Trenton limestone of Ontario, New York and Minnesota.

Collection.—U. S. National Museum.

Family TRINUCLEIDAE

Genus CRYPTOLITHUS Green

CRYPTOLITHUS BELLULUS (Ulrich)

Plate LVI, Figs. 5, 6

Trinucleus bellulus Ulrich, 1878, Jour. Cincinnati Soc. Nat. Hist., vol. i, p. 99, pl. iv, fig. 15.

Description.—"Body small, nearly flat, and symmetrical. Cephalic shield about three times as wide as long, subquadrate, with a distinct thoracic ring at the base, which is straight, with the posterior angles acutely angular or slightly rounded, and without any long spines; glabella prominent, pyriform and produced posteriorly, into a long spine, reaching to the pygidium; cheeks not as prominent as the glabella, triangular, and finely punctate; marginal fillet wide, marked in front by from three to four rows of deep, rounded pores or punctures; the rows increase by implantation as they approach the posterior lateral margins, where they number from six to seven.

"The thorax consists of six articulations; axial lobe depressed, convex, narrow, and carrying on each side between the segments two rows of minute punctures; lateral lobes flat, and three times as wide as the central lobe; pleura straight, and furrowed on the outer half.

"Pygidium small, acutely semi-elliptic, being about four times as wide as long, and broadly rounded in outline behind, with a raised and thickened margin; axial lobe very small, and composed of four obscurely defined segments; lateral lobes each with three segments.

"Length of largest known specimen, 6 mm.; length of cephalic shield, 3.5 mm.; breadth of do., 7 mm.; length of thorax, 1.25 mm.; breadth of do., 4.5 mm.; length of pygidium, 75 mm.; breadth of do., 4 mm."—Ulrich, 1878.

This interesting species is distinguished from all American and European species of the genus in the straightness or slight concavity of the posterior edge of the cephalon, and in the relative flatness of the border. The thorax also is shorter and the neck spine longer. In young specimens such as the original type, these peculiarities are especially marked. In old examples the posterior edge of the cephalon turns somewhat posteriorly at the ends, but it is still much less curved than in all other species.

Occurrence.—MARTINSBURG SHALE (Eden division). Jordans Knob, one and one-half miles northeast of Fort Loudon, Cowans Gap, five miles northeast of McConnellsburg, and Tuscarora Mountain, two and one-half miles southeast of McConnellsburg, Pennsylvania. Eden shale at Covington, Kentucky.

Collection.—U. S. National Museum.

CRYPTOLITHUS RECURVUS Ulrich n. sp.

Plate LVI, Figs. 14-17

Description.—This new species has been discriminated by E. O. Ulrich, who has had the opportunity of studying a large number of foreign and American specimens of this genus. *Cryptolithus recurvus* differs from the Trenton form usually identified as *Cryptolithus tesselatus* Green or *Trinucleus concentricus* Hall by the great width and decided posterior recurvance of the border and by its steeper slope, the cephalon as a whole being therefore more convex. *C. concentricus* resembles it in the last respect, but its border is of less width and has fewer rows of pits. Among the differences distinguishing the species from all the American species of the genus is the finely punctate and not reticulate marking of the glabella and lateral lobes.

The type specimens figured were collected in the Eden shale at Covington, Kentucky, and in the uppermost Trenton limestone at the same place.

Occurrence.—MARTINSBURG SHALE (Eden division). Jordans Knob, one and one-half miles northeast of Fort Loudon, Pennsylvania.

Collection.—U. S. National Museum.

CRYPTOLITHUS TESSELATUS Green

Plate LI, Figs. 19, 20; Plate LII, Fig. 17

Cryptolithus tesselatus Green, 1832, Monograph Trilobites North America, p. 73, cast 38, pl. i, fig. 4.

Trinucleus concentricus Hall, 1847, Pal. New York, vol. i, p. 249, pl. lxv, figs. 4a, c.

Trinucleus concentricus Weller, 1903, Geol. Surv. New Jersey, Pal., vol. iii, p. 192, pl. xiv, figs. 3, 4.

Description.—" Head semi-circular or subcrescent-form in outline, the genal angles either destitute of spines or produced into long, slender, straight spines. Glabella smooth, very prominent, ovoid in outline, the widest portion being in front, with a short, blunt spine posteriorly; cheeks smooth, prominent, but depressed considerably below the glabella, from which they are separated by a well-defined dorsal furrow; eyes wanting. The entire anterior and lateral margins of the head are surrounded by a broad, somewhat flattened or concave border, which is marked in front by from three to five concentric rows of deep, rounded pits; one or two additional rows are introduced on the sides, and toward the genal angles the pits often become irregularly scattered. Length, 10 mm.; width, 15 mm.; convexity, 6 mm."—Weller, 1903.

Several distinct species are doubtless included in the many descriptions that have been published under the name of *Cryptolithus tesselatus* and more particularly *Trinucleus concentricus.* The specimens from the base of the Martinsburg shale, however, are undoubtedly the same specifically as the Trenton forms upon which Green and Hall based their figures and descriptions. The New Jersey Trenton specimens described as above by Weller likewise belong to the same species.

This species is generally quoted as ranging from the base of the Trenton to the middle part of the Maysville group, but the species when restricted will probably be found to be limited to the Trenton rocks. In Pennsylvania and southward it occurs in the Sinuites zone of the Trenton at the base of the Martinsburg shale.

Occurrence.—MARTINSBURG SHALE (Sinuites and Corynoides beds). Williamsport, Maryland, and Chambersburg, Pennsylvania.

Collections.—Maryland Geological Survey, U. S. National Museum.

Family RAPHIOPHORIDAE

Genus AMPYX Dalman

AMPYX (LONCHODOMAS) NORMALIS (Billings)

Plate XLV, Figs. 13, 14

Ampyx normalis Billings, 1865, Pal. Foss., vol. i, Geol. Surv. Canada, p. 295, text fig. 286.

Ampyx (*Lonchodomas*) *normalis* Grabau and Shimer, 1910, N. A. Index Fossils, vol. ii, p. 259.

Description.—" Head, without the movable cheek, triangular, the width about one-third greater than the length; fixed cheeks, gently convex, smooth; neck segment consisting of a flat plate, inclining backwards. The glabella elongate-ovate, greatest width about the mid-length, one-fourth narrower at the neck segment, the apex extending a little over the front margin of the head; the rostrum, apparently, when perfect, equal to the whole length of the head, not round but fluted; two or three ovate or nearly circular scars, one each side of the glabella in the posterior half.

" Pygidium triangular, width twice the length, the two posterior sides gently convex, and the margin abruptly bent down or bevelled nearly vertically, the upper edge of the bevel angular and with indications of a slightly elevated linear rim; axis very depressed convex or nearly flat, its width at the anterior margin about one-fourth of the whole width, extending the whole length or nearly so, crossed by obscure undulating furrows. Side lobes gently convex.

"Length of the head without the rostrum, 5 or 6 lines; length of the pygidium about 4 lines."—Billings, 1865.

Fragmentary specimens of an *Ampyx* from the Echinospherites bed of Maryland and Pennsylvania agree so closely with Billings' figures and description that they are believed to represent the same species in spite of the differences in horizons.

Occurrence.—CHAMBERSBURG LIMESTONE (Echinospherites bed). Southern Pennsylvania and at Pinesburg Station, Maryland.

Collection.—U. S. National Museum.

AMPYX (LONCHODOMAS) HALLI Billings

Plate XXXIX, Figs. 9-11

Ampyx halli Billings, 1862, Rept. Econ. Geol. Vermont, p. 231, text fig. 365.
Ampyx halli Billings, 1865, Pal. Foss., vol. i, Geol. Surv. Canada, p. 24, text figs. 25a-c.
Lonchodomas halli Raymond, 1905, Ann. Carnegie Mus., vol. iii, No. 2, p. 332, pl. x, figs. 3-7.

Description.—"*Cephalon.*—Cranidium triangular, the greatest width at the neck segment. The glabella extends about half its own length beyond the anterior angles of the fixed cheeks, and is then prolonged into a long, fluted spine, which curves gently upward. This spine is prismatic, with a deep furrow on each of its four sides. The furrow on the upper side extends back to about the region of the fixed cheeks. Glabella widest at the anterior angles of the fixed cheeks, and contracting posteriorly, so that it forms about one-fifth of the whole width at the neck segment. On the cast there are two small nodes on each side of the glabella near its posterior end, one pair a little in front of the other. A distinct carina extends along the top of the glabella to the posterior end of the dorsal furrow on the rostrum.

"*Thorax.*—A specimen from Valcour Island retains the last two segments of the thorax. They are narrow, extend horizontally, and on the pleura are deeply grooved. The fourth segment is 5 mm. wide, .3 mm. long and the axis is 1.6 mm. wide. The pygidium of the same specimen is 1.25 mm. long, 4.3 mm. wide, and the axis is 1.3 mm. wide at the anterior end.

"*Pygidium.*—The pygidium is about three times as wide as long, usually regularly rounded posteriorly, sometimes somewhat triangular. Axis wide, prominent, extending to the posterior end of the pygidium. The exfoliated axis shows seven to ten pairs of nodes very similar to those noticed by Ruedemann on specimens of *Lonchodomas hastatus,* from Rysedorph Hill. The pleura show three or four pairs of rather indistinct ribs. The margin is abruptly deflected all around."—Raymond, 1905.

This little trilobite is one of the common fossils of the Middle Chazyan (Crown Point) limestone of the Lake Champlain area, the types coming from Highgate Springs, Vermont.

Occurrence.—STONES RIVER LIMESTONE (Middle division). Pennsylvania and Maryland. The old quarry at Chambersburg, Pennsylvania, has afforded a number of cephala with the long spines preserved.

Collections.—Maryland Geological Survey, U. S. National Museum.

Order OPISTHOPARIA

Family CORYNEXOCHIDAE Angelin

Genus DOLICHOMETOPUS Angelin

DOLICHOMETOPUS sp.

Plate XXVI, Figs. 1-9

Description.—More or less distorted cranidà and pygidia of a probable new species of this genus of trilobites occurs in the basal part of the Elbrook limestone. Although the studies of this and allied species have not progressed far enough to warrant description, illustrations are introduced on pl. XXVI to show the varying aspect of such fossils under pressure.

Occurrence.—ELBROOK LIMESTONE. Small quarry on the eastern outskirts of Waynesboro, Pennsylvania.

Collection.—U. S. National Museum.

Family MESONACIDAE

Genus OLENELLUS Hall

OLENELLUS THOMPSONI (Hall)

Plate XXIV

Olenus thompsoni Hall, 1859, 12th Ann. Rept. New York State Cab. Nat. Hist., p. 59, fig. 1, p. 60.

Olenellus thompsoni Walcott, 1886, U. S. Geol. Surv. Bull., No. 30, p. 167, pl. xvii, figs. 2, 4, 9; pl. xxii, fig. 1; pl. xxiii, fig. 1.

Olenellus thompsoni Walcott, 1890, 10th Ann. Rept. U. S. Geol. Surv., pl. lxxxii, figs. 1, 1a; pl. lxxxiii, figs. 1, 1a.

Olenellus thompsoni Walcott, 1910, Smithsonian Misc. Coll., No. 53, p. 336, pl. xxxiv, fig. 9; pl. xxxv, figs. 1-7.

Description.—"General form ovate, the length and breadth being nearly as six to five. Head broad lunate, with the postero-lateral angles much extended; the width from the center to the outer margin of the eye almost equal to the width of the cheek. Eyes (which are much crushed in the specimen) elongate semi-oval, equal in length to the space between the anterior angles and the frontal margin; glabella distinctly lobed, narrower in front.

"Thorax with the lateral lobes about once and a half as wide as the middle lobe, consisting of 14 articulations, the third one of which is much longer than the others, and curving downwards with an extension reaching as far as the line of articulation of the seventh rib. The posterior articulations are bent abruptly backwards, so that the free extremities are parallel with the axis. Pygidium small, pointed, without visible rings and having a narrow ridge running down the center."—Hall, 1859.

Occurrence.—ANTIETAM SANDSTONE and TOMSTOWN LIMESTONE. Near Smithsburg, and at Eakles Mills in Washington County, Maryland. The type fossil of the Lower Cambrian in the eastern United States and Canada.

Collections.—Maryland Geological Survey, U. S. National Museum.

Family SOLENOPLEURIDAE

Genus HYSTRICURUS Raymond

HYSTRICURUS CONICUS (Billings)

Plate XXXIII, Figs. 10-12

Bathyurus conicus Billings, 1859, Canadian Nat. and Geol., vol. iv, p. 266, text fig. 12d.

Bathyurus conicus Whitfield, 1889, Bull. Amer. Mus. Nat. Hist., vol. ii, p. 61, pl. xiii, figs. 15-21.

Hystricurus conicus Raymond, 1913, Bull. Victoria Memorial Mus., 1, p. 60, pl. vii, fig. 9.

Description.—Glabella conical, rounded at the anterior and almost straight across the occipital border; no trace of glabellar furrows; surface marked by larger pustules, slightly more than their own diameter apart.

Pygidium semicircular with the anterior margin not as sharply curved as the posterior, which is bordered by a narrow, flattened rim. Surface strongly trilobate, with the axial lobe extending to the posterior margin where it is obtusely pointed. Axial lobe marked by five transverse, short, sharply elevated rings, each of which is marked by a central spine-like tubercle, and one or two lateral nodes. Lateral lobes with four rings having two to four nodes on each.

The Maryland specimens referred to this species consist of pygidia having the same general outline and the sharply elevated rings ornamented with prominent nodes. The species has hitherto been found in the Beekmantown limestone of Canada, Vermont and New York.

Occurrence.—BEEKMANTOWN LIMESTONE (Cryptozoon steeli zone). Vicinity of Williamsport and Hagerstown, Maryland.

Collection.—U. S. National Museum.

Family BATHYURIDAE Walcott

Genus GONIURUS Raymond

GONIURUS CAUDATUS (Billings)

Plate XXXVI, Fig. 14

Bathyurus caudatus Billings, 1865, Pal. Foss., vol. i, Geol. Surv. Canada, p. 261, fig. 245.

Goniurus caudatus Raymond, 1913, Bull. Victoria Memorial Mus., vol. i, p. 66.

Description.—Pygidium quite convex, with a strong triangular spine behind. Axis conical; occupying less than one-third of the width, strongly convex and clearly outlined by the dorsal furrow; apex of axis rounded and with four or five rings. Side lobes, with four or five broad and short ribs, which extend about half way to the margin. A smooth, slightly convex border all around extends backward, and forms the terminal spine.

The well-marked triangular terminal spine of this species causes its identification to be extremely easy. So far only the pygidium of the species has been discovered.

Occurrence.—BEEKMANTOWN LIMESTONE (Ceratopea zone). Vicinity of Halfway, Maryland. The types are from the Canadian rocks of Newfoundland.

Collection.—U. S. National Museum.

Family OLENIDAE

Genus TRIARTHRUS Green

TRIARTHRUS FISCHERI Billings

Plate LI, Fig. 16

Triarthrus fischeri Billings, 1865, Pal. Foss., vol. i, Geol. Surv. Canada, p. 291, text fig. 280.

Description.—A small cephalon of *Triarthrus* found in the Sinuites bed at Chambersburg, Pennsylvania, is so similar to Billings' illustration of *T. fischeri* copied on pl. LI that it is believed to represent the same species in spite of the supposed difference in their geological horizons. It is possible that the strata in which the type of *T. fischeri* occurred are younger than now believed, and again it would not be surprising if this species, like many others, is repeated at several horizons in the geologic column.

Triarthrus fischeri differs conspicuously from *T. becki* in the absence of tubercles along the median line of the axis. The types are from the Chazyan of Newfoundland.

Occurrence.—MARTINSBURG SHALE (Sinuites bed). Chambersburg, Pennsylvania.

Collection.—U. S. National Museum.

TRIARTHRUS BECKI Green

Plate LI, Figs. 17, 18; Plate LII, Figs. 18-20; Plate LVI, Figs. 7-13

Triarthrus becki Green, 1832, Monograph Trilobites North America, p. 87, cast 34, pl. i, fig. 6.

Calymene becki Hall, 1847, Pal. New York, vol. i, pp. 237, 250, pl. lxvi, figs. 2a-k.

Description.—"General form an elongated ellipse, with the posterior extremity narrower, and the sides often straight; buckler broadly semioval, the posterior angles rounded; glabella of equal width from base to front, rounded before, deeply trilobate on each side, with a prominent thoracic ring at the base; frontal lobe narrowed longitudinally; thorax with 13 segments, those of the central lobe with a short spine or tubercle upon the back, those of the lateral lobes deeply grooved along the center; caudal shield with six or seven segments in the middle lobe, and five in the lateral lobes; posterior extremity obtuse."—Hall, 1847.

Specimens of *Triarthrus* occur at several horizons in the Martinsburg shale of Maryland, and although their preservation is not always good, all seem to have the tubercle on the center of each axial segment, characteristic of the well-known and widely distributed *T. becki* Green.

Occurrence.—MARTINSBURG SHALE. Chambersburg, Pennsylvania (Sinuites bed). Williamsport, Maryland (Corynoides bed). Fort Loudon, Pennsylvania, and Rickard Mountain, Maryland (Eden division).

Collections.—Maryland Geological Survey, U. S. National Museum.

Family ASAPHIDAE

Genus ISOTELUS DeKay

ISOTELUS STEGOPS Green

Plate LVI, Figs. 3, 4

Isotelus stegops Green, 1832, Monograph Trilobites North Amer., p. 71, cast 26, 27.

Description.—The species of *Isotelus* occurring in the Eden shale of the Ohio Valley hitherto referred to *Isotelus gigas* DeKay seems to represent a distinct species for which the name *Isotelus stegops* Green is here adopted. According to the researches of E. O. Ulrich as yet unpublished, Green's casts of *Isotelus stegops,* the originals of which came from Newport, Kentucky, show no good differences from the Eden shale species of that region.

Compared with *Isotelus maximus* Locke, which *I. stegops* most closely resembles, the Eden form has the eye further forward, smaller spines, and the flattened border, especially of the pygidium, less distinct.

Occurrence.—MARTINSBURG SHALE (Eden division). Jordans Knob, one and one-half miles northeast of Fort Loudon, and other localities in Pennsylvania.

Collection.—U. S. National Museum.

ISOTELUS MEGISTOS Locke

Plate LVIII, Figs. 10, 11

Isotelus megistos Locke, 1842, Amer. Jour. Sci., vol. xlii, p. 366, pl. iii, fig. 9.
Asaphus (Isotelus) megistos Meek, 1873, Geol. Surv. Ohio, Pal., vol. i, p. 159, pl. xiv, fig. 13.

Description.—Under this name and also those of *Isotelus maximus* Locke and *I. gigas* DeKay, a number of distinct species ranging through the Mohawkian and Cincinnatian have undoubtedly been confused, with the result that these names have little stratigraphic significance. The discrimination of these species has been undertaken by E. O. Ulrich, whose work upon them is still in manuscript form. He has determined that the fragments found in the Fairview deposits of Maryland and Pennsylvania are identical specifically with the types of Locke's *Isotelus megistos* and also with the specimen illustrated later by Meek as *Asaphus (Isotelus) megistos.*

Formerly the separation of these species was based upon the presence or absence of the genal spine, but it is now known that each species contains spinuous and aspinous forms, the difference between the two being presumably that of sex. The aspinous (? female) forms of these several species are quite difficult to distinguish from each other, but the spinous examples show good characters of differentiation. Thus, in the case of *I. maximus* and *I. megistos,* long considered synonymous, the free checks of each are different. In *I. megistos* the base of the spine is much wider and it tapers much more rapidly. The hypostoma furnishes further differences, for in *I. megistos* it shows coarser venations, the inner edges of the limb are straighter, and the whole hypostoma is relatively longer.

Occurrence.—MARTINSBURG SHALE (Fairview division, Orthorhynchula bed). Pennsylvania to Tennessee.

Collection.—U. S. National Museum.

ISOTELUS GIGAS DeKay

Plate XLVIII, Figs. 23-25

Isotelus gigas DeKay, 1824, Annals Lyceum Nat. Hist. New York, vol. i, p. 176, pl. xii, fig. 1.
Isotelus gigas Hall, 1847, Pal. New York, vol. i, p. 231, pl. lx-lxiii.
Isotelus gigas Weller, 1903, Pal. New Jersey, vol. iii, p. 192, pl. xiv, figs. 6, 7.
Isotelus gigas Raymond, 1914, Bull. Mus. Comp. Zool., vol. lviii, p. 248, pl. i, figs. 1, 2, pl. ii, figs. 2-5; pl. iii, fig. 3.

Description.—" Outline of an entire individual subelliptical, with the anterior and posterior extremities somewhat pointed; the trilobation nearly obsolete. Head subtriangular to semi-elliptical in outline, convex, slightly flattened in front; the anterior margin rather sharply rounded; facial sutures meeting at an angle, at or just behind the frontal margin, from this point they describe a broad, subarcuate curve, and after passing around the eyes, they curve outward and then downward, intersecting the posterior margin at some distance outside of the eyes; glabella obscurely defined and more obscurely lobed; occipital furrow and segment obsolete; free cheeks marked by an intramarginal furrow, above which their general surface is elevated into a more or less conspicuous node, crowned by the eye. Thorax with a broad axial lobe, occupying more than one-third the width, consisting of eight segments. Pygidium subtriangular in outline of nearly the same size and shape as the head, its lobation very obscure, especially in the larger individuals, the dorsal furrows being hardly distinguishable; axis much narrower at its anterior extremity than the axis of the thorax, tapering rapidly to the obtusely rounded posterior extremity, which lies at about one-fourth the length of the pygidium from the posterior margin; plurae convex, smooth in the larger individuals, but in younger ones marked by about ten obscure segments, which also continue across the axis; the entire margin of the pygidium, except where it joins the thorax, bordered by a rather broad, slightly depressed, marginal border; the anterior, lateral angles bent abruptly downward."—Weller, 1903.

This frequently quoted trilobite has been often described and illustrated with the result that several species have undoubtedly been confused under the name. The specimens from the Cumberland Valley are fragmentary, although they agree so far as they go with the above description. The complete examples figured are from the type area of the species in New York.

Occurrence.—CHAMBERSBURG LIMESTONE (Christiania bed). Pennsylvania, Maryland, and Virginia.

Collections.—Maryland Geological Survey, U. S. National Museum.

ISOTELUS sp.

Plate XXXVII, Fig. 9

Description.—A single imperfect free cheek of *Isotelus* has been found in the Frederick limestone and is figured in the present report. It is of little value in determining the age of this limestone, as species of this general type have a long geologic range.

Occurrence.—FREDERICK LIMESTONE. Just east of Frederick, Maryland.

Collection.—U. S. National Museum.

Genus ASAPHELLUS Callaway

ASAPHELLUS GYRACANTHUS Raymond

Plate XXXII, Figs. 8-10

Asaphus canalis? Cleland, 1900 (not Conrad), Bull. Amer. Pal., vol. iii, p. 128, pl. xvi, figs. 7, 8.

Isotelus canalis Weller, 1902, Pal. New Jersey, vol. iii, p. 132, pl. v, figs. 5, 6.

Asaphellus gyracanthus Raymond, 1910, Ann. Carnegie Mus., vol. vii, No. 1. p. 39, pl. xiv, figs. 5-7.

Description.—Entire cephalon unknown. Free cheek broad, flat, triangular in outline, bearing a long spine at the genal angle. Glabella flat with a narrow depressed border in front and scarcely any traces of dorsal furrows. Eyes prominent with their longest diameter 5 mm. and between them a minute pustule. The pygidium is uniformly convex with a narrow, depressed border, and is semicircular in outline. Its axial lobe is narrow and improminent, with traces of three or four rings at the anterior end. Size of the pygidium varies from 10 mm. in width and 7 mm. in length to 50 mm. by 40 mm. Hypostoma quadrangular.

This species much resembles *Hemigyraspis collieana* Raymond with fragments of which it is associated in Maryland, but its cephalon is longer and narrower and the axial lobe of the pygidium not so prominent.

Occurrence.—BEEKMANTOWN LIMESTONE (Stonehenge member). Vicinity of Hagerstown, Maryland. Tribes Hill limestone of New York and upper part of Kittatinny limestone of New Jersey.

Collection.—U. S. National Museum.

Genus HEMIGYRASPIS Raymond

HEMIGYRASPIS COLLIEANA Raymond

Plate XXXII, Figs. 11-15

Asaphus marginalis **Collie (not Hall), 1903, Bull. Geol. Soc. Amer., vol. xiv, p. 413.**

Hemigyraspis collieana **Raymond, 1910, Ann. Carnegie Mus., vol. vii, p. 41, pl. xiv, figs. 9-13.**

Description.—"Cephalon short and wide, glabella smooth, not outlined, no glabellar furrows. Neck-furrow shallow, hardly visible. Eyes nearly halfway to the front of the cephalon, large, very far apart. Between the eyes is a small median tubercle. Free cheeks short, wide, with long narrow spines at the genal angles. The anterior limb of the facial suture meets the frontal margin in front of the eye. There is a narrow depressed border on the front of the cranidium.

"Axial lobe of thorax one-third the total width; pleura grooved. Pygidium short, wide, semicircular in outline. Axial lobe narrow, rather prominent, showing traces of two or three rings. Pleural lobes convex, without traces of ribs. Border narrow, concave; doublure narrow, convex. Hypostoma quadrangular, widest in front, central portion convex, with a furrow and narrow border around the sides and posterior end. Surface of all parts, including the hypostoma, covered with imbricating striae.

"One pygidium is 9.5 mm. long and 18 mm. wide; a larger one is 14 mm. long and 28 mm. wide."—Raymond, 1910.

As noted by Raymond this species much resembles *Asaphus gyracanthus*, but its cephalon is shorter and wider, the eyes are farther apart and the axial lobe of the pygidium is much more prominent.

Occurrence.—BEEKMANTOWN LIMESTONE (Stonehenge member). Hagerstown, Maryland and Bellefonte, Pennsylvania.

Collection.—U. S. National Museum.

Genus SYMPHYSURUS Goldfuss

SYMPHYSURUS CONVEXUS (Cleland)

Plate XXXII, Figs. 16-18

Asaphus convexus ? Cleland, 1900, Bull. Amer. Pal., vol. iii, p. 128 (256), pl. xvi, fig. 4.

Bathyurus sp. Cleland, 1900, Idem., pl. xvi, fig. 9.

Illacnurus columbiana Weller, 1903, Pal. New Jersey, vol. iii, p. 133, pl. v, figs. 1-4.

Bathyurus ? levis Cleland, 1903, Bull. Amer. Pal., vol. iv, p. 36, pl. ii, figs. 1, 2.

Symphysurus convexus Raymond, 1910, Ann. Carnegie Mus., vol. vii, No. 1, p. 42, pl. xiv, figs. 14-16.

Description.—Entire cephalon unknown; glabella oblong, convex, with the eyes located halfway between the front and back. A small median tubercle present, below the eyes. Thorax unknown, but its axial lobe is probably narrow. Pygidium semicircular with a distinct axial lobe. Several indistinct annulations are present.

The types of both this species and its synonym *Bathyurus ? levis* Cleland were obtained in the Tribes Hill limestone at Fort Hunter, New York. The species was identified by Weller in the Canadian portion of the Kittatinny limestone at Columbia, New Jersey, and under the belief that the species belonged to *Illaenurus*, the new name *Illaenurus columbiana* was proposed, the name *Illaenurus convexus* being preoccupied.

Occurrence.—BEEKMANTOWN LIMESTONE (Stonehenge member). Hagerstown and Funkstown, Maryland.

Collection.—U. S. National Museum.

Genus ONCHOMETOPUS Schmidt

ONCHOMETOPUS SIMPLEX Raymond and Narraway

Plate XLVII, Fig. 18

Onchometopus simplex **Raymond and Narraway, 1910, Ann. Carnegie Mus., vol. vii, p. 51, pl. xvi, figs. 6-8.**

Description.—" Cranidium moderately convex, slightly incurved at the front. Glabella flat, obscurely defined, expanding in front of the eyes and extending to the anterior margin; glabellar furrows absent, dorsal furrows present back of the eyes, very shallow. Neck-furrow absent. Eyes of medium size, situated a trifle more than their own length in front of the posterior margin. Behind the eyes there is a small median tubercle on the glabella. Free cheeks rounded at the genal angles.

" Thorax of eight flat segments. Axial lobe a little more than one-third the total width. Pleura with shallow grooves.

" Pygidium rounded in outline, three-fifths as long as wide. Axial lobe obscurely defined, the posterior end usually a little more prominent than the other portions. There are no annulations. The surface is uniformly convex, without concave border.

" This species is similar to *Onchometopus obtusus* (Hall) of the Chazy, but the shell lacks the very coarse punctae of that form, and there are fewer traces of glabellar furrows. It differs from *Onchometopus susae* (Whitfield) in having a longer pygidium with a narrower and more distinct axial lobe.

" *Onchometopus* may be readily distinguished from *Isotelus* by the presence of a median tubercle on the glabella, the absence of a concave border on both cephalon and pygidium, and by the somewhat narrower axial lobe in the thorax."—Raymond and Narraway, 1910.

The interesting Maryland trilobite referred to the above species differs from all other Chambersburg forms in the absence of the concave border on both the cephalon and pygidium. Although imperfect it agrees fairly well in outline with the types of *Onchometopus simplex*.

Occurrence.—CHAMBERSBURG LIMESTONE (Nidulites bed). Wilson, Maryland. Black River limestone of Minnesota and Pennsylvania.

Collection.—U. S. National Museum.

Family ILLAENIDAE

Genus ILLAENUS Dalman

ILLAENUS AMERICANUS Billings

Plate LI, Figs. 26-29

Illaenus americanus Billings, 1859, Canadian Nat. Geol., vol. iv, p. 371.
Illaenus americanus Billings, 1865, Pal. Fossils, vol. i, Geol. Surv. Canada, p. 329, figs. 316a-d, 318.
Illaenus americanus Raymond and Narraway, 1908, Ann. Carnegie Mus., vol. iv, Nos. 3, 4, pl. lx, figs. 1-3.

Description.—" Oblong, distinctly tri-lobed; length two or three inches; width from three-fifths to five-sixths the length.

" Head large, strongly convex, its height usually a little greater than its length measured on a straight line, sometimes abruptly bent down at less than half the length from behind, often uniformly arched from the front to the posterior margin, equal to about one-fourth of a sphere; length from front to posterior margin about two-thirds the width between the cheek angles in a straight line. The glabella is moderately convex; the dorsal furrows extend from one-fourth to a little more than one-third the whole length of the head, measured on the curve, and have an obscure sigmoid curve, at first outwards and then inwards, their anterior extremities usually turning a little outwards; they are distant from each other not quite one-half the whole width of the head. The eyes are of moderate size, about two lines in length, about half their length from the posterior margin, and half the width of the glabella from the dorsal furrows. The cheek angles are rounded, and the posterior margin of the head makes with the lateral lower margin, as seen in a side view usually a right angle, but in some specimens an obtuse angle of nearly 100°, owing to the variable extent to which the front part of the head is produced downwards. In some the portion of the posterior margin outside of the eye curves forwards, and brings the cheek angle to a position in front of the eye. In others, it is behind the eye. The space between the eye and the dorsal furrows is convex, and the eye itself seems to be rather strongly protuberant or subconical. The movable cheek is subtriangular, its width at the posterior margin about one and a half the distance of the eye from the dorsal furrow, its length along the lower margin a little greater than its posterior width. The anterior margin of the whole head is uniformly rounded, with the exception of a slight concave curve just outside of the suture. In some specimens in which the front part of the head is most abruptly bent down the middle portion of the front margin is depressed convex or nearly straight.

"Thorax with ten segments. Axis moderately convex, from a little more than one-third to nearly one-half the width of the whole animal, a little wider at the anterior than at the posterior segment; the sides sometimes straight, and sometimes slightly curved outwards. On each side of the axis there is a flat space between the side of the axis and the bend of the pleurae. The width of this space is between one-third and one-half the width of the axis. The pleurae are bent at the fulcra at an angle which varies in different individuals, from 25° to 45°, and at nearly one-half their length from the side of the axis.

"Pygidium usually a little shorter than the thorax; varying from moderately to rather strongly convex; the posterior margin broadly and uniformly rounded; the anterior angles truncated nearly half the whole length of the pygidium; the straight sides formed by the truncation forming an angle of from 40° to 60° with the longitudinal axis of the body. The axis of the pygidium is well defined at the anterior margin by the dorsal furrows, which die out at about one-third or one-half the length, converging towards each other, and sometimes obscurely defining the apex."—Billings, 1865.

Occurrence.—MARTINSBURG SHALE (Sinuites bed). Chambersburg, Pennsylvania. Trenton limestone of Ottawa, Canada, and many other localities.

Collection.—U. S. National Museum.

Genus BUMASTUS Murchison

BUMASTUS TRENTONENSIS Emmons

Plate LI, Figs. 30-33

Bumastus trentonensis Emmons, 1842, Nat. Hist. New York, Geol., vol. ii, p. 390, fig. 1.

Bumastus trentonensis (part) Clarke, 1897, Geol. Minnesota, vol. iii, pt. 2, p. 718.

Bumastus milleri Raymond and Narraway, 1908, Ann. Carnegie Mus., vol. iv, p. 249, pl. lxi, figs. 9, 10, pl. lxii, figs. 3-5.

Description.—Emmons' figure of his type specimen of *Bumastus trentonensis* represents an example with eight segments to the thorax. Before this specimen could be restudied it was lost and the validity of the name has been questioned. It is unnecessary to enter into a history of the synonymy of this species, as this was fully discussed in 1908 by Raymond and Narraway. However, a species of *Bumastus* with eight segments occurs in the Trenton limestone of New York which, according to the present arrangement of species of the genus, has no name. This species agrees with Emmons' figure fairly well and it seems reasonable to retain his name of *Bumastus trentonensis.*

Occurrence.—MARTINSBURG SHALE (Sinuites bed). Chambersburg, Pennsylvania. Trenton limestone of New York.

Collection.—U. S. National Museum.

Family DIKELOCEPHALIDAE

Genus SAUKIA Walcott

SAUKIA STOSEI Walcott

Plate XXVII, Figs. 6-8

Saukia stosei Walcott, 1914, Smithsonian Misc. Coll., vol. lvii, No. 13, p. 384, pl. lxix, figs. 3-5; pl. lxx, figs. 12, 12a.

Description.—"This species belongs to the *S. pepinensis* form of *Saukia,* and is most nearly related to *Saukia fallax,* but it has a proportionately larger palpebral lobe. The associated pygidium differs from the pygidium found with *S. fallax* in Texas in having a longer axial lobe, and the surface is strongly granulated instead of being smooth as in *S. fallax.*"—Walcott.

Occurrence.—CONOCOCHEAGUE LIMESTONE. Near Scotland, Franklin County, Pennsylvania. Near Funkstown, Maryland.

Collections.—Maryland Geological Survey, U. S. National Museum.

Family PROETIDAE

Genus PROETUS Steininger

PROETUS LATIMARGINATUS Weller

Plate LI, Figs. 21-25

Proetus latimarginatus Weller, 1903, Geol. Surv. New Jersey, Pal., vol. iii, p. 195, pl. xiv, figs. 17-24 (? 25).

Description.—"Head sublunate in outline, the genal angles produced into long, sharp spines. Glabella elevated, broadly subconical, rounded in front; lateral furrows nearly obsolete exteriorly, but sometimes their position is indicated by dark lines on the surface, which seem to indicate an internal thickening of the test; the two anterior pairs are short and lie in front of the eye-lobes; they are close together, and are directed obliquely backward from the margin of the glabella; the posterior pairs are more conspicuous than the others, and are sometimes marked by slight depressions; they are situated a little in front of the middle of the eye-lobes, and are directed obliquely backward from the margin of the glabella, becoming more curved posteriorly, joining the occipital furrow at nearly right angles. The dorsal furrow well defined throughout. Occipital furrow sharply impressed, deeper than the dorsal furrow. Occipital segment with subparallel margins, scarcely as highly elevated as the glabella, marked by a small, rounded tubercle at its central point. Palpebral lobes of moderate width, sub-semicircular in outline, depressed below the level of the glabella. Facial sutures curving into the margin of the glabella, both in front and behind the palpebral lobes; posteriorly they intersect the margin of the head close to the axial lobe; in front of the palpebral lobes they curve outward nearly to the margin of the head, where they make a rather sharp bend and recurve inwardly, intersecting the anterior margin at some distance from its median point. Anterior limb of the cranidium broad, with a convex marginal border, between which and the glabella there is a rather broad, shallow, concave furrow. Free cheeks depressed-convex, with the eyes abruptly elevated, marked by a rather broad marginal border on both the lateral and posterior margins, on the inner side of which there is a rather sharply impressed furrow. Pygidium small, sub-semicircular in outline; the posterior margin regularly rounded; the anterior margin straight nearly to the lateral angles, where it is curved backward. Axis narrow, not reaching to the posterior margin, marked by six or seven annulations. Pleurae convex, much depressed below the axis, marked by five or six grooved segments, only the anterior two or three of which reach the margin of the pygidium. Thorax unknown. The entire surface of well-preserved specimens is finely granulose."—Weller, 1903.

The specimens from the basal Martinsburg shale are not as complete as the types upon which the above description was based, but there seems little doubt of their specific identity.

Occurrence.—MARTINSBURG SHALE (Sinuites bed). Chambersburg, Pennsylvania. Trenton limestone of New Jersey.

Collection.—U. S. National Museum.

Genus CYPHASPIS Burmeister

CYPHASPIS MATUTINA Ruedemann

Plate LI, Figs. 12-14

Cyphaspis matutina Ruedemann, 1901, New York State Mus. Bull., No. 49, p. 62, pl. iv, figs. 5-7.

Description.—"The glabella is short, roundish, subquadrangular, moderately and uniformly convex, sloping equally to all sides; surrounded by deep dorsal furrows and an equally deep frontal furrow. Three pairs of glabellar furrows are discernible, the first two faint, short and oblique, the third semicircular, extending to the occipital furrow, and separating a pair of less convex lobes, which extend a little beyond the lateral margin of the first and second lobes; the broad border slopes steeply to a narrow rim, somewhat upturned at the margin. The glabella and rim are apparently completely smooth, but show under the glass fine transverse striae. Neck ring nearly flat, depressed, with a central tubercle; occipital furrow distinct, nearly straight. Sutures begin at the anterolateral angles of the margin, extend in the direction of the second glabellar lobe to near the glabella, and then curve backward."—Ruedemann, 1901.

This species was based upon two small cranidia, both of which are illustrated in the present report. The material here identified with *C. matutina* consists of imperfect cranidia only, so that nothing further can be added to the specific description.

Occurrence.—MARTINSBURG SHALE (Sinuites bed). Chambersburg, Pennsylvania. Rysedorph conglomerate at base of Trenton, Rensselaer County, New York.

Collection.—U. S. National Museum.

Family LICHADIDAE

Genus AMPHILICHAS Raymond

AMPHILICHAS TRENTONENSIS (Conrad)

Plate LI, Figs. 8-10

Asaphus ? Trentonensis Conrad, 1842, Jour. Acad. Nat. Sci. Philadelphia, vol. viii, p. 277, pl. xvi, fig. 16.

Platynotus trentonensis Hall, 1847, Pal. New York, vol. i, p. 235, pl. lxiv, figs. 1a-d.

Platymetopus trentonensis Weller, 1903, Geol. Surv. New Jersey, Pal., vol. iii, p. 200, pl. xv, figs. 17-19.

Description.—"Head ventricose, the curve along the median line from the posterior to the anterior margins being very nearly a semicircle, sub-semicircular in outline, attaining a breadth of 35 or 40 mm. The glabella very large, occupying nearly the entire breadth of the cranidium, strongly protuberant in front; with a single pair of glabellar furrows, which originate at the anterior, lateral margins, and, after curving inward, then backward and then slightly outward again, forming something more than a semicircle, they join the occipital furrow, dividing the glabella into three lobes; the frontal or median lobe is broad in front, becoming narrower posteriorly to a point back of the middle of the head, and then again broadens out, becoming nearly as wide on the occipital furrow as it was on the anterior margin; the two lateral lobes about as prominent as the median lobe, subcrescentiform in outline. Dorsal furrows concave inward, about as deeply impressed as the glabellar furrows. Fixed cheeks rather broad along the posterior margin of the head, becoming rapidly narrower to a point just behind the palpebral lobe; the palpebral lobe rather prominent, the cheek becoming very narrow anteriorly. Occipital furrow and occipital segment well defined, extending across the fixed cheeks. The entire surface ornamented with small, low, rounded tubercles, somewhat variable in size. Free cheeks, thorax and pygidium unknown."—Weller, 1903.

The above description by Weller is the most detailed that has so far been published, and as the specimens now under study show no additional features both his description and figures are reproduced.

Occurrence.—MARTINSBURG SHALE (Sinuites bed). Carlisle and Chambersburg, Pennsylvania, and Strasburg, Virginia.

Collection.—U. S. National Museum.

Family ODONTOPLEURIDAE

Genus ACIDASPIS Murchison

ACIDASPIS ULRICHI n. sp.

Plate XXXVII, Figs. 6-8

Description.—The most interesting species in the fauna of the Frederick limestone is a remarkably spinose trilobite represented by rather numerous fragments of the free cheek with its extended genal spine. Unlike most American species of *Acidaspis* and allied genera, the spines on the free cheek of the present one continue to the end of the genal spine. These spines are regularly and closely placed and are of considerable length along the free cheek. They decrease in length along the genal spine, but they are still conspicuous at its end. Another unusual feature is a great curvature of the free cheek with its genal spine, apparently indicating that the latter were directed over the thorax of the trilobite.

The general aspect of this trilobite is not unlike certain European species of *Acidaspis*. This species can be recognized easily from its free cheeks, but more of the trilobite is necessary before its affinities can be definitely determined.

The specific name is in honor of Dr. E. O. Ulrich in appreciation of his work on the faunas and stratigraphy of the Appalachian Valley.

Occurrence.—FREDERICK LIMESTONE. Frederick, Maryland.

Collections.—Maryland Geological Survey, U. S. National Museum.

Order PROPARIA

Family CALYMENIDAE

Genus CALYMENE Brongniart

CALYMENE GRANULOSA (Foerste)

Plate LVI, Figs. 1, 2

Calymene callicephala granulosa Foerste, 1909, Bull. Sci. Lab. Denison Univ., vol. xiv, p. 294.

Description.—This species is one of several that have usually been identified as *Calymene callicephala*, but the latter name has been dropped on account of uncertainty as to the species represented. The Eden form of *Calymene* differs conspicuously from other Cincinnatian species of the genus in the presence of numerous granules upon the carapace. Other differences, such as smaller size and a less strongly elevated anterior border of the cephalon, may be noted, but the granulose surface is the best marked feature.

Occurrence.—MARTINSBURG SHALE (Eden division). Jordans Knob, one and one-half miles northeast of Fort Loudon, Pennsylvania; Cowans Gap, five miles northeast of McConnellsburg; and Tuscarora Mountain, two and one-half miles southeast of McConnellsburg, Pennsylvania; Rickard Mountain, Washington County, Maryland. Eden shale at Cincinnati, Ohio.

Collections.—Maryland Geological Survey, U. S. National Museum.

CALYMENE SENARIA Conrad

Plate LI, Fig. 15

Calymene senaria Conrad, 1841, 5th Ann. Rept. Geol. Surv. New York, pp. 38, 49.

Calymene senaria Hall, 1847, Pal. New York, vol. i, p. 238, pl. 64, figs. 3a-n.

Calymene senaria Weller, 1903, Geol. Surv. New Jersey, Pal., vol. iii, p. 203, pl. xv, fig. 23.

Description.—"Head sub-semicircular or sublunate in outline, the anterior and lateral margins being more or less nearly regularly rounded, and the posterior broadly sinuous, with the posterior lateral extremities bluntly subangular or abruptly rounded. Free cheeks irregularly triangular in outline, with thick, rounded, lateral margins, defined by a distinct, rounded marginal furrow, which is continuous with the furrow separating the anterior end of the glabella from the prominent, elevated, anterior margin of the head. Facial sutures originating just in front of the genal angles, passing obliquely forward and inward for a little more than half the distance to the eyes, then curving inward to the base of the eye-lobe, and after passing around the eyes, extending forward and intersecting the anterior margin at points a little nearer together than the breadth between the eyes. Eyes small and rather prominent. Glabella more prominent than the cheeks and separated from them by deep, dorsal furrows, about as wide behind as its length, including the occipital segment, much narrower in front; the frontal and three pairs of lateral glabellar lobes separated by three pairs of glabellar furrows, of which the anterior pair is much the faintest and shortest; each member of the second pair extends about one-fourth the distance across the glabella, slightly curved posteriorly, the posterior pair deeper and wider than either of the others, each member extending about one-third the distance across the glabella and directed obliquely backward. Occipital furrow deep and prominent, connecting with the dorsal furrows and less conspicuously with the marginal furrows of the posterior margin of the fixed cheeks, arching slightly forward at the middle of the glabella. Occipital segment well defined, arching a little forward, about as high as the most prominent portion of the glabella in front. Fixed cheeks convex, provided with a deep, broad furrow along their posterior margin.

"Pygidium wider than long, more or less subtrigonal in outline, but with the anterior margin broadly rounded. Axis well defined, convex, extending nearly to the posterior margin, with five or six transverse segments, which grow fainter posteriorly. The pleurae convex, each with about five segments, which are furrowed distally. Whole surface of the test minutely granular."—Weller, 1903.

The fragments of this species noted in the basal part of the Martinsburg shale agree in all characters with the New Jersey Trenton specimens described in detail by Weller as above.

Occurrence.—MARTINSBURG SHALE (Sinuites bed). Chambersburg, Pennsylvania, and Strasburg, Virginia.

Collections.—Maryland Geological Survey, U. S. National Museum.

Family CHEIRURIDAE

Genus CERAURUS Green

CERAURUS PLEUREXANTHEMUS Green

Plate XLIII, Figs. 22, 23

Ceraurus pleurexanthemus Green, 1832, Monthly Amer. Jour. Geol., vol. i, p. 560, pl. iv, fig. 10.

Ceraurus pleurexanthemus Green, 1832, Mono. Trilobites North America, p. 84, text fig. 10, cast 33.

Ceraurus pleurexanthemus Hall, 1847, Pal. New York, vol. i, p. 242, pl. lxv, figs. 1a-c, 1e-g.

Ceraurus pleurexanthemus Weller, 1903, Geol. Surv. New Jersey, Pal., vol. iii, p. 204, pl. xv, fig. 28.

Ceraurus pleurexanthemus Raymond and Benton, 1913, Bull. Mus. Comp. Zool., vol. liv, p. 528, pl. i, fig. 1; pl. ii, figs. 1, 2, 7.

Description.—"Head crescentiform in outline, with the posterior lateral angles extended into long, curved, genal spines, which are attached to the fixed cheeks. Free cheeks irregularly triangular in outline, the eyes small. Facial suture starting at the lateral margin, and after extending inward toward the glabella, making a sharp turn forward just back of the eye, and after passing around the eye, curving gently forward, cutting the anterior margin of the head in front of the glabella. Glabella prominent, convex, broadest in front, extending nearly to the anterior margin of the head. Glabellar furrows well defined, but not extending across the glabella. The two anterior pairs straight, each portion extending over about one-fourth the width of the glabella. The third pair extending inward about as far as the other two, and then bending abruptly backward and joining the occipital furrow, leaving the posterior glabellar lobes more or less detached. Occipital furrow deep and well defined, arching a little forward upon the glabella extended laterally upon the fixed cheeks nearly to the lateral margins, where it joins a marginal furrow just in front of the genal spine, which passes anteriorly. Occipital segment well defined. Dorsal furrow rather sharply impressed. Fixed cheeks convex, their posterior lateral angles extended into prominent, curved, genal spines. Whole surface of the head, except the dorsal, glabellar, occipital and marginal furrows, strongly granulose or papillose, with some scattered tubercles larger than the others."—Weller, 1903.

The above description by Weller applies in detail to the characters of the head fragments found in the Chambersburg limestone. Several species have been confused under the name of *Ceraurus pleurexanthemus* and better material may show the Chambersburg limestone specimens to be incorrectly referred here.

Occurrence.—Chambersburg Limestone (Caryocystites bed). Fort Loudon, Franklin County, Pennsylvania. Black River of New York, Canada, etc.

Collections.—Maryland Geological Survey, U. S. National Museum.

Genus PLIOMEROPS Raymond

Pliomerops salteri (Billings)

Plate XXXVI, Fig. 13

Amphion salteri Billings, 1861, Canadian Nat. and Geol., p. 322, text fig. 6.
Amphion salteri Billings, 1865, Pal. Foss., vol. i, Geol. Surv. Canada, p. 352, text fig. 339.

Description.—Pygidium small, about 6 mm. long and 10 mm. wide at the base. Glabella convex, oblong, one-third the width of the head, with straight sides and a narrow margin in front; neck furrow extending entirely across; three pairs of glabellar furrows directed slightly backward, their inner extremities separated by about one-third the width of the glabella. Fixed cheeks covered with small tubercles and separated from the glabella by a deep groove on each side.

Pygidium 6 mm. long and about the same at its greatest width; front margin rounded and the posterior somewhat straight. Axis conical and strongly convex with five or six well-defined segments. Pleurae of the pygidium five on each side and nearly parallel with the axis in their posterior half, then curving inward to join the axial segments.

Identified somewhat doubtfully in the Middle Beekmantown (Ceratopea zone) in the Appalachian Valley of Maryland and southern Pennsylvania. Imperfect pygidia with the characteristic pleurae were observed in exposures along the Cumberland Valley Railroad northeast and southeast of Halfway, Maryland.

Occurrence.—BEEKMANTOWN LIMESTONE (Ceratopea zone). Halfway, Maryland.

Collection.—U. S. National Museum.

Family PHACOPIDAE

Genus PTERYGOMETOPUS Schmidt

PTERYGOMETOPUS CALLICEPHALUS (Hall)

Plate XLIII, Figs. 18-21

Phacops callicephalus Hall, 1847, Pal. New York, vol. i, p. 247, pl. lxv, figs. 3a-i.

Pterygometopus callicephalus Clarke, 1894, Geol. Minnesota, vol. iii, pt. 2, p. 731, text figs. 51, 52; p. 732.

Pterygometopus callicephalus Weller, 1903, Geol. Surv. New Jersey, Pal., vol. iii, p. 206, pl. xv, figs. 29-32.

Description.—"Head sublunate in outline, obtusely subangular in front, genal angles broad and rounded, with no indication of spinules. Glabella large, depressed-convex, broad and rounded in front, becoming much narrower behind; frontal lobe large, subelliptical in outline;

anterior pair of glabellar furrows starting from opposite the anterior extremities of the eyes, directed obliquely backward and each one extending over a little more than one-third the width of the glabella; second pair of glabellar furrows shorter and a little shallower than the first, directed obliquely forward; third pair of glabellar furrows directed toward the axis of the glabella for a short distance and then bending abruptly backward and joining the occipital furrow, leaving the small, basal glabellar lobes wholly detached. Occipital furrow rather deep and broad. Occipital segment rather broad, its elevation about even with the glabella in front, its posterior margin convex. Palpebral lobes prominent, their elevation being nearly that of the glabella, separated from the glabella by the deep dorsal furrow, and marked by a conspicuous furrow just within the border of the eye. Eyes large, lunate, their inner margins elevated nearly or quite to the height of the glabella, their anterior ends opposite the first glabellar furrows and their posterior ends reaching nearly to the occipital furrow. Cheeks, outside the eyes, sloping rather abruptly to the lateral margins of the head; marked along the posterior margins to a point about one-half the distance from the eye to the margin by the narrow, but rather sharply impressed, occipital furrow, whose distal extremity is rather abrupt; the lateral borders marked by an ill-defined marginal furrow, which originates at the outer extremity of occipital furrow, and after passing forward nearly parallel with the margin, joins the dorsal furrow just in front of the eye.

"Pygidium subtriangular in outline, rather abruptly rounded or subangular posteriorly. Axis prominent, but rather narrow, its margin slightly incurved and abruptly rounded behind, marked by from eight to ten somewhat sinuous annulations; the pleurae slightly flattened adjacent to the axis, but soon curving rather abruptly to the lateral margins, marked by about six grooved segments, with slight traces of others posteriorly.

"Surface of the glabella, palpebral lobes, occipital segment and cheeks inside the marginal furrow distinctly pustulose, the little tubercles being more or less irregular in size; upon the cheeks outside the border of the eyes the papillae are much less conspicuous than upon the glabella and the marginal border is perfectly smooth. Pygidium unornamented, except by the grooves marking the segments, which do not extend entirely to the border, thus leaving a plain, perfectly smooth, narrow marginal border."—Weller, 1903.

Occurrence.—CHAMBERSBURG LIMESTONE (Tetradium cellulosum bed). Several localities south of Chambersburg, Pennsylvania. This species has hitherto been supposed to be restricted to the Trenton rocks of the United States and Canada.

Collection.—U. S. National Museum.

Subclass EUCRUSTACEA

Superorder BRANCHIOPODA

Order NOTOSTRACA

Genus RIBEIRIA Sharpe

RIBEIRIA ? NUCULITIFORMIS Cleland

Plate XXXI, Figs. 13, 14

Ribeiria ? nuculitiformis **Cleland, 1900, Bull. Amer. Pal., vol. iii, p. 133 (261), pl. xvi, figs. 10-14.**

Description.—Shell small, varying from 1.5 mm. by 3 mm. to 6 mm. by 12 mm., compressed laterally, with the dorsal margin concave and the sides convex. In casts, a deep notch about one-fourth the length of the shell is shown just below the beak and extends obliquely towards the middle of the ventral side.

The shell of this interesting crustacean much resembles a species of the pelecypod genus *Nuculites,* whence the specific name.

Occurrence.—BEEKMANTOWN LIMESTONE (Stonehenge member). Hagerstown, Maryland. An extremely abundant fossil in the Tribes Hill limestone at Fort Hunter, New York.

Collection.—U. S. National Museum.

Superorder OSTRACODA

Family LEPERDITIIDAE

Genus ISOCHILINA Jones

ISOCHILINA GREGARIA (Whitfield)

Plate XXXVI, Figs. 10-12

Primitia gregaria Whitfield, 1889, Bull. Amer. Mus. Nat. Hist., vol. ii, p. 58, pl. xiii, figs. 3-5.

Isochilina gregaria Jones, 1890, Quart. Jour. Geol. Soc. London, vol. xlvi, p. 22, pl. i, figs. 9, 10.

Isochilina amiana Ulrich, 1891, Jour. Cincinnati Soc. Nat. Hist., vol. xiii, pt. 1, p. 180, pl. xi, figs. 12a-c.

Isochilina ottawa var. *intermedia* Jones, 1891, Cont. Micro-Pal., Geol. Surv. Canada, pt. 3, p. 66, pl. x, figs. 10, 11.

Description.—Carapace about 4 mm. long, obliquely oval in form; hinge line straight, in length about three-fifths that of the valves. Surface of valves convex, most elevated across the narrow end. Sulcus poorly defined, broadly triangular extending from about the middle of the valve to the hinge. Surface of valves marked by numerous widely spaced pits. On each side of the sulcus there is usually a well-defined node or tubercle and often one is at its lower extremity.

A species of similar size and shape and with the surface markings of the Vermont type specimens occurs in poor preservation, but sometimes in abundance on the weathered limestone surfaces of the Middle Beekmantown of Pennsylvania and Maryland.

Occurrence.—BEEKMANTOWN LIMESTONE (Ceratopea zone). Several of the outcrops along the National Highway west of Hagerstown and the turnpike to Williamsport, Maryland.

Collections.—Maryland Geological Survey, U. S. National Museum.

ISOCHILINA SEEYLI (Whitfield)

Plate XXXV, Fig. 12

Primitia seelyi Whitfield, 1889, Bull. Amer. Nat. Hist., vol. ii, p. 60, pl. xiii, figs. 6, 7.

Isochilina seelyi Jones, 1890, Quart. Jour. Geol. Soc. London, vol. xlvi, p. 22, pl. i, fig. 7.

Description.—Valves about 4 mm. in length, and not quite 3 mm. long, with the straight or dorsal margin a trifle more than three-fifths of the entire length. Valves convex, and wider at the posterior end; cardinal angles distinct. Anterior and posterior ends with flattened margin, narrowing along the basal border and disappearing along the mid-ventral edge. Surface covered with moderately large, depressed pits, most of which have an elevated granule in the center. A nearly circular, smooth spot, and above it a rapidly widening area also without pits, extending to the dorsal border, replaces the usual sulcus or tubercles of the surface of such ostracoda.

The surface punctae and the smooth spot in the anterodorsal part of the valve easily distinguish this species. The types were found in the Beekmantown limestone at Shoreham, Vermont.

Occurrence.—BEEKMANTOWN LIMESTONE (Turritoma zone). Huyett, Maryland.

Collections.—Maryland Geological Survey, U. S. National Museum.

Genus LEPERDITIA Rouault

LEPERDITIA FABULITES (Conrad)

Plate XXXIX, Fig. 16; Plate XLIII, Figs. 1-5

Cytherina fabulites Conrad, 1843, Proc. Acad. Nat. Sci. Philadelphia, vol. i, p. 332.

Leperditia fabulites Ulrich, 1891, Jour. Cincinnati Soc. Nat. Hist., vol. xiii, p. 173, pl. xi, figs. 1a-d, 2.

Leperditia fabulites Ulrich, 1894, Geol. Minnesota, vol. iii, pt. 2, p. 634, pl. xliii, figs. 1-14.

Leperditia fabulites Weller, 1903, Geol. Surv. New Jersey, Pal., vol. iii, p. 208, pl. xiii, figs. 11, 12.

Description.—" Carapace of medium size, obliquely subovate, comparatively long, widest posteriorly; ventral curves moderate, strongest just behind the mid-length; cardinal line straight, comparing with the length of the valve as two is to three, the two extremities almost equally angular; hight of ends about as three is to four, both obliquely truncate above, the anterior narrowly rounded in the middle; the posterior outline more broadly and evenly curved though having the usual backward swing. Ventral edge of carapace obtuse, scarcely flattened, with a slight furrow on each side near the edge of the right valve in which a row of minute punctae is generally distinguishable; overlap extending all around the free edges, strongest ventrally; except in rare instances, neither valve has a flange or flattened border, and when present it is in all cases very narrow and undefined; dorsal edge somewhat thickened, especially upon the left side. Surface of the valves smooth or very faintly pitted, rather evenly convex with the greatest thickness somewhat beneath the center; a low ridge-like thickening along the posterior half of the dorsal margin of the left valve is to be noticed. Eye tubercle just distinguishable in most cases, rarely so distinct as in the specimen figured, often not to be detected. On the inner surface, however, it is always marked by a distinct pit. Muscle spot not distinguishable externally except when the specimens are weathered, but on the inner side it is often well marked and surrounded by fine reticulating radial lines, short dorsally, longest post-ventrally. On the inner side of the ventral edge of the right valve there are two rows of small papillae, three to five in each, the number seeming to increase with age. The purpose of these papillae, one series of which occurs in the anterior third, the other in the posterior evidently was to prevent undue overlapping of the valves by presenting an obstacle to the entering ventral edge of the left valve."—Ulrich, 1894.

Although this species has been cited as a wide-spread characteristic fossil of both the Stones River and Black River groups, the typical form is really restricted to the latter rocks. The original types were described from the Platteville limestone of Wisconsin, the equivalent of the Lowville limestone of more eastern localities.

Occurrence.—CHAMBERSBURG LIMESTONE (Tetradium cellulosum bed). Fort Loudon and other localities in Franklin County, Pennsylvania. STONES RIVER LIMESTONE. Pinesburg and Wilson, Maryland.

Collections.—Maryland Geological Survey, U. S. National Museum.

Genus LEPERDITELLA Ulrich

LEPERDITELLA TUMIDA (Ulrich)

Plate XLIII, Figs. 10-12

Leperditia tumida Ulrich, 1892, Amer. Geol., vol. x, p. 264, pl. ix, figs. 1-3.
Leperditella tumida Ulrich, 1894, Geol. Minnesota, vol. iii, pt. 2, p. 636.

Description.—Valves ovate, leperditoid, with a straight back, rather short, with the posterior end widest, tumid, the convexity of the surface, except for a slight flattening and lengthening of the dorsal and anterior slopes, nearly uniform. Surface obscurely punctate, otherwise smooth, there being no external signs of either the eye-tubercle or muscle spot. Right valve a little smaller than the left and fitting into a groove in it.

Length of a large right valve, 2.6 mm.; height, 1.82 mm.; thickness, 0.75 mm.

This is one of the characteristic microscopic fossils of the Lowville limestone in the Ohio and Appalachian valleys.

Occurrence.—CHAMBERSBURG LIMESTONE (Tetradium cellulosum bed). Fort Loudon and other localities in Franklin County, Pennsylvania.

Collections.—Maryland Geological Survey, U. S. National Museum.

Genus APARCHITES Jones

APARCHITES MINUTISSIMUS (Hall)

Plate LV, Fig. 33

Leperditia (*Isochilina*) *minutissima* Hall, 1872, 24th Rep. New York State Cab. Nat. Hist., p. 231, pl. viii, fig. 13 (advance sheets, 1871, p. 7).
Leperditia (*Isochilina*) *minutissima* Hall and Whitfield, 1875, Geol. Surv. Ohio, Pal., vol. ii, p. 102, pl. iv, fig. 4.
Aparchites minutissimus Ulrich, 1889, Geol. Surv. Canada, Cont. Micro.-Pal., pt. 2, p. 49, pl. ix, fig. 5.

Description.—" Carapace minute, less than two-hundredths of an inch in length, the width being about two-thirds the length, greatest at the anterior third, giving a broadly ovate outline, with a straight cardinal margin of about two-thirds the length of the valve.

"Surface of the valves smooth, rising into an obtusely pointed prominence at the anterior third of the length; basal margins of the valves not overlapping, so far as can be ascertained."—Hall and Whitfield, 1875.

This minute ostracod may be readily recognized by its *Leperditia*-like carapace with non-overlapping valves, the surface of which is smooth and rises into an obtuse prominence. An abundant fossil in the Cincinnatian rocks of the Ohio Valley, particularly in the Eden shale.

Occurrence.—MARTINSBURG SHALE (Eden division). Jordans Knob, one and one-half miles northeast of Fort Loudon, Pennsylvania, and debris on the west slope of Rickard Mountain, Washington County, Maryland.

Collection.—U. S. National Museum.

Family BEYRICHIIDAE

Genus DREPANELLA Ulrich

DREPANELLA MACRA Ulrich

Plate XLIII, Figs. 13-15

Drepanella macer Ulrich, 1894, Jour. Cincinnati Soc. Nat. Hist., vol. xiii, p. 119, pl. viii, figs. 4a-c.

Drepanella macra Ulrich and Bassler, 1908, Proc. U. S. Nat. Mus., vol. xxxv, p. 291, fig. 17, pl. xli, figs. 12-14.

Description.—"Valves subquadrate, about 2.0 mm. long and 1.25 mm. high, with the body very thin and shallow, the thickness of the entire carapace at a point near the middle being only about 0.3 mm. Ventral margin straight or sinuate; ends subequal, the posterior a little the most curved; postero and antero-dorsal regions angular, the angles 10 or 15 degrees greater than a right angle. Ventral edge slightly thickened. Marginal or sickle-shaped ridge high, projecting beyond the dorsal edge, running parallel with and very close to the abrupt posterior margin; then curving more rapidly than does the outline of the valve into the ventral margin, it gradually increases its distance from the ventral edge, and in a slightly flexuous manner traverses the valve for almost its entire length, terminating at a point near the middle of the anterior margin. Postero-median ridge consisting of three prominently confluent nodes, the uppermost projecting considerably beyond the dorsal margin. Antero-median node large, prominent and of triangular form. Antero-dorsal node projecting prominently beyond the edge, but not as high, and only about half as large as the antero-median one."—Ulrich, 1894.

The types of this striking ostracod were found in the topmost division (Lebanon) of the Stones River limestone of Central Tennessee.

Occurrence.—CHAMBERSBURG LIMESTONE (Tetradium cellulosum bed). Fort Loudon, Pennsylvania.

Collections.—Maryland Geological Survey, U. S. National Museum.

Genus MACRONOTELLA Ulrich

MACRONOTELLA ULRICHI Ruedemann

Plate XLIII, Figs. 6-9

Macronotella ulrichi Ruedemann, 1901, New York State Mus. Bull., No. 49, p. 83, pl. vi, figs. 6-16; pl. vii, fig. 1.

Description.—"Valves three-fourths circular to subovate; dorsal outline rarely straight, mostly prominent in the central part, specially in older specimens; cardinal angles obtusely rounded to shortly truncate; posterior margin with a little longer truncation, lateral and ventral margins forming approximately a continuous circular line; in larger specimens the anterior and posterior margins more strongly rounded, and the ventral margin less curved; free edges in most specimens with a broad depressed border and beveled edge. Surface strongly convex, culminating in the dorsocentral region; in some specimens almost smooth, with only faint, widely and irregularly distributed circular impressions; others with very large deep pits; on the apex always a flat. smooth circular area. Valve projecting slightly above the straight cardinal line, and forming a broad, low, triangular, reentrant cardinal area.

"Dimensions: Length, 2.7 mm.; height, 2.1 mm.; thickness, .7 mm."—Ruedemann, 1901.

This fine ostracod is easily distinguished by its strongly convex valves with a flat, smooth area at the apex of the surface which elsewhere is marked by circular impressions or deep pits.

Occurrence.—CHAMBERSBURG LIMESTONE (Tetradium cellulosum bed). Fort Loudon, Franklin County, Pennsylvania. The type specimens were found in the Rysedorph conglomerate at Rysedorph Hill, Rensselaer County, New York.

Collection.—U. S. National Museum.

Genus CERATOPSIS Ulrich

CERATOPSIS CHAMBERSI (Miller)

Plate LV, Fig. 34

Beyrichia chambersi Miller, 1874, Cincinnati Quart. Jour. Sci., vol. i, p. 234, fig. 27.

Beyrichia chambersi Hall and Whitfield, 1875, Pal. Ohio, vol. ii, p. 104, pl. iv, figs. 11, 12.

Ceratopsis chambersi Ulrich, 1894, Geol. Minnesota, vol. iii, pt. 2, p. 676, pl. xlvii, figs. 19-22.

Description.—" Carapace minute, the extreme length not exceeding half a line, and the greatest width not more than two-thirds as much as the length. Form of the valves broad ovate, with one side, for a space equal to about one-fourth of the width of the figure, cut away, forming the straight hinge-line, which is equal in length to about six-sevenths of the entire length of the carapace. Greatest width of the valve a little more than one-third of the length from the anterior end. Surface of the valves highly convex, most prominent near the middle of the length, crossed by three curving sulci, none of which reach the ventral border, the middle of the curve being directed towards the posterior extremity. The middle sulcus is stronger and much deeper than the others, while the posterior one is faintly marked, and situated at about the posterior third of the length. The anterior sulcus is short, comparatively deep, nearly semicircular, and situated within the anterior third of the length, and about midway between the cardinal and basal borders. From the anterior margin of this depression, or between it and the anterior border of the valve, there rises a strong, thickened, lanceolate, or scythe-shaped, curved spine, which equals in length two-fifths, or sometimes one-half that of the entire valve. The anterior and posterior surfaces of the spine are convex, the latter most strongly so, while the lateral edges are sharp and the ventral one generally deeply serrate, although a few specimens have been noticed without the serrations, perhaps from wearing. The margin of the valve is bordered by a thickened rim, within which there is often a slightly depressed channel. Surface of the crust smooth, or very finely granulose."—Hall and Whitfield, 1875.

Occurrence.—MARTINSBURG SHALE (Eden division). Southern Pennsylvania and on the west slope of Rickard Mountain in Maryland.

Collections.—Maryland Geological Survey, U. S. National Museum.

Genus ULRICHIA Jones

ULRICHIA BIVERTEX (Ulrich)

Plate LV, Fig. 32

Leperditia bivertex Ulrich, 1879, Jour. Cincinnati Soc. Nat. Hist., vol. ii, p. 11, pl. vii, figs. 5, 5a.

Ulrichia ? bivertex Ruedemann, 1912, New York State Mus. Bull., No. 162, p. 120, pl. ix, figs. 11, 12.

Description.—"Length, 1.00 mm.; breadth, .75 mm. Carapace minute, subreniform; dorsal margin straight, over two-thirds as long as the entire length of the valve; anterior and posterior extremities equal in width; ventral curve nearly uniform. Valves strongly convex. Tubercle at the anterior end, near the dorsal margin large, rising abruptly, obtusely rounded, and slightly directed posteriorly. Posterior tubercle situated near the dorsal margin, and about half the length of the valve from the posterior extremity, less obtusely rounded, and more prominent than the anterior tubercle. Between the tubercles there is a deep sulcus, extending from the dorsal margin to one-half the distance across the valve. Surface smooth. On the interior there is a corresponding pit for each tubercle, and a divisional ridge between them."—Ulrich, 1879.

Occurrence.—MARTINSBURG SHALE (Eden division). Jordans Knob, one and one-half miles northeast of Fort Loudon, Pennsylvania.

Collection.—U. S. National Museum.

Family CYPRIDAE

Genus BYTHOCYPRIS Brady

BYTHOCYPRIS CYLINDRICA (Hall)

Plate LV, Figs. 28-31; Plate LII, Figs. 14-16

Leperditia (Isochilina) cylindrica Hall, 1872, 24th Rep. New York State Cab. Nat. Hist., p. 231, pl. viii, fig. 12 (Extract 1871, p. 7, pl. iv, fig. 12).

Bythocypris cylindrica Ulrich, 1894, Geol. Minnesota, vol. iii, pt. 2, p. 687, pl. xliv, figs. 29-35, p. 688.

Description.—" Carapace minute, seldom exceeding two-hundredths of an inch in length, nearly twice as long as wide; valves very convex and cylindrical, the anterior and posterior ends subequal and strongly rounded; cardinal line much shorter than the length of the valve; tubercle obsolete. Surface smooth."—Hall, 1872.

An abundant fossil in all divisions of the Trenton and Cincinnatian rocks of the United States and Canada.

Occurrence.—MARTINSBURG SHALE (Eden division). Southern Pennsylvania and in the debris from the same on Fairview and Rickard Mountains in Maryland.

Collections.—Maryland Geological Survey, U. S. National Museum.

Superorder CIRRIPEDIA

Family LEPIDOCOLEIDAE Clarke

Genus LEPIDOCOLEUS Faber

LEPIDOCOLEUS JAMESI (Hall and Whitfield)

Plate LV, Figs. 1-4; Plate LII, Figs. 24, 25

Plumulites jamesi Hall and Whitfield, 1875, Geol. Surv. Ohio, Pal., vol. ii, p. 106, pl. iv, figs. 1-3.

Lepidocoleus jamesi Faber, 1886, Cincinnati Soc. Nat. Hist., vol. ix, p. 15, pl. i, figs. A-F.

Lepidocoleus jamesi Ruedemann, 1901, New York State Museum Bull., No. 42, p. 521, pl. ii, figs. 10-12.

Description.—" General form of the plates triangular, with the apex a little inclined to one side, the lateral margins gradually and rapidly diverging from the initial point, one of them considerably longer than the other.

Basal margin sigmoidal, the convex portion situated next to the longest lateral face, the concave portion to the shorter, and the shorter lateral margin deflected downwards in some cases (probably the marginal row of plates).

"The surface of the plates is flattened or slightly convex on the sides, and very faintly depressed along the middle, the whole marked by rather closely arranged, annulating, and scaliform transverse lines parallel with the basal or sigmoidal margin, and marking stages of growth. These transverse lines are usually faintest near the apex, and gradually increase in width with the increased growth of the plate, but in some cases they are quite irregular in their distances.

"The length from the apex to the basal margin of the plate is usually a little greater than the transverse diameter, and seldom exceeds a sixteenth of an inch, the largest specimens seen not measuring a line in their greatest diameter."—Hall and Whitfield, 1875.

Occurrence.—MARTINSBURG SHALE (Eden division). Jordans Knob, one and one-half miles northeast of Ft. Loudon; Tuscarora Mountain, two and one-half miles southeast of McConnellsburg, Pennsylvania; and in sandstone debris on the east slopes of Rickard Mountain, Washington County, Maryland. Also in the Corynoides bed at Williamsport, Maryland.

Collections.—Maryland Geological Survey, U. S. National Museum.

Superorder MALACOSTRACA

Division PHYLLOCARIDA

Family CERATIOCARIDAE

Genus CARYOCARIS Salter

CARYOCARIS SILICULA n. sp.

Plate LII, Figs. 21-23

Description.—Pod-shaped bodies which have been identified by Salter as the carapace of phyllopods under the name of *Caryocaris*, are known in the Canadian shales of America, but no more recent species have been described. The discovery of well-preserved examples of similar phyllopods in considerable numbers in the lower part of the Martinsburg shale just above the Sinuites zone is of considerable interest. These Middle Ordovician phyllopods all conform to a single type for which the name *Caryocaris silicula* is proposed. The species differs from the others of the genus in its narrower or more elongated carapace, and a more nearly equal anterior and posterior extremity. The latter characteristic is so marked that it is difficult to discriminate the two extremities.

A complete carapace is about 11 mm. long and 3.5 mm. high. No other portions of the organism than the carapace have been noted.

Occurrence.—MARTINSBURG SHALE (Corynoides bed). Strasburg, Virginia, and in the same zone northward to Chambersburg, Pennsylvania.

Collections.—Maryland Geological Survey, U. S. National Museum.

PLATE XXIV

PAGE

Olenellus thompsoni (Hall) 339

A large, almost entire individual of this characteristic trilobite with the third segment unusually prolonged. (After Walcott.)

Fragments of the free checks or of the segments are the portions most frequently found in the Antietam Sandstone of Maryland.

Cambrian. Georgia slate, Parker's quarry, Georgia, Vermont.

LOWER CAMBRIAN TRILOBITE *Olenellus thompsoni* Hall.

PLATE XXV

PAGE

Figs. 1-4. OBOLLELA MINOR Walcott 233

1. Cast of pedicle valve, enlarged.
2. Exterior of pedicle valve.
3. Exterior of brachial valve.
4. Cast of interior of brachial valve and edge view of same.

Cambrian (Waucoban), near Stissingville, Dutchess County, New York.

Figs. 5-8. HYOLITHES COMMUNIS Billings 318

5, 6. Lateral views of two specimens, enlarged.

7, 8. Transverse sections showing irregularities in thickness of shell.

Cambrian (Waucoban), Troy, New York.

Fig. 9. SCOLITHUS LINEARIS Haldemann 276

Fragment of drifted Antietam Sandstone, preserving the tubes of this species.

Pebble, five miles southwest of Washington, D. C.

Figures 1 to 8 are after Walcott.

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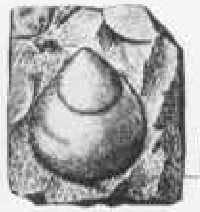

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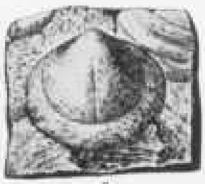

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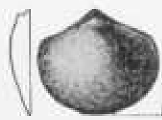

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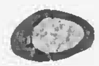

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LOWER CAMBRIAN. ANTIETAM SANDSTONE FOSSILS.

PLATE XXVI

PAGE

Fig. 1-9. Dolichometopus n. sp 338

1. A cranidium slightly elongated by pressure from direction indicated by arrow. × 3.
2. A similar but less distorted cranidium. × 3.
3. Rock fragment with cranidium of nearly normal shape. × 3.
4. A large cranidium of the same species. Lateral pressure has narrowed the head. × 1.5.
5. A small pygidium of normal shape. × 1.5.
6. A large pygidium of apparently the same species, slightly distorted. × 1.5.
7. Very small undistorted cranidium. × 3.
8. Two cranidia of normal size. The upper head is slightly shortened while the lower one is laterally compressed by pressure from the direction of the arrow, making it appear elongate. × 3.
9. Three well preserved cranidia with arrow showing direction of pressure. The upper left hand specimen is of another species with broader fixed cheeks. The upper of the two specimens on the right is shortened obliquely, the lower one anteroposteriorly. × 3.

Cambrian. Elbrook limestone (20 feet above base). Small quarry on eastern outskirts of Waynesboro, Pennsylvania.

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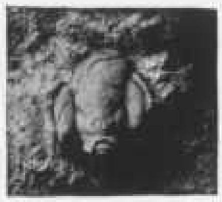

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MIDDLE CAMBRIAN. ELBROOK LIMESTONE FOSSILS.

PLATE XXVII

PAGE

Figs. 1-5. EOÖRTHIS DESMOPLEURA (Meek) 237

1. Brachial valve enlarged.
2. Pedicle valve, with characteristic surface.
3, 4. Cast of pedicle valve and side outline of same.
5. Exterior of pedicle valve showing surface characters.

Ordovician (Ozarkian ?), El Paso County, Colorado.

Figs. 6-8. SAUKIA STOSEI Walcott 351

6. Surface of limestone with cranidia, free cheek, and pygidium weathered out in relief. × 3.
7. Side view of cranidium and free cheek shown in Fig. 6. × 3.
8. Another view of cranidium and free cheek shown in Fig. 6.

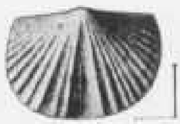
Cambrian (Ozarkian), Conococheague ls., near Scotland, Franklin County, Pennsylvania.

Fig. 9. FOSSIL REEF-FORMING CALCAREOUS ALGAE 190

Photograph of a rock mass forming the edge of a reef of fossil algae (*Cryptozoon*) overlapped by stratified layers of the argillaceous Conococheague limestone. This algal growth developed regular concentric layers in its lower part (A), but these layers or laminae became rather loosely interwoven in the upper portion (B). In the upper righthand corner (C) the overlapping edges of laminated Conococheague limestone may be noted. One-eighth natural size.

Cambrian (Ozarkian), Conococheague ls., one mile south of Clear Spring, Maryland.

Figures 1 to 8 are after Walcott.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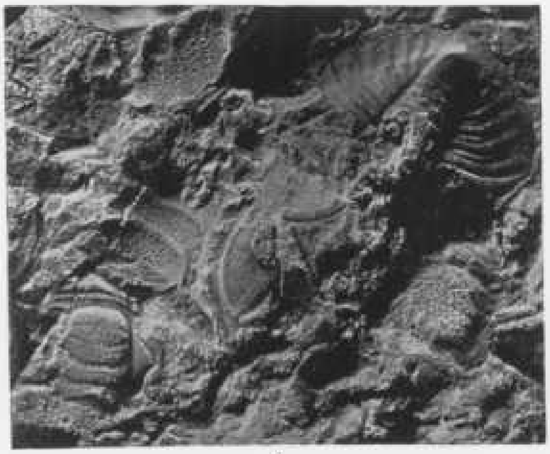
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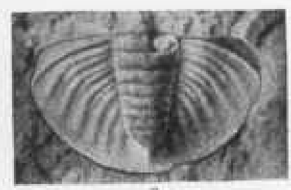
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UPPER CAMBRIAN (OZARKIAN). CONOCOCHEAGUE LIMESTONE FOSSILS.

PLATE XXVIII

PAGE

1. Edge view of a fragment showing the varying diameter of the bodies formed by the undulating layers in this species. At the top the laminae are less undulating and in fact become almost horizontal. This upper portion represents the beginning of a new growth of the organism.
2. Photograph of a fragment illustrating the view which would be seen in a cross-section taken through the middle line of Fig. 1. The variable diameter of the concentric masses is characteristic.

   Cambrian (Ozarkian), Conococheague. Near crossing of the Norfolk and Western Railroad and turnpike, one mile southwest of Antietam Station, Maryland.

1

2

UPPER CAMBRIAN (OZARKIAN). CONOCOCHEAGUE LIMESTONE FOSSILS.

PLATE XXIX

PAGE

Fig. 1. CRYPTOZOON PROLIFERUM Hall 189

Photograph of the upper side of a well preserved example of this characteristic fossil, the original of which is 22 inches wide. The unequal size of the confluent heads is a characteristic feature in this species.

Cambrian (Ozarkian), Hoyt ls. near Saratoga Springs, New York.

Fig. 2, 3. CRYPTOZOON UNDULATUM Bassler n. sp 190

2. Edge view of lower portion of a specimen showing the rather evenly undulating layers which form a pseudocolumnar structure.
3. Under side of same specimen illustrating the relatively equal proportions of the areas formed by the undulating layers.

Cambrian (Ozarkian), Conococheague ls., one mile south of Pleasant Hill School (2½ miles southeast of Funkstown), Maryland.

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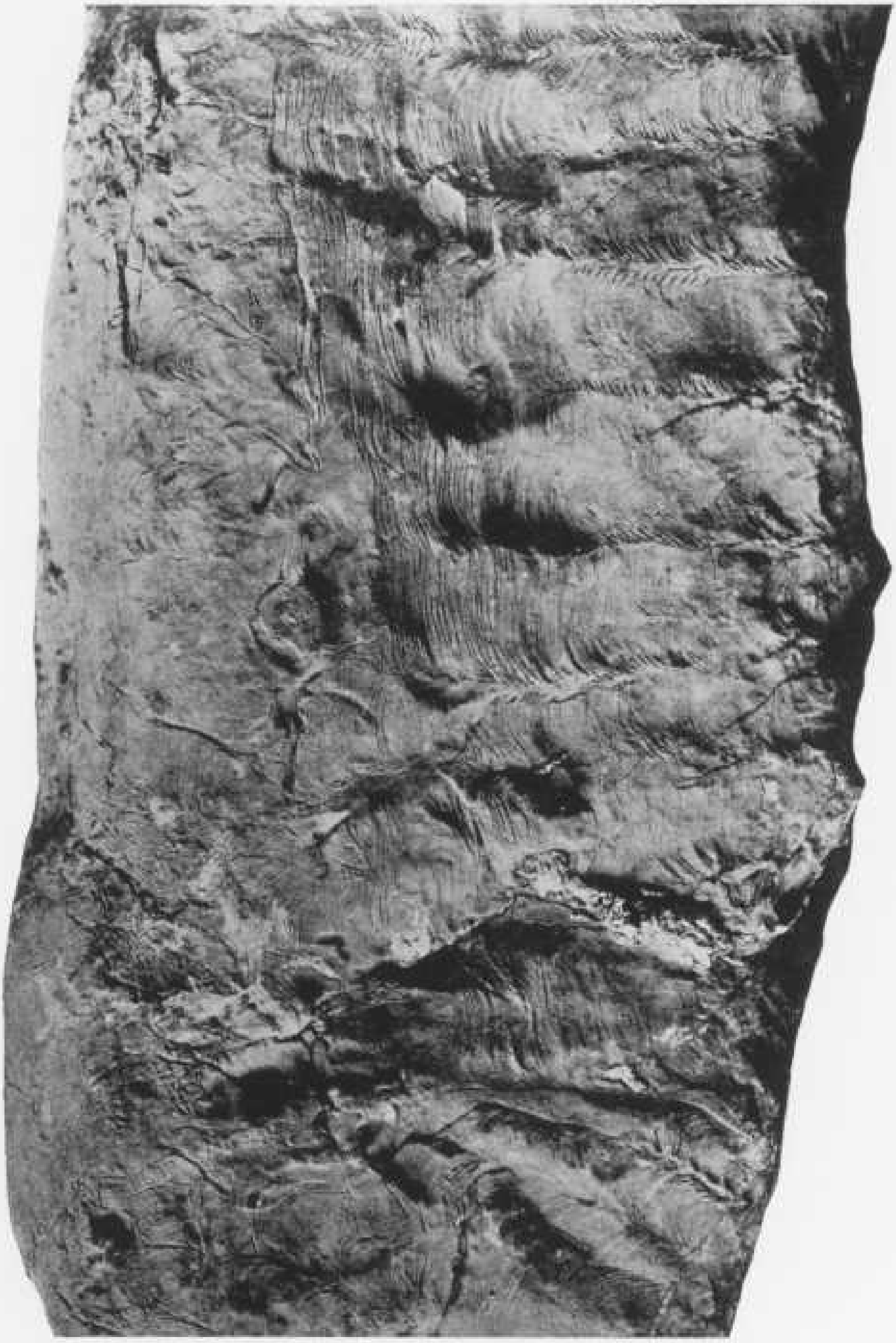
UPPER CAMBRIAN (OZARKIAN). CONOCOCHEAGUE LIMESTONE FOSSILS.

PLATE XXX

PAGE

Edge view of a specimen, two-thirds natural size. In the lower third the laminae are undulated strongly, giving the appearance of vertical columns in cross-section. The undulation is less pronounced in the middle third but the laminae are still quite distinct. In the upper third above the black line the distinct lamination disappears and the layers show the beginning of a new growth which is again quite undulating.

Cambrian (Ozarkian), Conococheague ls., one mile south of Pleasant Hill School ($2\frac{1}{2}$ miles southeast of Funkstown), Maryland.



UPPER CAMBRIAN (OZARKIAN). CONOCOCHEAGUE LIMESTONE FOSSILS.

PLATE XXXI

PAGE

Fig. 1. PALÆOPHYCUS TUBULARE Hall 192
View of the cylindrical stems of this species, two-thirds natural size.
Ordovician (Canadian), Tribes Hill ls. of New York.

Figs. 2-5. OPHILETA COMPLANATA Vanuxem 302
2, 3. Top and side views of the type of *Pleurotomaria hunterensis* Cleland, representing a large specimen of *Ophileta complanata*.
4, 5. Lower and upper views of a smaller specimen.
Ordovician (Canadian), Tribes Hill ls., Fort Hunter, New York.

Fig. 6. PLEUROTOMARIA FLORIDENSIS Cleland 291
Enlarged view of the type example.
Ordovician (Canadian), Tribes Hill ls., Fort Hunter, New York.

Figs. 7-12. DALMANELLA WEMPLEI Cleland 246
7. A large brachial valve. × 2.
8, 9. Two pedicle valves with side outline of one. × 2.
Ordovician (Canadian), Kittatinny ls., Columbia, New Jersey.
10. Brachial valve.
11, 12. Two pedicle valves, showing alternation of coarse and fine costae.
Ordovician (Canadian), Tribes Hill ls., Fort Hunter, New York.

Figs. 13, 14. RIBEIRIA NUCULITIFORMIS Cleland 362
13. Lateral view of well preserved cast showing the notch.
14. Posterior view of a cast.
Ordovician (Canadian), Tribes Hill ls., Fort Hunter, New York.

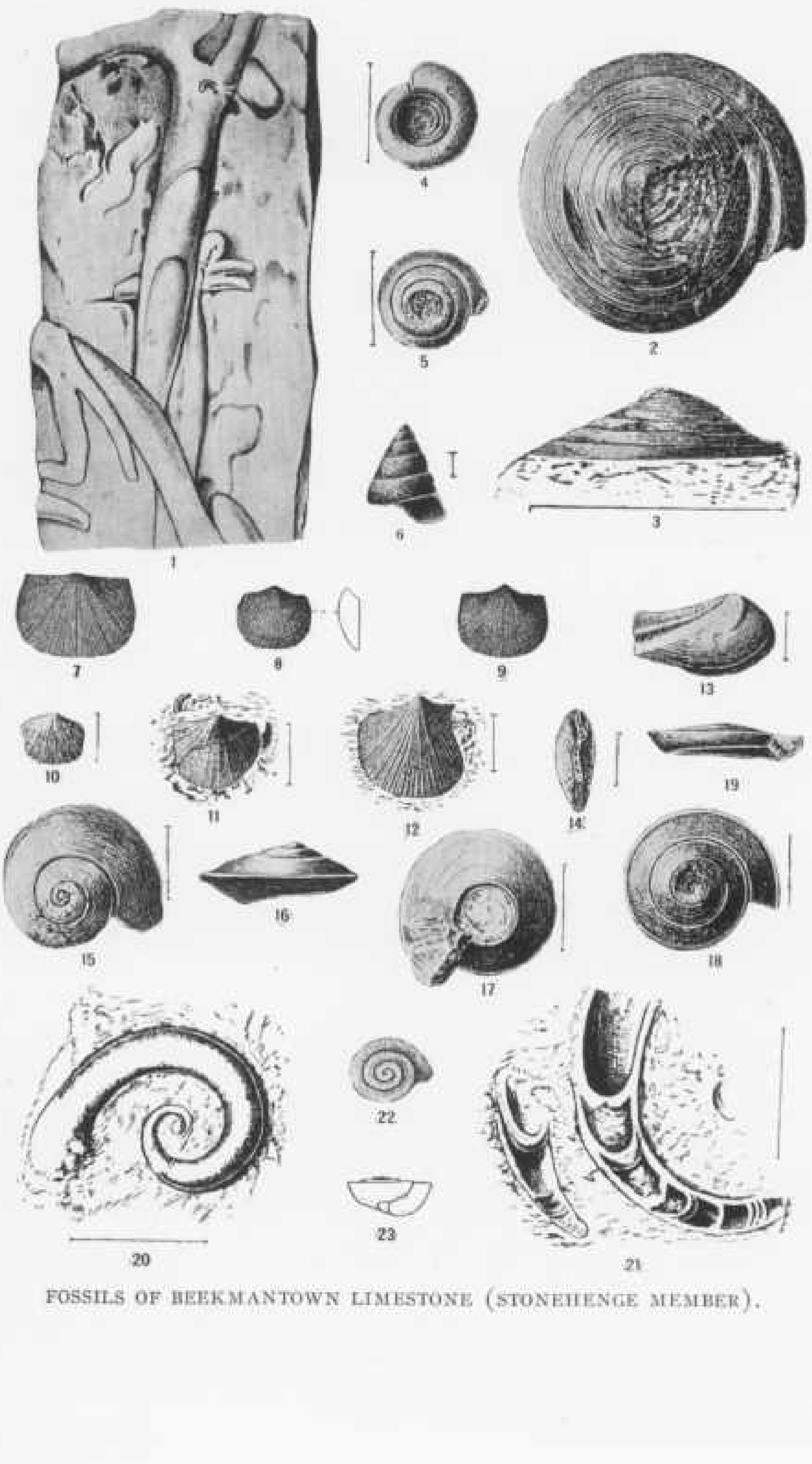
Figs. 15-17. RAPHISTOMA ? OBTUSUM Cleland 307
Upper, side, and lower views of the type, enlarged.
Ordovician (Canadian), Tribes Hill ls., Fort Hunter, New York.

Figs. 18, 19. OPHILETA LEVATA Vanuxem 304
Top and side views of the type of *Ophileta discus* Cleland determined by that author to be the same as *Ophileta levata*.
Ordovician (Canadian), Tribes Hill ls., Fort Hunter, New York.

Figs. 20, 21. ECCLIOMPHALUS MULTISEPTARIUS Cleland 305
20. Top view of the type.
21. Natural section showing the partitions.
Ordovician (Canadian), Tribes Hill ls., Fort Hunter, New York.

Figs. 22, 23. RAPHISTOMA COLUMBIANUM Weller 307
Top view and side outline of the type example.
Ordovician (Canadian), Kittantinny ls., Columbia, New Jersey.

Fig. 1 after Hall, 2-6, 10-21 after Cleland, and 7-9, 22-23 after Weller.



FOSSILS OF BEEKMANTOWN LIMESTONE (STONEHENGE MEMBER).

PLATE XXXII

PAGE

Figs. 1, 2. CYRTOCERAS BEEKMANENSE Whitfield 330

1. Lateral view of an incomplete shell, showing septa and living chambers.
2. Ventral view of same specimen.

Ordovician (Canadian), Beekmantown ls. (Division D. 1), Beekmantown, N. Y.

Figs. 3, 4. CYRTOCERAS GRACILE Cleland 329

Ventral and lateral views of the type.

Ordovician (Canadian), Tribes Hill ls., Fort Hunter, New York.

Fig. 5. ORTHOCERAS PRIMIGENIUM Vanuxem 322

Natural longitudinal section, illustrating tapering of shell and closeness of septa.

Ordovician (Canadian), Beekmantown ls., Beekmantown, New York.

Figs. 6, 7. CYCLOSTOMICERAS CASSINENSE (Whitfield) 331

Lateral and ventral views of a young specimen preserving only the living chamber and several septa.

Ordovician (Canadian), Beekmantown ls., Cassin beds, Fort Cassin, Vermont.

Figs. 8-10.. ASAPHELLUS GYRACANTHUS Raymond 345

8. Pygidium.
9. Free cheek.
10. An imperfect cranidium.

Ordovician (Canadian), Tribes Hill ls., Fort Hunter, New York.

Figs. 11-15. HEMIGYRASPIS COLLIEANA Raymond 346

11. An imperfect cranidium.
12. A free cheek. × 2.
13. Well preserved pygidium.
14. An imperfect pygidium.
15. Hypostoma.

Ordovician (Canadian), Stonehenge ls., Bellefonte, Pennsylvania.

Figs. 16-18. SYMPHYSURUS CONVEXUS (Cleland) 347

16. The cranidium figured by Weller as *Illaenurus columbiana.*

Ordovician (Canadian), Kittatinny ls., Columbia, New Jersey.

17, 18. Two small pygidia.

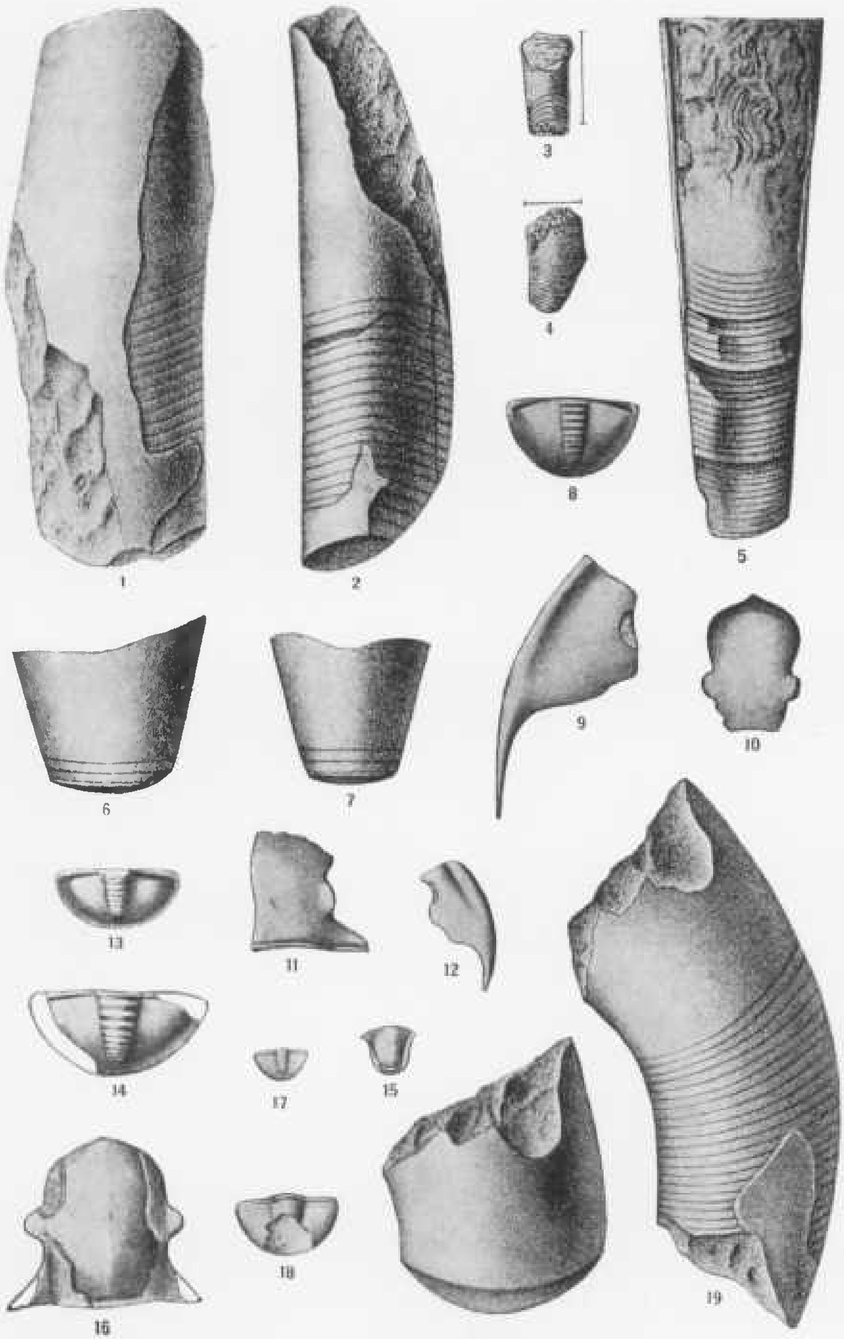
Ordovician, Tribes Hill ls., Fort Hunter, New York.

Figs. 19, 20. OOCERAS KIRBYI (Whitfield) 328

19. Lateral view of the type.
20. View of the outer chamber separated from the shell to show depth of the septum.

Ordovician (Canadian), Beekmantown ls. (Division D. 1), Beekmantown, New York.

Figs. 1, 2, 5, 19, 20 are after Whitfield; 6, 7 after Ruedemann; 3, 4 after Cleland; and 8, 18 after Raymond.



FOSSILS OF BEEKMANTOWN LIMESTONE (STONEHENGE MEMBER).

PLATE XXXIII

PAGE

Figs. 1-3. OPHILETA COMPACTA Salter 304
1, 2. Lower and upper sides of a specimen.
3. Schematic cross-section of the same.
Ordovician (Canadian), Beekmantown ls., Beekmantown, New York.

Figs. 4, 5. SYNTROPHIA LATERALIS Whitfield 267
4. Pedicle valve. × 2.
5. Sketch of hinge of same.
Ordovician (Canadian), Kittatinny ls., Columbia, New Jersey.

Figs. 6, 7. ECCLIOPTERUS TRIANGULUS (Whitfield) 302
6, 7. Top and side views of a cast of the interior.
Ordovician (Canadian), Beekmantown ls., Providence Island, Vermont.

Figs. 8, 9. MACLURITES AFFINIS (Billings) 297
8. Top view.
9. Cross-section of the shell.
Ordovician (Canadian), Division F of Quebec group. Keppel Island, Newfoundland.

Figs. 10-12. HYSTRICURUS CONICUS (Billings) 340
10. Glabella. × 2.
11. Pygidium. × 2.
12. Profile of glabella in outline.
Ordovician (Canadian), Beekmantown ls., Beekmantown, New York.

Figs. 13-15. TETRADIUM SIMPLEX Bassler n. sp. 199
13. Weathered fragment of limestone showing edge view of tubes.
14. Top view of corallum.
15. Portion of same. × 4.
Ordovician (Canadian), lower part of the Beekmantown ls. just above the Stonehenge member, eastern edge of Hagerstown, Maryland.

Figs. 1-3, 10-12 are after Whitfield; 4, 5, after Weller; 6, 7, after Ulrich; and 8 and 9 after Billings.

FOSSILS OF BEEKMANTOWN LIMESTONE (CRYPTOZOON STEELI ZONE).

PLATE XXXIV

PAGE

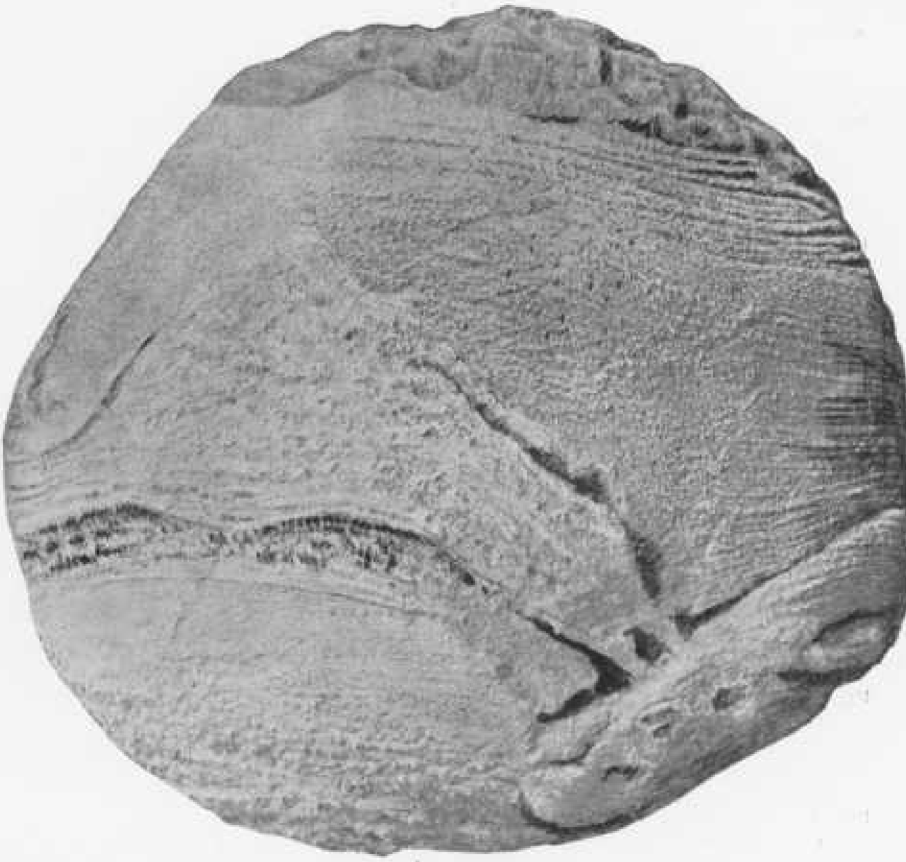
Fig. 1. Cryptozoon steeli Seely 191
A small weathered, rounded specimen.
Ordovician (Canadian), Cryptozoon steeli zone of the Beekmantown ls., near Williamsport, Maryland.

Fig. 2. Ophileta compacta Salter 304
Casts of two examples embedded in the rock.
Ordovician (Canadian), Cryptozoon steeli zone of the Beekmantown ls., Paradise Church, Maryland.

Fig. 3. Eccyliomphalus sp. 305
Specimen of a small narrow species. The ridges running across the shell are calcite-filled fractures of the rock.
Ordovician (Canadian), Beekmantown ls., near Paradise Church, Maryland.

Fig. 4. Eccyliomphalus sp. 305
Sections of several examples of an undetermined, large, loosely-coiled gastropod shell.
Ordovician (Canadian), Beekmantown ls., lower part, Hagerstown, Maryland.

Fig. 5. Cyrtoceras ? sp. 329
View of a curved cephalopod showing appearance on a weathered surface. In the fresh rock all trace of the structure is generally gone.
Ordovician (Canadian), Lower Stonehenge division of the Beekmantown ls., near Funkstown, Maryland.
Figures 3, 4 and 5 are introduced to show the usual aspect of the fossils found in the Beekmantown limestone of Maryland.



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3

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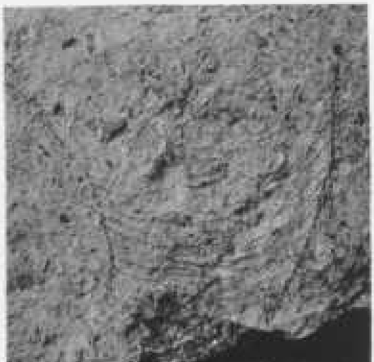

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FOSSILS OF BEEKMANTOWN LIMESTONE (CRYPTOZOON STEELI ZONE).

PLATE XXXV

PAGE

Figs. 1-3. PLEUROTOMARIA ?? GREGARIA Billings........................ 290

1, 2. Side view of an example enlarged and natural size.

3. Another view of the same.

Ordovician (Canadian), Beekmantown ls., St. Ann, Canada.

Figs. 4, 5. HORMOTOMA GRACILENS (Whitfield)......................... 293

Two nearly complete specimens. Enlarged.

Ordovician (Canadian), Beekmantown ls. (Division D), Beekmantown, New York.

Fig. 6. DALMANELLA ELECTRA (Billings)............................. 245

Pedicle valve. × 2.

Ordovician (Canadian), Kittatinny ls., Columbia, New Jersey.

Figs. 7, 8. MACLURITES OCEANUS (Billings)........................... 299

Top and side views of the type.

Ordovician, Quebec group, Port aux Choix, Newfoundland.

Figs. 9, 10. ECCYLIOPTERUS DISJUNCTUS (Billings)..................... 301

9. View of the spire.

10. Lower side of the shell.

Ordovician (Canadian), Beekmantown ls., Leeds and Grenville counties, Canada.

Fig. 11. TURRITOMA ACREA (Billings)............................... 293

Drawing of the type specimen natural size.

Ordovician (Canadian), Division G of Quebec group, Port aux Choix, Newfoundland.

Fig. 12. ISOCHILINA SEELYI Whitfield................................ 363

View of a right valve with lateral and ventral edge views. × 4.

Ordovician (Canadian), Beekmantown ls., Providence Island, Lake Champlain, Vermont.

Fig. 13. CYRTOCERINA MERCURIUS Billings............................ 331

Side view of the type specimen.

Ordovician (Canadian), Point Levis, Quebec.

Fig. 14. TROCHOLITES INTERNISTRIATUS Whitfield....................... 326

Lateral view of specimen showing surface sculpture of the various stages of the shell.

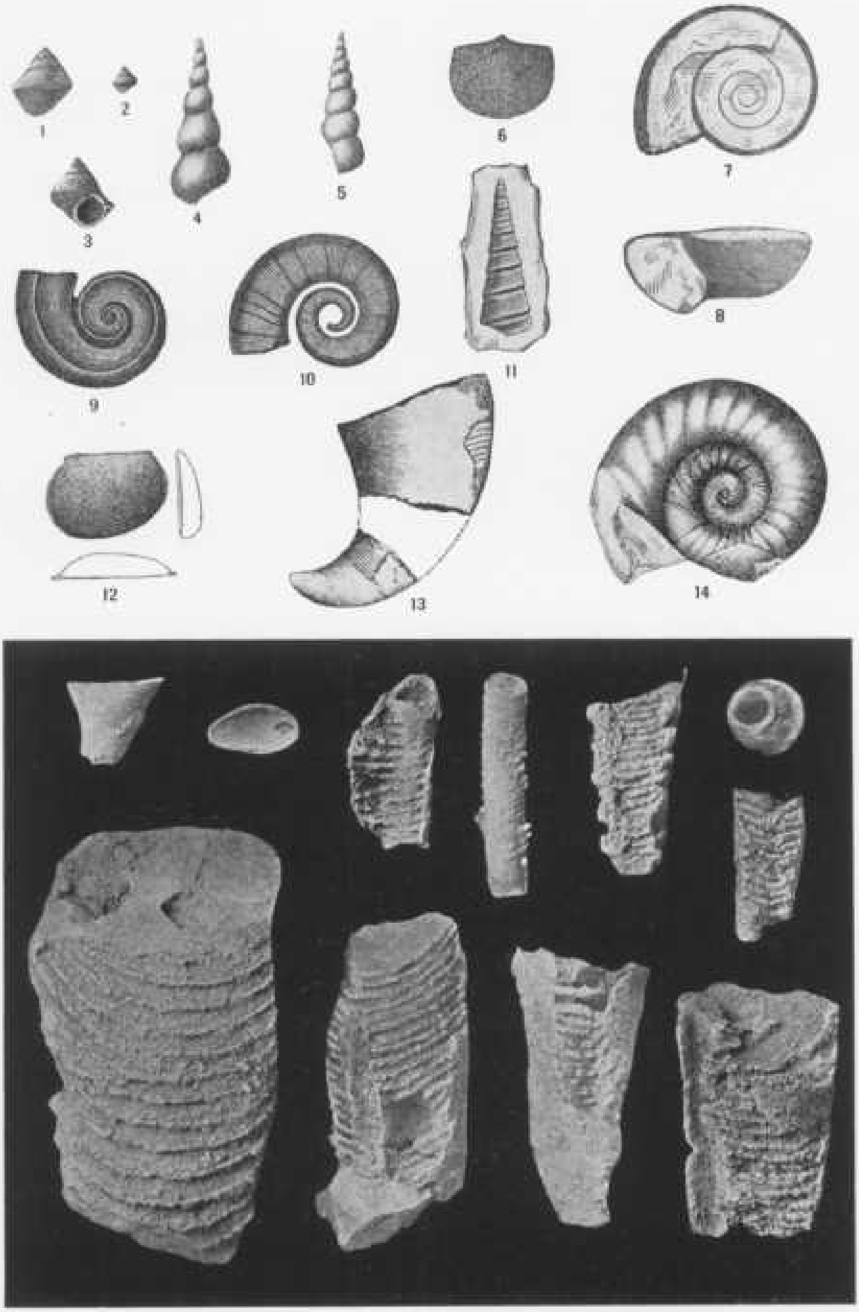
Ordovician (Canadian), Beekmantown ls., Cassin beds, Fort Cassin, Vermont.

Fig. 15. CAMEROCERAS and CYRTOCERINA............................... 331

A group of specimens showing occurrence and condition of preservation of these cephalopods in Maryland strata. The two left-hand views represent a species of *Cyrtocerina*. The remaining figures are of an undetermined species of *Cameroceras*. These fossils occurred as imperfectly silicified, iron-stained pseudomorphs on the weathered edges of rifts and caves in the limestone.

Ordovician (Canadian), Beekmantown ls., quarries at Legore, Maryland.

Figs. 1-3, 7-11, and 13 are after Billings; 4, 5, 12 are after Whitfield; 6 after Weller; and 14 after Ruedemann.



FOSSILS OF THE BEEKMANTOWN LIMESTONE.

PLATE XXXVI

PAGE

Figs. 1-3. MACLURITES SORDIDUS (Hall) 298

1, 2. Lower side of two specimens.

3. Upper side of a partial cast.

Ordovician (Canadian), Beekmantown ls., Beekmantown, New York.

Figs. 4, 5. PLEUROTOMARIA ?? CANADENSIS Billings 289

4. Side view of a cast.

5. View showing spire of specimen with shell preserved.

Ordovician (Canadian), Beekmantown ls., Leeds and Grenville counties, Canada.

Figs. 6, 7. RAPHISTOMINA LAURENTINA (Billings) 308

6. Side view.

7. Top view of a cast.

Ordovician (Canadian), Romaine formation, Mingan Islands, Canada.

Figs. 8, 9. HORMOTOMA ARTEMESIA (Billings) 291

8. Cast of the interior of a fragment.

9. A partly restored, well preserved specimen.

Ordovician (Canadian), Beekmantown ls., Leeds and Grenville counties, Canada.

Figs. 10-12. ISOCHILINA GREGARIA Whitfield 363

10. View of right valve and outline showing elevation. × 4.

11. Left valve of a larger example, with sketch of outline. × 4.

12. Internal cast of right valve and outline. × 4.

Ordovician (Canadian), Beekmantown ls., east shore of Lake Champlain, Vermont.

Fig. 13. PLIOMEROPS SALTERI (Billings) 359

Pygidium. Enlarged.

Ordovician (Canadian), Beekmantown ls., Phillipsburg, Quebec.

Fig. 14. GONIURUS CAUDATUS (Billings) 340

Pygidium, illustrating the large triangular spine.

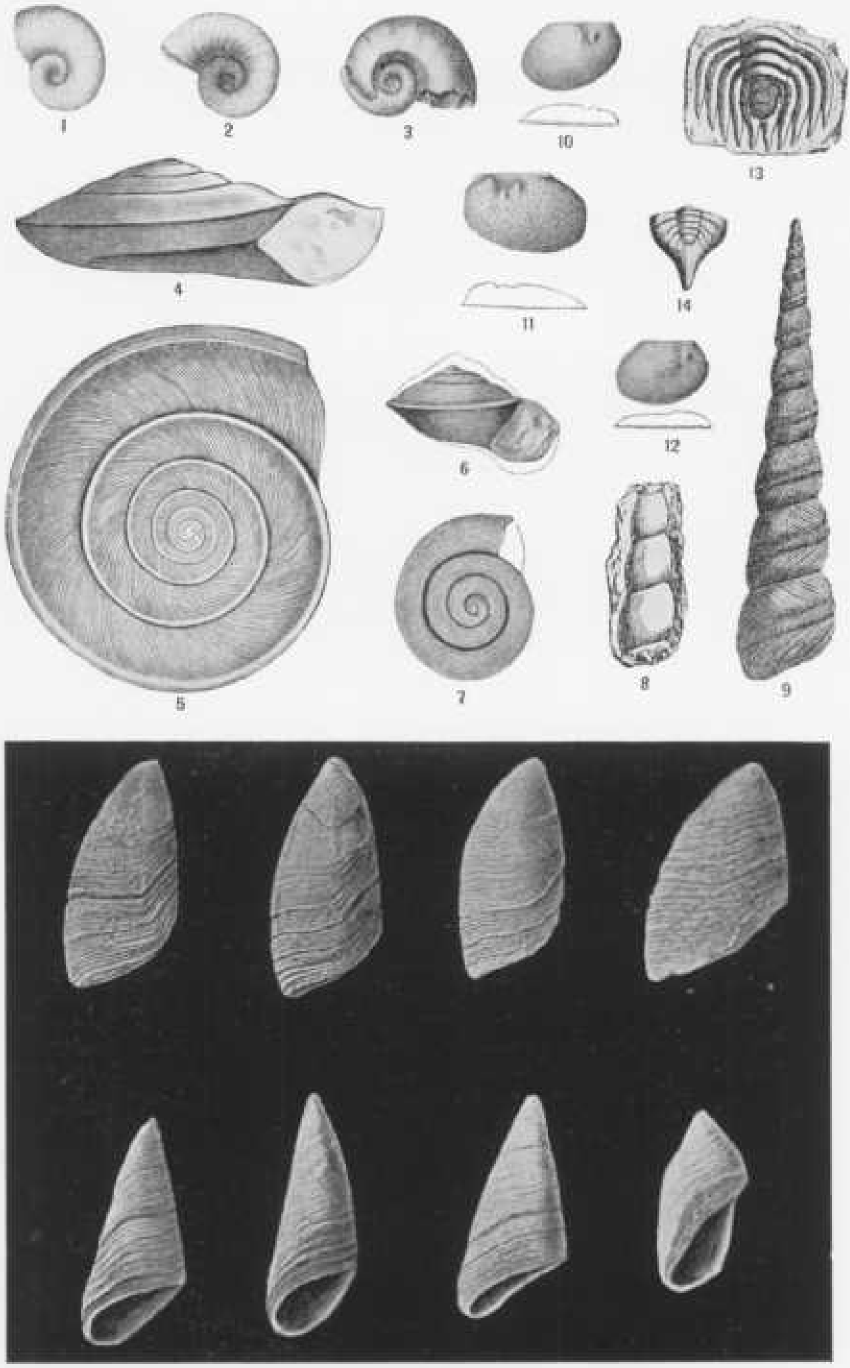
Ordovician (Canadian), Division G and H of the Quebec group. Port aux Choix, Newfoundland.

Fig. 15. CERATOPEA KEITHI Ulrich 299

Side and edge views of a group of specimens.

Ordovician (Canadian), Beekmantown, Ceratopea zone, western edge of Bristol. Tennessee and Wytheville, Virginia.

Figs. 1-3, 10-12 are after Whitfield; 4-9, 13, and 14 are after Billings.



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FOSSILS OF THE BEEKMANTOWN LIMESTONE.

PLATE XXXVII

PAGE

Figs. 1-4. STROPHOMENA STOSEI Bassler n. sp. 250

1. A brachial valve and interior of a brachial valve nearby. × 2.5.
2. A pedicle valve of a specimen referred to this species doubtfully on account of its high hinge area. × 2.5.
3. A crushed pedicle valve. × 2.5.
4. Fragment of a larger shell referred to the species.

Ordovician (Chazyan), Frederick ls., stone fences just east of Frederick, Maryland.

Fig. 5. RETEOCRINUS ? sp. undet. 209

A plate-like structure with seven rays. × 6. Other examples exhibit only six rays. None of the specimens shows a basal portion connecting the rays.

Ordovician (Chazyan), Frederick ls., just east of Frederick, Maryland.

Figs. 6-8. ACIDASPIS ULRICHI Bassler n. sp. 355

Three specimens illustrating the unusual development of long spines not only along the free cheeks but even to the tip of the genal spine, and the extraordinary curvature suggesting that the spines were directed over the thorax. × 2.

Ordovician (Chazyan), Frederick ls., east of Frederick, Maryland.

Fig. 9. ISOTELUS sp. undet. 345

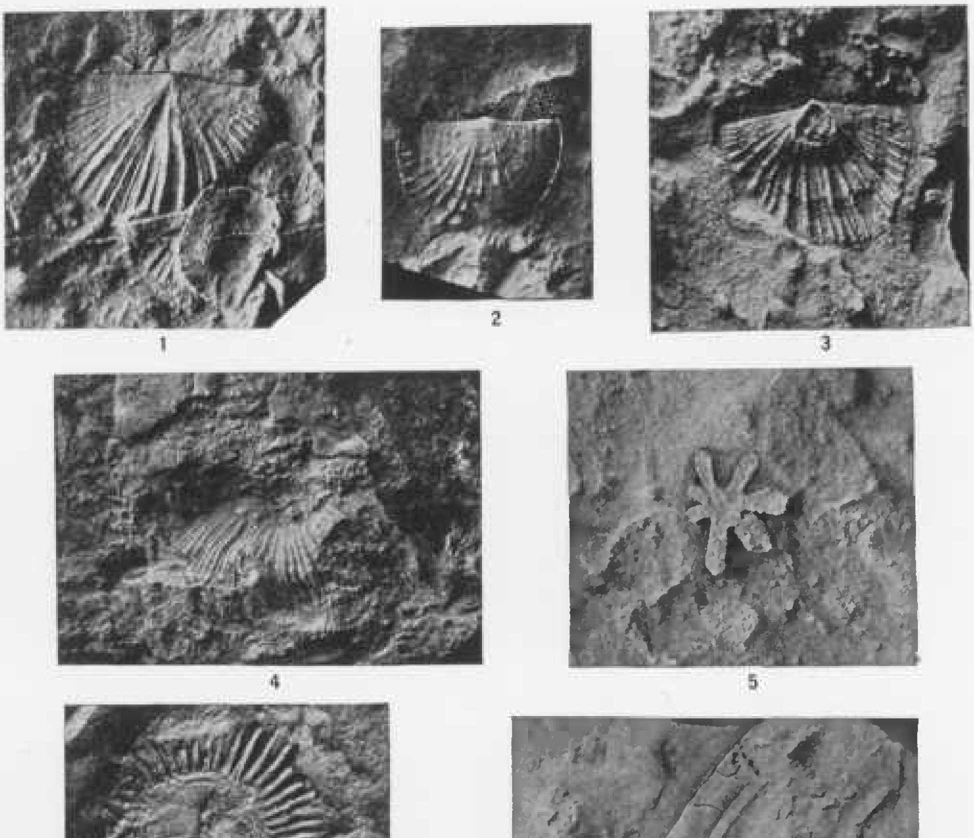
Imperfect free cheek. × 1.5.

Ordovician (Chazyan), Frederick ls., east of Frederick, Maryland.

Fig. 10. CAMEROCERAS sp. 321

Endosiphuncle composed of crystalline matter, embedded in limestone.

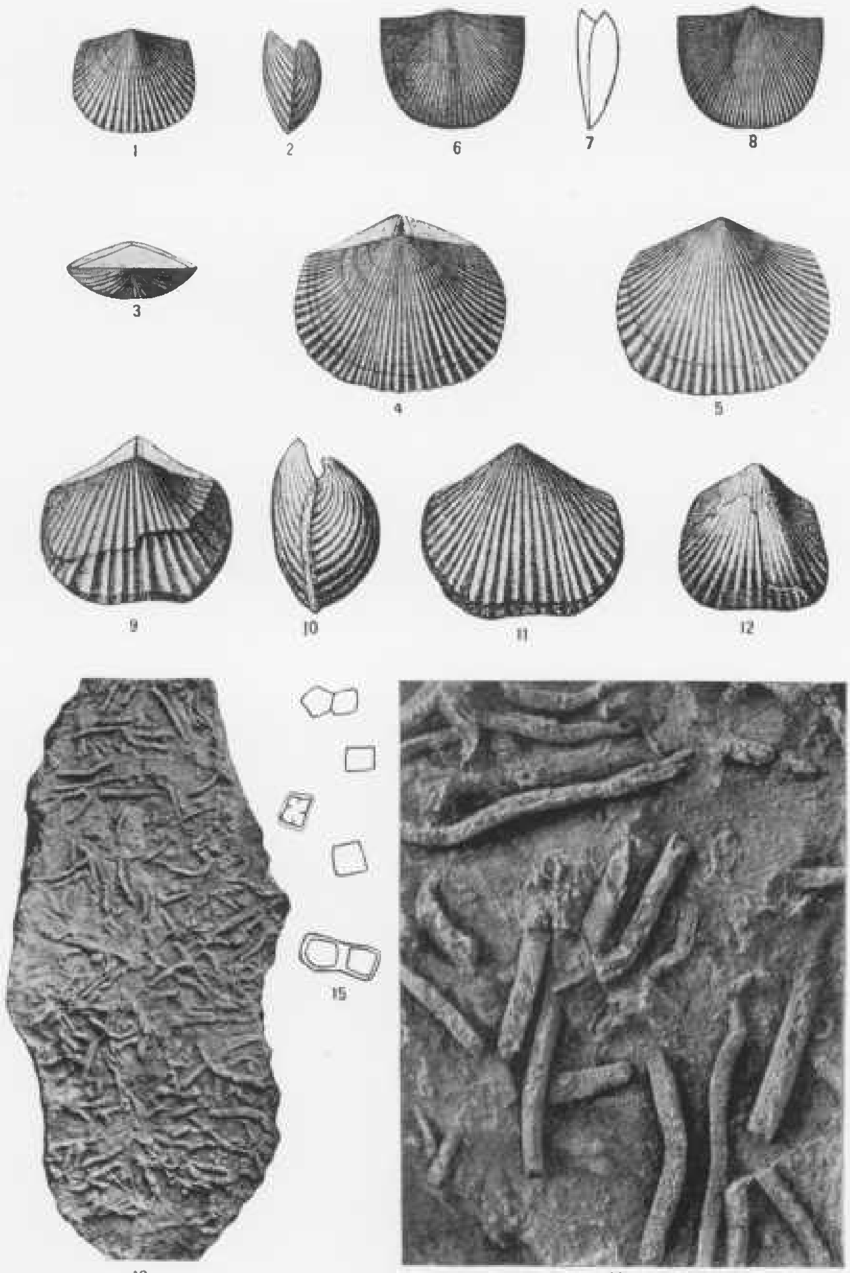
Ordovician (Chazyan), Frederick ls., east of Frederick, Maryland.



FOSSILS OF THE FREDERICK LIMESTONE.

PLATE XXXVIII

Figs. 1-5, 9-12 are after Raymond and 6-8 are after Billings.



FOSSILS OF THE STONES RIVER LIMESTONE.

PLATE XXXIX

PAGE

Figs. 1.5. LOPHOSPIRA BICINCTA (Hall) 294

1. A perfect, silicified shell.
2. Portion of the last whorl of same, showing direction and regularity of lines of growth. × 2.
3. Right side of last whorl of Fig. 1.

Ordovician (Chazyan), Stones River ls., Murfreesboro, Tennessee.

4. A large cast of the interior on which some of the external lines of growth are obscurely preserved.

Ordovician (Chazyan), Black River group, Beloit, Wisconsin.

5. Vertical section of an elongated specimen.

Ordovician (Chazyan), Black River group, Dixon, Illinois.

Figs. 6-8. BUCANIA SULCATINA (Emmons) 309

6. Side view of a large individual.
7. View of a specimen. × 2.
8. A young individual. × 6.

Ordovician (Chazyan), Lake Champlain area.

Figs. 9-11. AMPYX (LONCHODOMAS) HALLI (Billings) 337

9. Head with rostral spine broken.
10. Pygidium with two of thoracic segments.
11. Side view of head.

Ordovician (Chazyan), Highgate Springs, Vermont.

Figs. 12-15. MACLURITES MAGNUS Lesueur 297

12-14. Top, side, and botttom views of same specimen, two-thirds natural size.

15. Interior view of an operculum, two-thirds natural size.

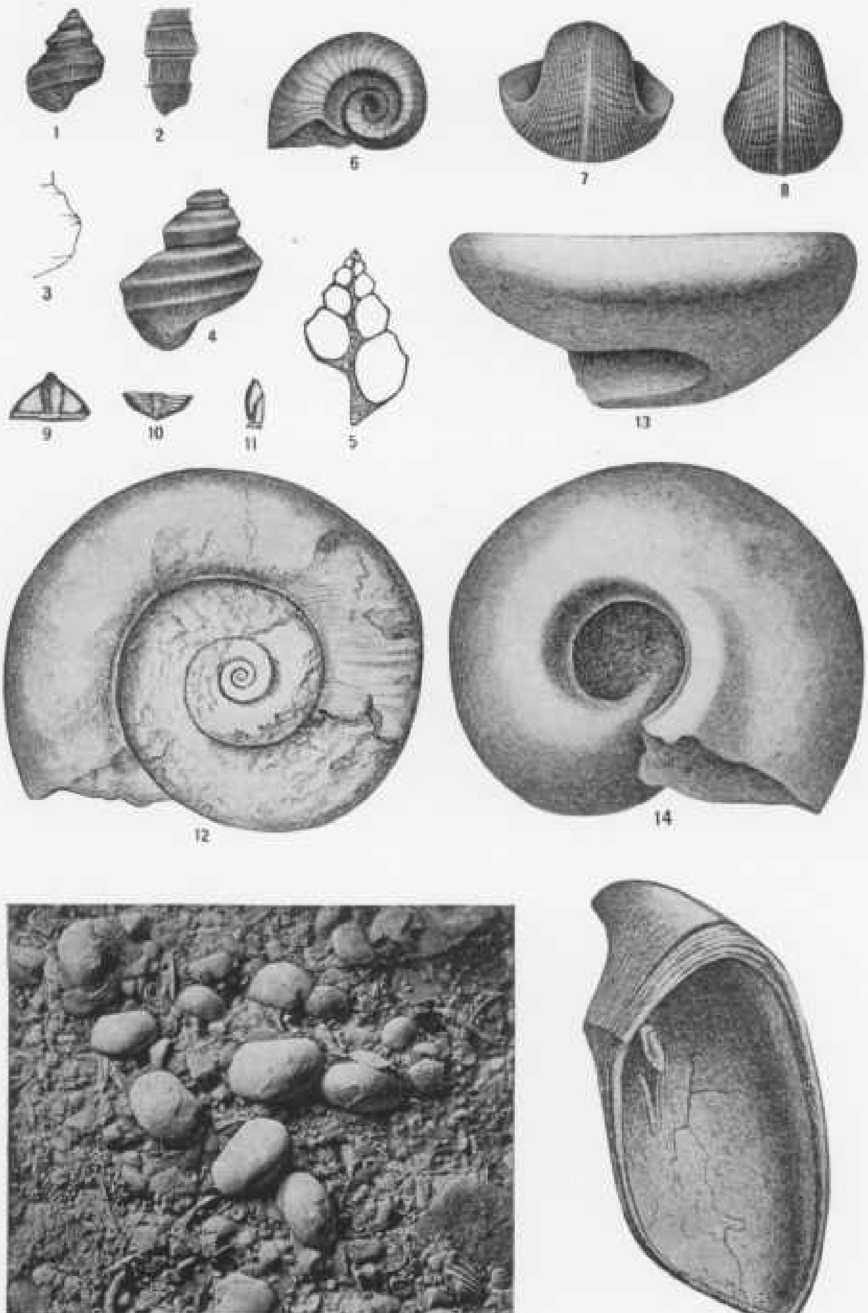
Ordovician (Chazyan), Lake Champlain area.

Fig. 16. LEPERDICIA FABULITES Conrad var 364

Surface of slab with numerous examples of this variety. × 1.3.

Ordovician (Chazyan), Stones River group, Lebanon ls., Columbia, Tennessee.

Figs. 1-5 are after Ulrich and Scofield; 6-8, 12-14 are after Raymond; and 9-11 are after Billings.



FOSSILS OF THE STONES RIVER LIMESTONE.

PLATE XL

PAGE

Figs. 1-3. HELOPORA DIVARICATA Ulrich 227

1. Segment natural size and × 7.
2. Portion of the same. × 18.
3. Transverse section. × 18.

Ordovician (Mohawkian), Black River (Decorah) shales, Minneapolis, Minnesota.

Figs. 4-6. CHASMATOPORA RETICULATA (Hall) 226

4. Frond showing the reverse side.
5. Portion of the same. × 9.
6. Small fragment exhibiting the reverse or celluliferous side. × 18.

Ordovician (Mohawkian), Trenton shales, Minneapolis, Minnesota.

Figs. 7-10. CHASMATOPORA SUBLAXA (Ulrich) 227

7, 8. Fragments showing obverse and reverse sides.

9. Celluliferous side of specimen, Fig. 7. × 9.

10. Reverse side of small fragment, Fig. 8, illustrating striated character. × 9.

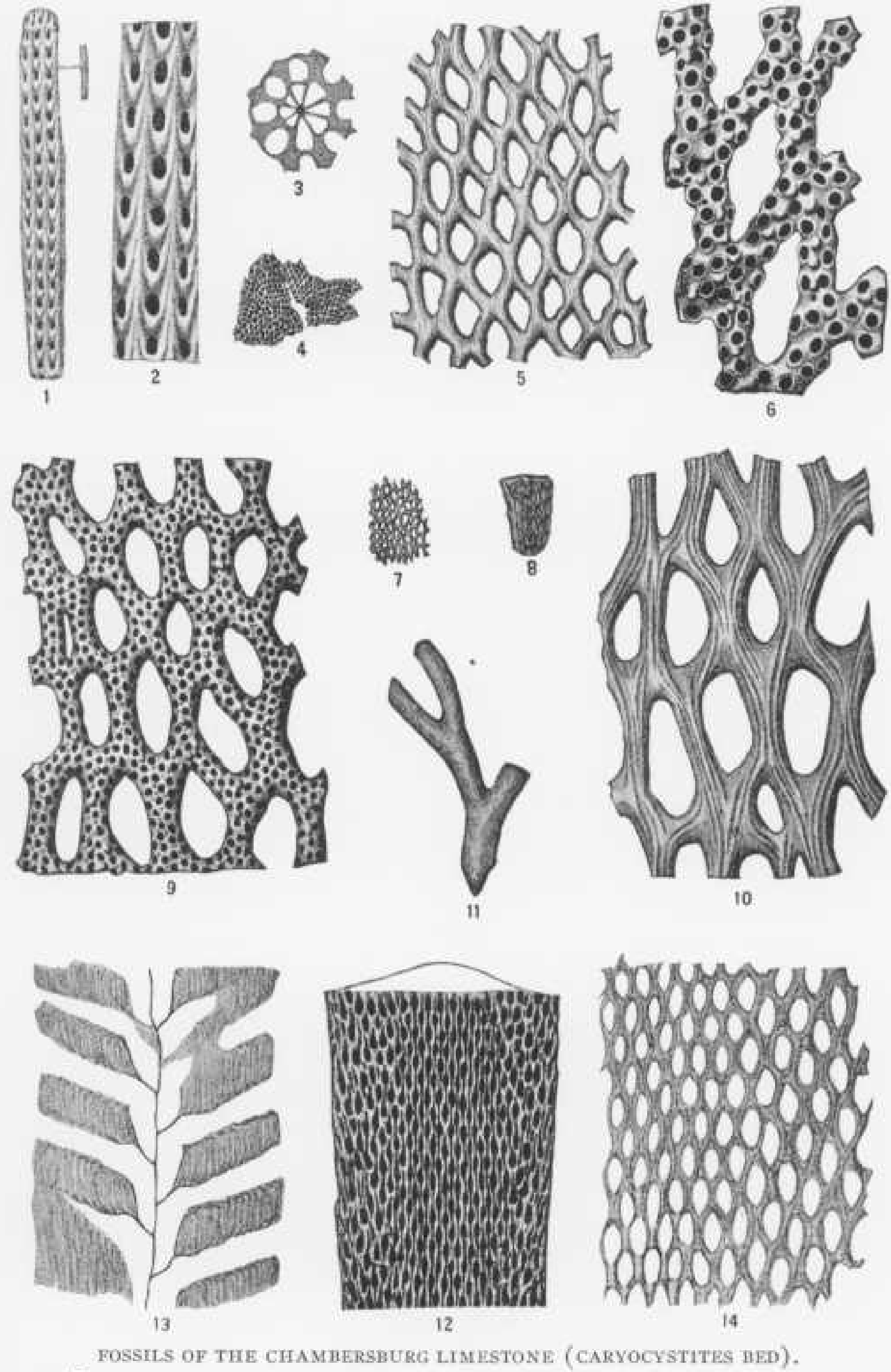
Ordovician (Mohawkian), Black River (Decorah) shales, Minneapolis, Minnesota.

Figs. 11-14. ESCHAROPORA CONFLUENS Ulrich 223

11. A specimen preserving the pointed articulating base.
12. Surface of example illustrating arrangement of apertures. × 9.
13. Vertical section. × 18.
14. Tangential section of a well preserved fragment. × 18.

Ordovician (Mohawkian), Black River (Decorah) shales, Minneapolis, Minnesota.

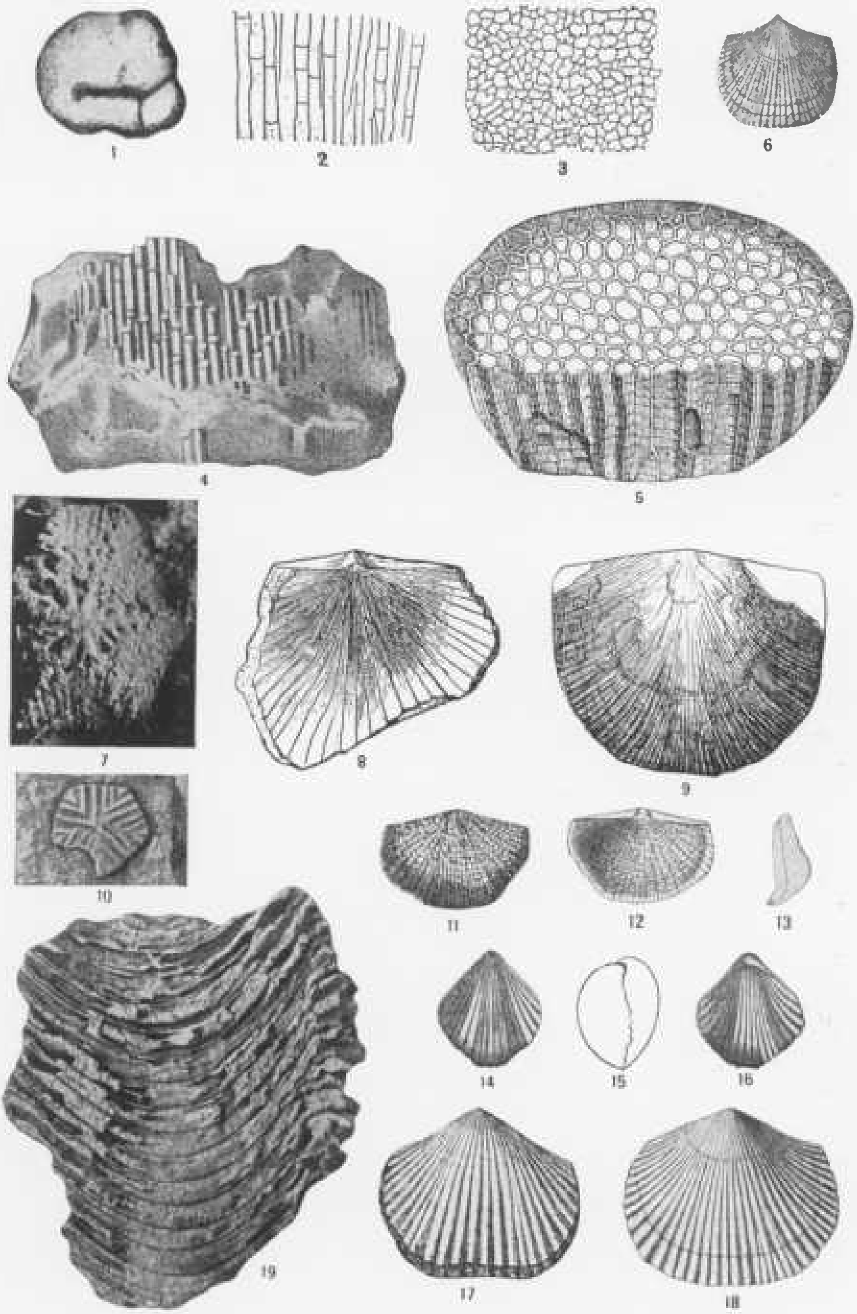
Figures after Ulrich.



FOSSILS OF THE CHAMBERSBURG LIMESTONE (CARYOCYSTITES BED).

PLATE XLI

Figs. 1-3, 6, 11-13, are after Winchell and Schuchert; 4 after Hall; 5, 14-16, after Billings; and 8, 9, 17, 18, after Raymond.



FOSSILS OF THE CHAMBERSBURG LIMESTONE (CARYOCYSTITES BED).

PLATE XLII

PAGE

Figs. 1, 2. STREPTELASMA PROFUNDUM (Conrad) 199

1. An entire specimen with a portion broken away to show the great depth of the body cavity.
2. View of the body cavity.

Ordovician (Mohawkian), Black River (Platteville) ls., Mineral Point, Wisconsin.

Figs. 3-5. TETRADIUM CELLULOSUM (Hall) 202

3. Section in the rock cutting the tubes longitudinally and showing their arrangement in bundles.
4. Portion of two bundles, enlarged.
5. Cross-section in rock, exhibiting the arrangement of the tubes and the occurrence of the characteristic four septa.

Ordovician (Mohawkian), Black River ls., Watertown, N. Y.

Fig. 6. CAMAROCLADIA RUGOSA Ulrich 196

Rock fragment composed almost entirely of the branches of this organism.

Ordovician (Mohawkian), Black River (Decorah) shales, St. Paul, Minnesota.

Figs. 7, 8. ORBIGNYELLA WETHERBYI (Ulrich) 214

7. Vertical section exhibiting the characteristic curved diaphragms. × 18.
8. Tangential section showing the angular tubes and the granular walls. × 18.

Ordovician (Mohawkian), Black River (Platteville) ls., Minneapolis, Minnesota.

Figs. 9-12. ZYGOSPIRA RECURVIROSTRIS (Hall) 272

9, 10. Brachial and pedicle valves of an entire specimen. × 2.

11, 12. Anterior and lateral views of the same.

Ordovician (Mohawkian), Trenton portion of the Jacksonburg, ls., Jacksonburg, New Jersey.

Figs. 13-15. HELICOTOMA PLANULATOIDES Ulrich 300

Three views of an entire silicified specimen.

Ordovician (Mohawkian), Black River (Lowville) ls., Mercer County, Kentucky.

Figs. 16, 17. HELICOTOMA VERTICALIS Ulrich 301

Basal and lateral views of a cast of the interior.

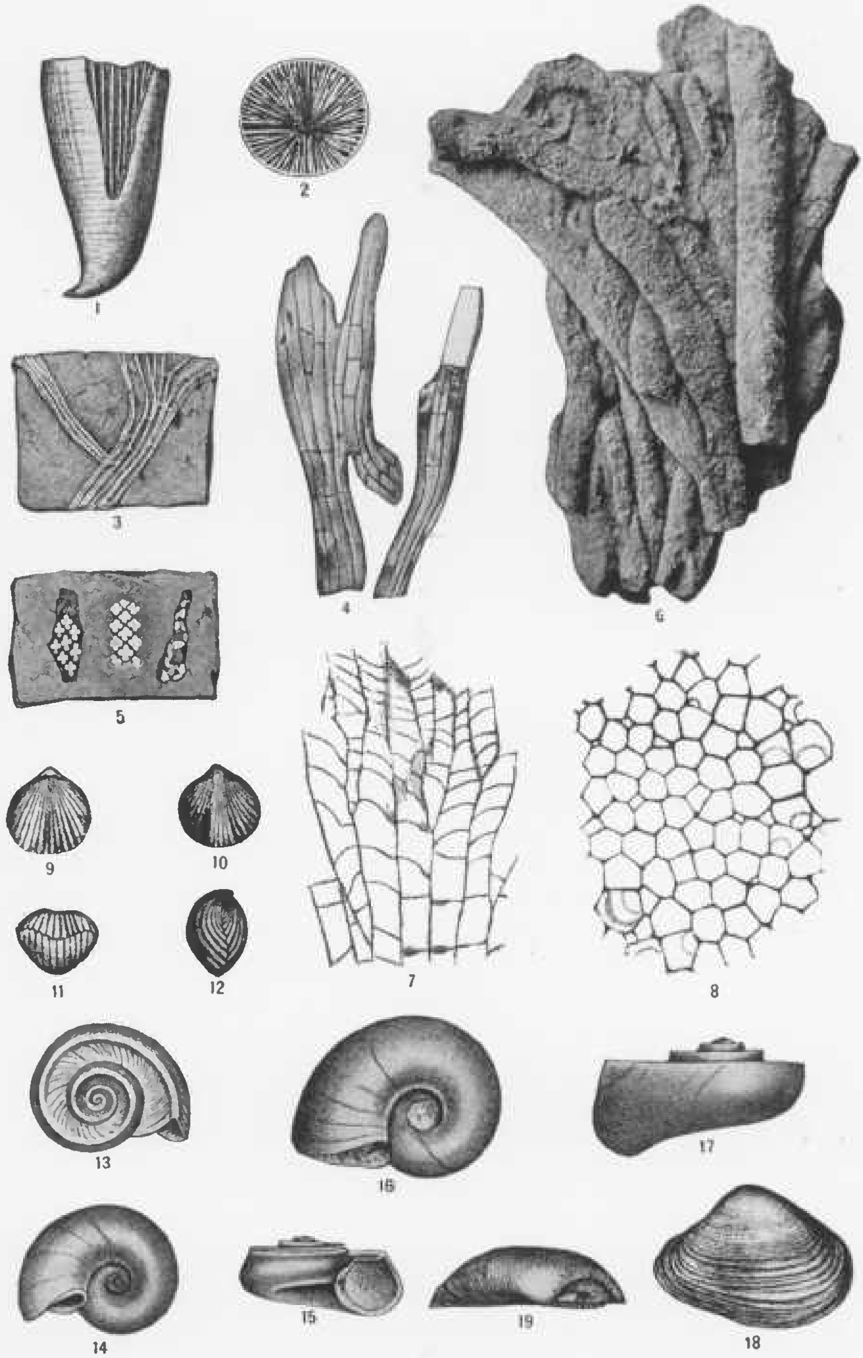
Ordovician (Mohawkian), Black River (Lowville) ls., High Bridge, Kentucky.

Figs. 18-20. CTENODONTA GIBBERULA Salter 277

18. Lateral view of a large right valve.
19. Cardinal view of the same.

Ordovician (Mohawkian), Stones River (Murfreesboro) ls., Murfreesboro, Tennessee.

Fig. 1, 2 are after Winchell and Schuchert; 3-5 are after Hall; 7, 8, 18-20 are after Ulrich; 9-12 are after Weller; and 13-17 are after Ulrich and Scofield.



FOSSILS OF THE CHAMBERSBURG LIMESTONE (TETRADIUM CELLULOSUM BED).

392 B

PLATE XLIII

PAGE

Figs. 1-5. Leperditia fabulites (Conrad) 364

1. Cast of interior of right (larger) valve showing impressions of papillae along ventral margin. × 2.

2, 3. Ventral and dorsal views of a complete carapace. × 2.

4. Left valve of the same. × 2.

5. Posterior view. × 2.

Ordovician (Mohawkian), Black River (Platteville) ls., Minneapolis, Minnesota.

Figs. 6-9. Macronotella ulrichi Ruedemann 368

6, 7. Ventral and lateral views of a large valve. × 14.

8, 9. Similar views of another specimen showing the specific characters well developed. × 14.

Ordovician (Mohawkian), Rysedorph conglomerate, Rysedorph Hill, Rensselaer County, New York.

Figs. 10-12. Leperditella tumida (Ulrich) 366

10. Right valve. × 10.

11, 12. Dorsal and posterior views of same in outline. × 10.

Ordovician (Mohawkian), Black River (Lowville) ls., High Bridge, Kentucky.

Figs. 13-15. Drepanella macra Ulrich 367

13. Left valve. × 20.

14, 15. Sectional views of same between points marked c and b.

Ordovician (Mohawkian), Stones River (Lebanon) ls., Lavergne, Tennessee.

Figs. 16, 17. Omospira alexandra (Billings) 308

16. Cast of the interior.

Ordovician (Mohawkian), Black River (Platteville) ls., Dixon, Illinois.

17. An imperfect, silicified shell.

Black River (Lowville) ls., Mercer County, Kentucky.

Figs. 18-21. Pterygometropus callicephalus (Hall) 360

18. A nearly complete pygidium of large size.

19. A small complete pygidium.

20. An incomplete head.

Ordovician (Mohawkian), Trenton portion Jacksonburg ls., Jacksonburg, New Jersey.

21. Complete individual.

Ordovician (Mohawkian), Trenton ls. of Canada.

Figs. 22, 23. Ceraurus pleurexanthemus Green 358

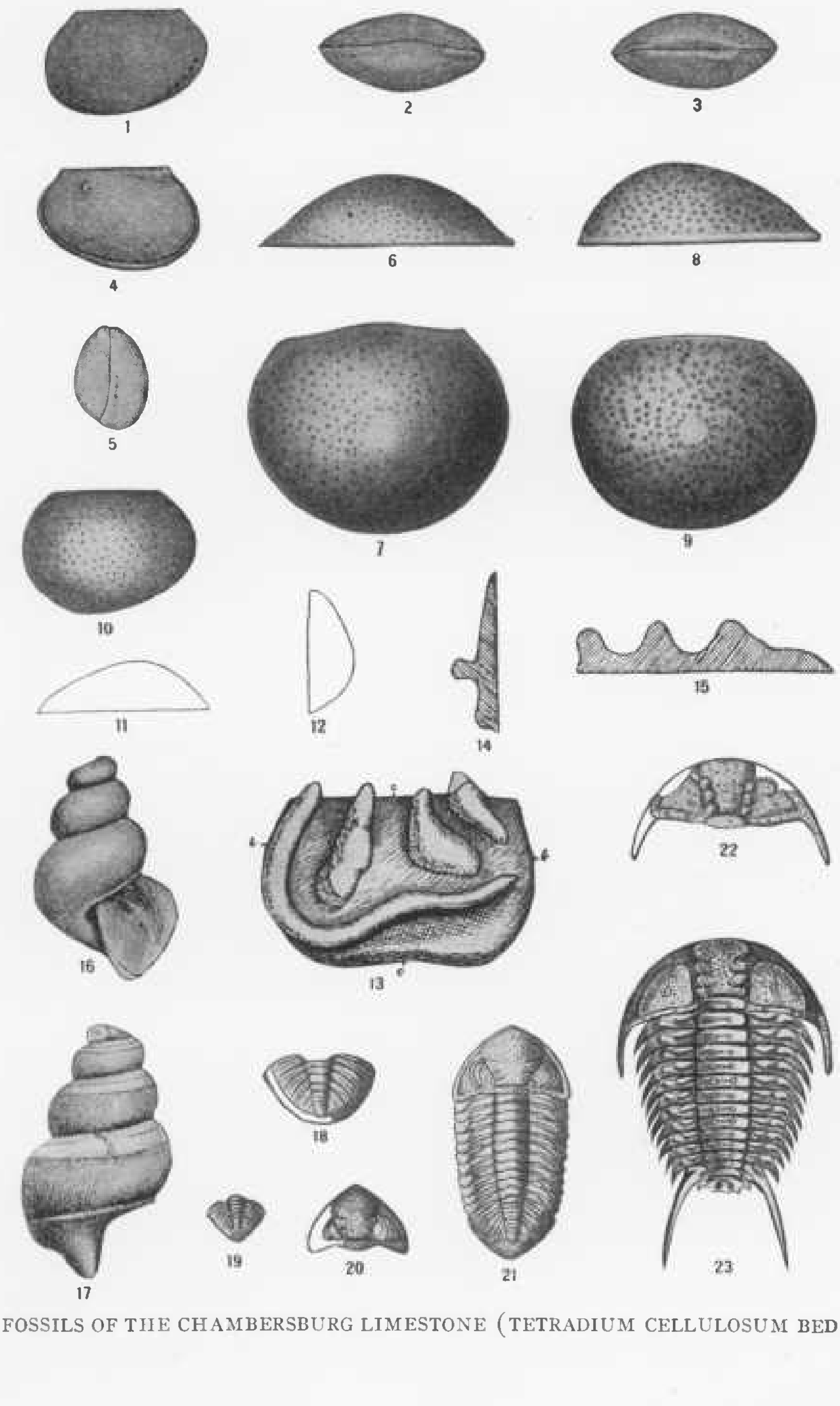
22. An incomplete cranidium.

Ordovician (Mohawkian), Trenton portion of Jacksonburg ls., Jacksonburg, New Jersey.

23. General aspect of species of this type. The original of this figure has since been referred to a new species, *C. dentatus* Raymond and Barton.

Trenton ls., of Canada.

Figs. 1-5, 10-15 are after Ulrich; 6-9 after Ruedemann; 16, 17, 21, 23 after Billings; 18-20, 22 after Weller.



FOSSILS OF THE CHAMBERSBURG LIMESTONE (TETRADIUM CELLULOSUM BED).

PLATE XLIV

PAGE

Figs. 1-5. Hemiphragma irrasum (Ulrich) 218

1. Surface of a zoarium illustrating the usual aspect. × 10.
2. Tangential section. × 18.
3. Vertical section exhibiting incomplete diaphragms in mature zone. × 9.

4, 5. Two specimens of the branching zoarium.

Ordovician (Mohawkian), Black River (Decorah) shales of Minnesota.

Figs. 6, 7. Dianulites petropolitanus Dybowski .... 21[illegible]

6. Vertical section. × 9.
7. Tangential section × 9 and a portion × 35 showing wall structure in detail.

Ordovician (Mohawkian), Trenton shales, Goodhue County, Minnesota.

Figs. 8-10. Helopora spiniformis Ulrich 228

8. A segment natural size and lower portion of same. × 18.

9, 10. Vertical and transverse sections of a segment. × 18.

Ordovician (Mohawkian), Stones River (Lebanon) ls., Lavergne, Tennessee.

Figs. 11-14. Rhinidictya neglecta Ulrich 229

11. Fragment, natural size, and portion of surface × 18, showing the usual aspects of the species.
12. Tangential section. × 18.

13, 14. Vertical and transverse section. × 18.

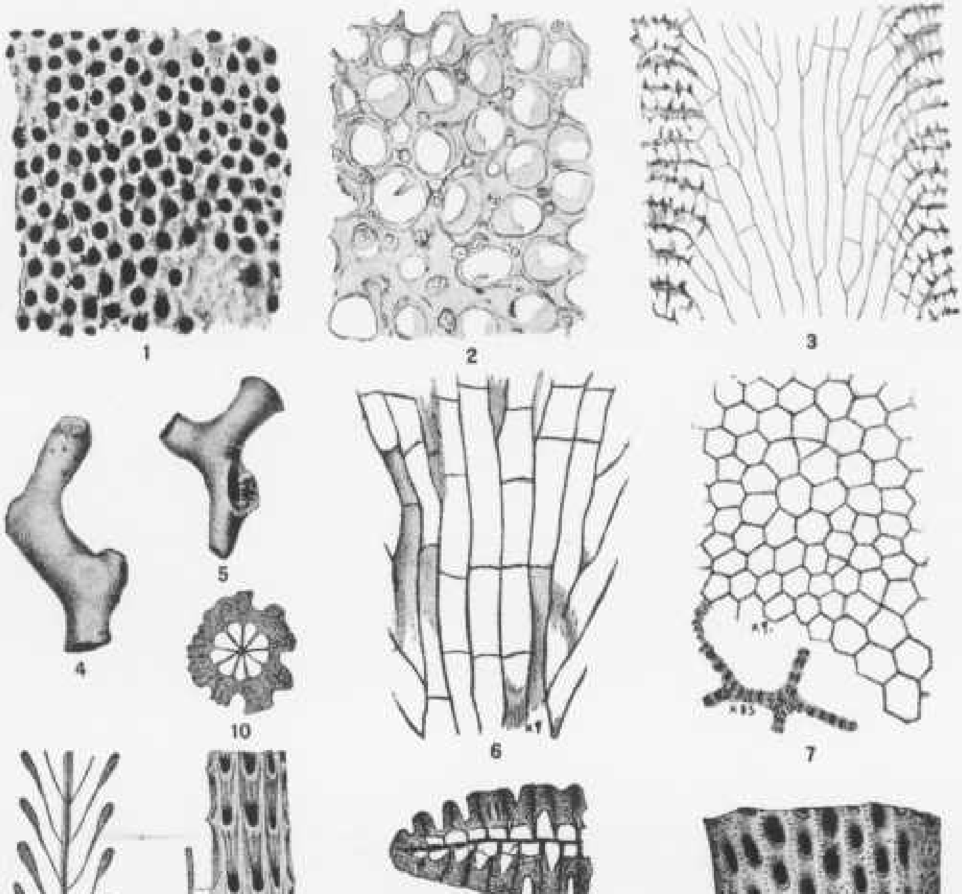
Ordovician (Mohawkian), Trenton ls., Burgin, Kentucky.

Figs. 15-17. Prasopora insularis Ulrich 215

15. Tangential section exhibiting the numerous mesopores. × 18.
16. Small portion of a tangential section through a macula and surrounding zoœcia. × 18.
17. Vertical section illustrating great abundance of cystiphragms and diaphragms. × 18.

Ordovician (Mohawkian), Trenton shales near Cannon Falls, Minnesota.

Figures are after Ulrich.



FOSSILS OF THE CHAMBERSBURG LIMESTONE (ECHINOSPHERITES BED).

PLATE XLV

PAGE

Figs. 1-3. Pianodema subequata (Conrad) 249

Pedicle and brachial valves of a well preserved example and profile of the same.

Ordovician (Mohawkian), Black River (Decorah) shales, Minneapolis, Minnesota.

Fig. 4. Rafinesquina minnesotensis (Winchell) 261

Brachial valve of the type form of this species.

Ordovician (Mohawkian), Black River ls., Rocktown, Wisconsin.

Figs. 5, 6. Rafinesquina minnesotensis inquassa (Sardeson) 264

Dorsal and profile views of an ordinary example of this variety.

Ordovician (Mohawkian), Black River (Platteville) ls., Mineral Point, Wisconsin.

Fig. 7. Receptaculites occidentalis Salter 194

Weathered surface of an imperfect specimen.

Ordovician (Mohawkian), Black River portion of Jacksonburg ls., near Springdale, New Jersey.

Figs. 8, 9. Dinorthis pectinella (Emmons) 248

8. Pedicle valve.
9. Incomplete brachial valve.

Ordovician (Mohawkian), Lowest Trenton portion of Jacksonburg ls., near Newton, New Jersey.

Figs. 10-12. Hebertella bellarugosa (Conrad) 239

10. Exterior of a large pedicle valve.
11. Interior of the same.
12. Exterior of a dorsal valve of the ordinary size.

Ordovician (Mohawkian), Trenton shales of Minnesota.

Figs. 13, 14. Ampyx (Lonchodomas) normalis (Billings) 336

Head and pygidium.

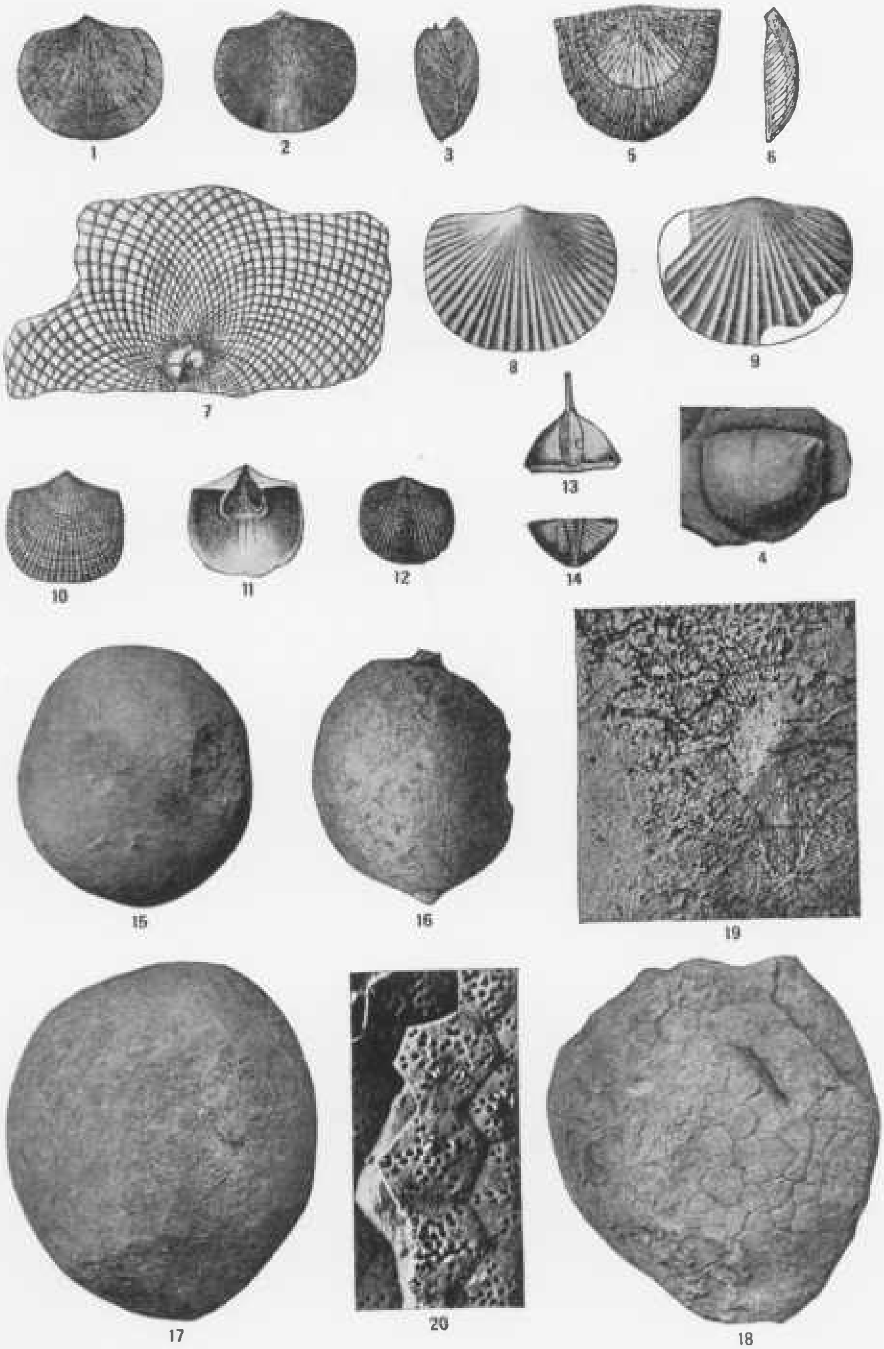
Ordovician, Chazyan of Newfoundland.

Figs. 15-20. Echinospherites aurantium var americanum Bassler n. var. 207

15. A specimen of average size showing the ovate form of this variety.
16. A well preserved small example preserving the point of attachment at the base. × 2.
17. A slightly distorted but otherwise typical specimen.
18. Compressed example with plates exposed by weathering.
19. Abraded outer surface of the plates showing pore rhombs. × 3.
20. Inner surface of calyx plates exhibiting pores. × 3.

Ordovician (Mohawkian), Echinospherites bed of Chambersburg ls., 3½ miles north of Greencastle, Pennsylvania.

Figs. 1-3, 5, 6, 10-12 are after Winchell and Schuchert; 7-9 after Weller; and 13, 14 after Billings.



FOSSILS OF THE CHAMBERSBURG LIMESTONE (ECHINOSPHERITES BED).

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Figs. 1-5. NIDULITES PYRIFORMIS Bassler.................................. 193

1. A nearly complete example partially embedded in limestone. The pyriform shape of the organism is shown.
2. Surface of same showing the usual aspect of the cups. × 4.
3. A group of examples on a limestone slab with their interior filled with crystalline calcite.
4. A fractured piece of limestone with cross-sections of this organism.
5. Weathered rock surface with *Nidulites* in various positions.

Ordovician (Mohawkian), Nidulites bed of Chambersburg ls., Strasburg, Virginia.

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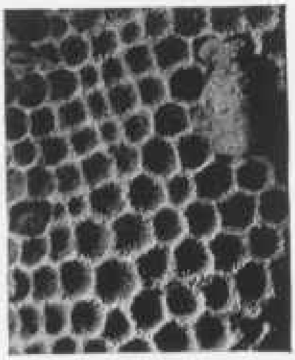

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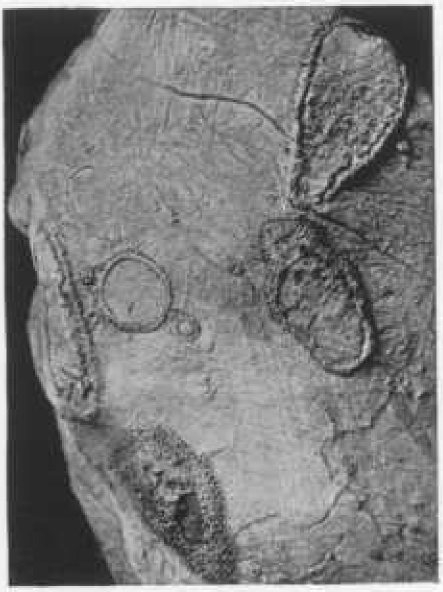

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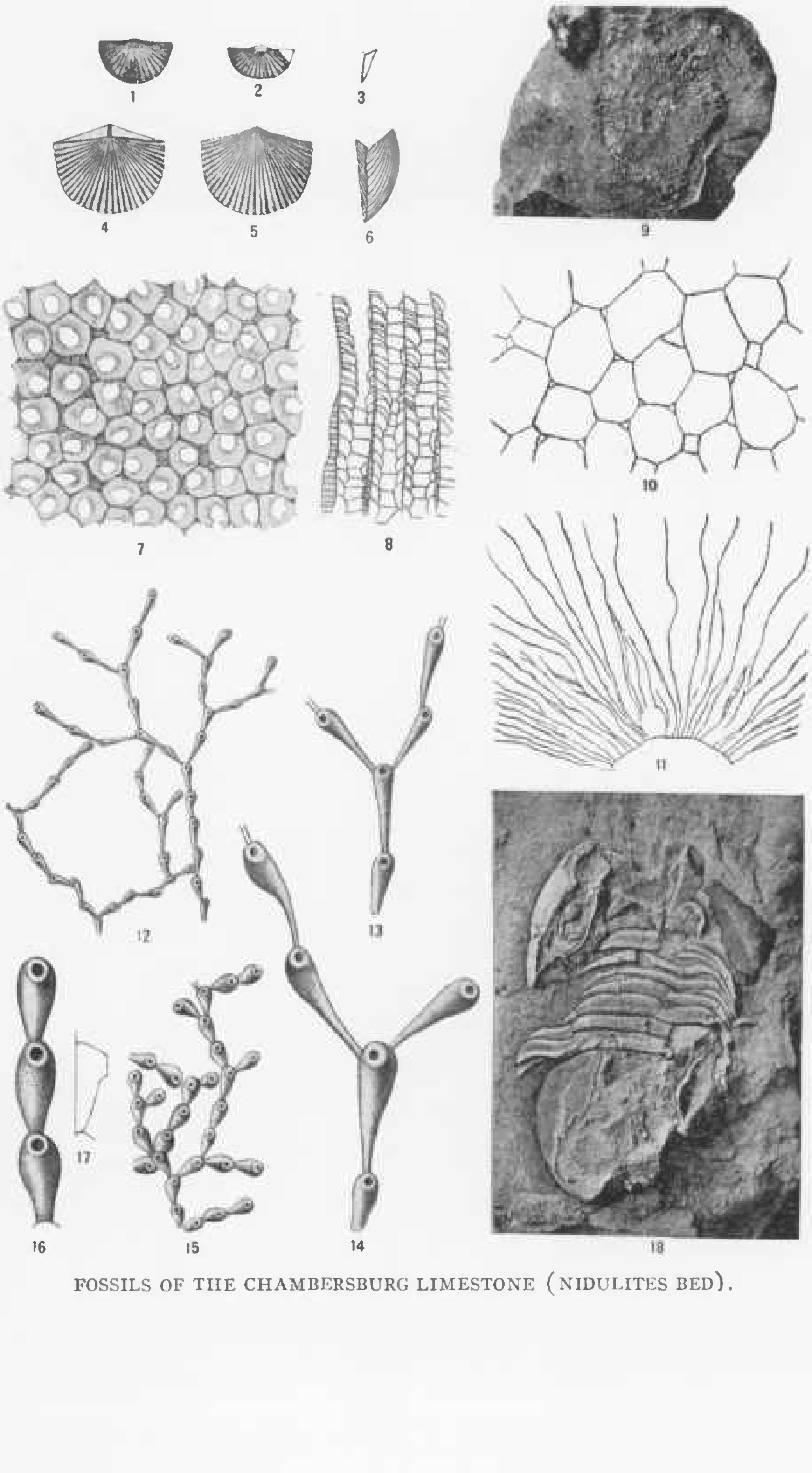
CHAMBERSBURG LIMESTONE (NIDULITES BED).

PLATE XLVII

Figs. 1-3 are after Weller; 4-6 are after Winchell and Schuchert; 7, 8, 12-17 after Ulrich.



FOSSILS OF THE CHAMBERSBURG LIMESTONE (NIDULITES BED).

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2. Posterior view of same. × 1.25.
3. Pedicle valve of normal dimensions. × 1.25.
4. Brachial valve of an entire shell. × 1.25.
5. Internal cast of pedicle valve showing casts of muscular and vascular impressions. × 1.25.
6. Interior view of brachial valve. × 1.25.
7. Pedicle valve with long cardinal line. × 1.25.

Ordovician (Mohawkian), Rysedorph conglomerate, Rysedorph Hill, Rensselaer County, New York.

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8, 9. Brachial and pedicle views of an entire specimen.

10, 11. Anterior and lateral views of the same.

Ordovician (Mohawkian), Lower Trenton portion of the Jacksonburg ls., near Newton, New Jersey.

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Exterior of a brachial valve. × 2.

Ordovician (Mohawkian), Trenton ls., Middleville, New York.

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13. Segment natural size.
14. Surface of upper part of original of Fig. 15 showing aged condition of zoœcia. × 18.
15. A small segment natural size and its upper part × 18 illustrating the youthful condition.

Ordovician (Mohawkian), Black River (Decorah) shales, St. Paul, Minnesota.

Figs. 16-18. CHRISTIANIA TRENTONENSIS Ruedemann 256

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17. Brachial valve. × 2.
18. Interior of brachial valve showing the quadrupal adductor scar divided by high vertical muscular walls. × 2.

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Ordovician (Mohawkian), Trenton ls., Watertown, New York.

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Type specimen showing the rapidly curving shell.

Ordovician (Mohawkian), Trenton ls., Middleville, New York.

Fig. 22. ORTHOCERAS ARCUOLIRATUM Hall 323

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Ordovician (Mohawkian), Trenton ls., Watertown, New York.

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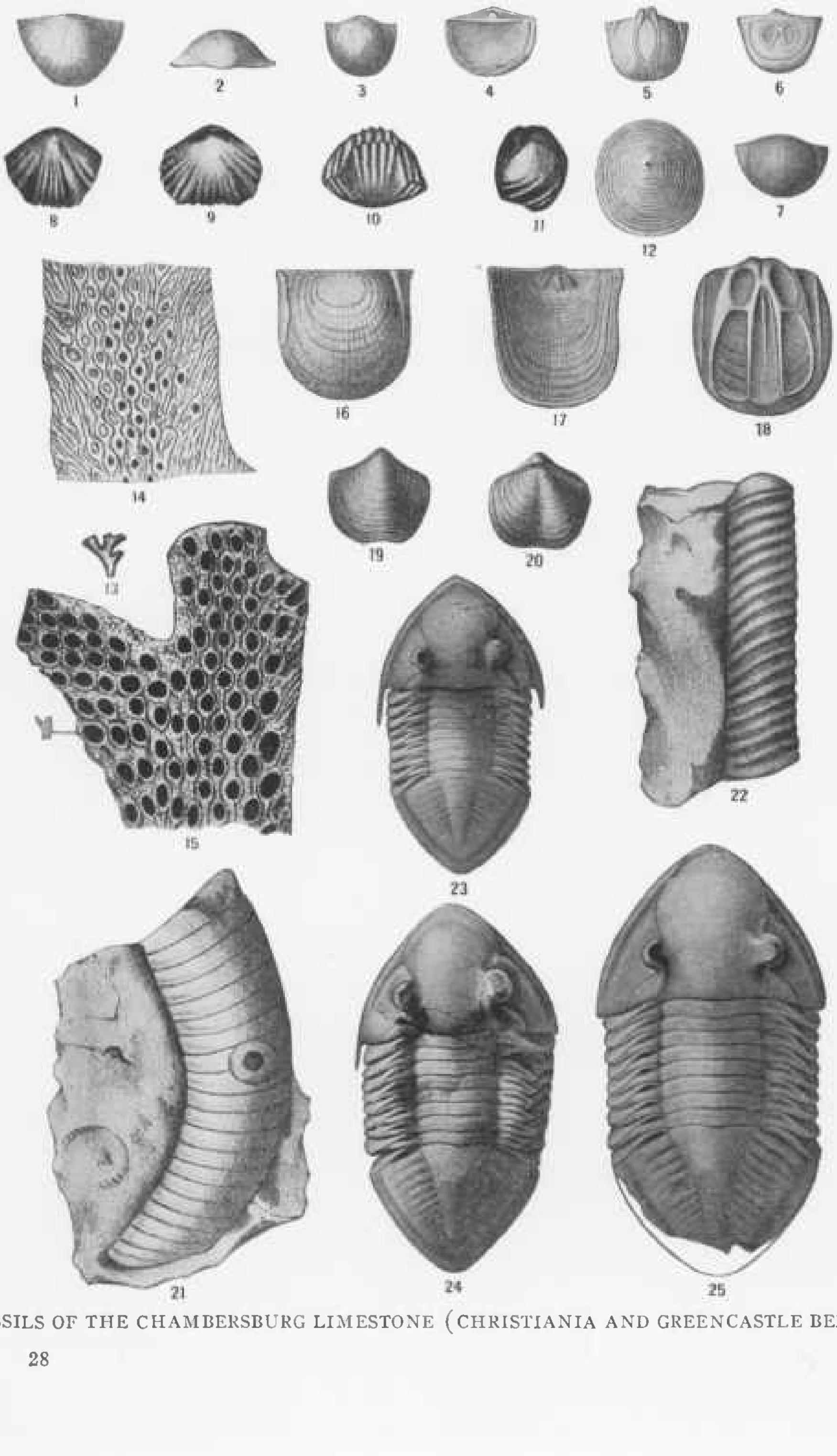
Ordovician (Mohawkian), Trenton ls., near Trenton Falls, New York.

Figs. 1-7, 16-18 are after Ruedemann; 8-11, 13-15 are after Ulrich; 12, 19, 20 are after Hall and Clarke; 21, 22 are after Hall.



FOSSILS OF THE CHAMBERSBURG LIMESTONE (CHRISTIANIA AND GREENCASTLE BEDS).

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Ordovician (Mohawkian), Sinuites bed at base of Martinsburg shale, 1 mile south of St. Thomas, Pennsylvania.

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Sinuites bed at base of Martinsburg shale 1 mile south of St. Thomas, Pennsylvania.

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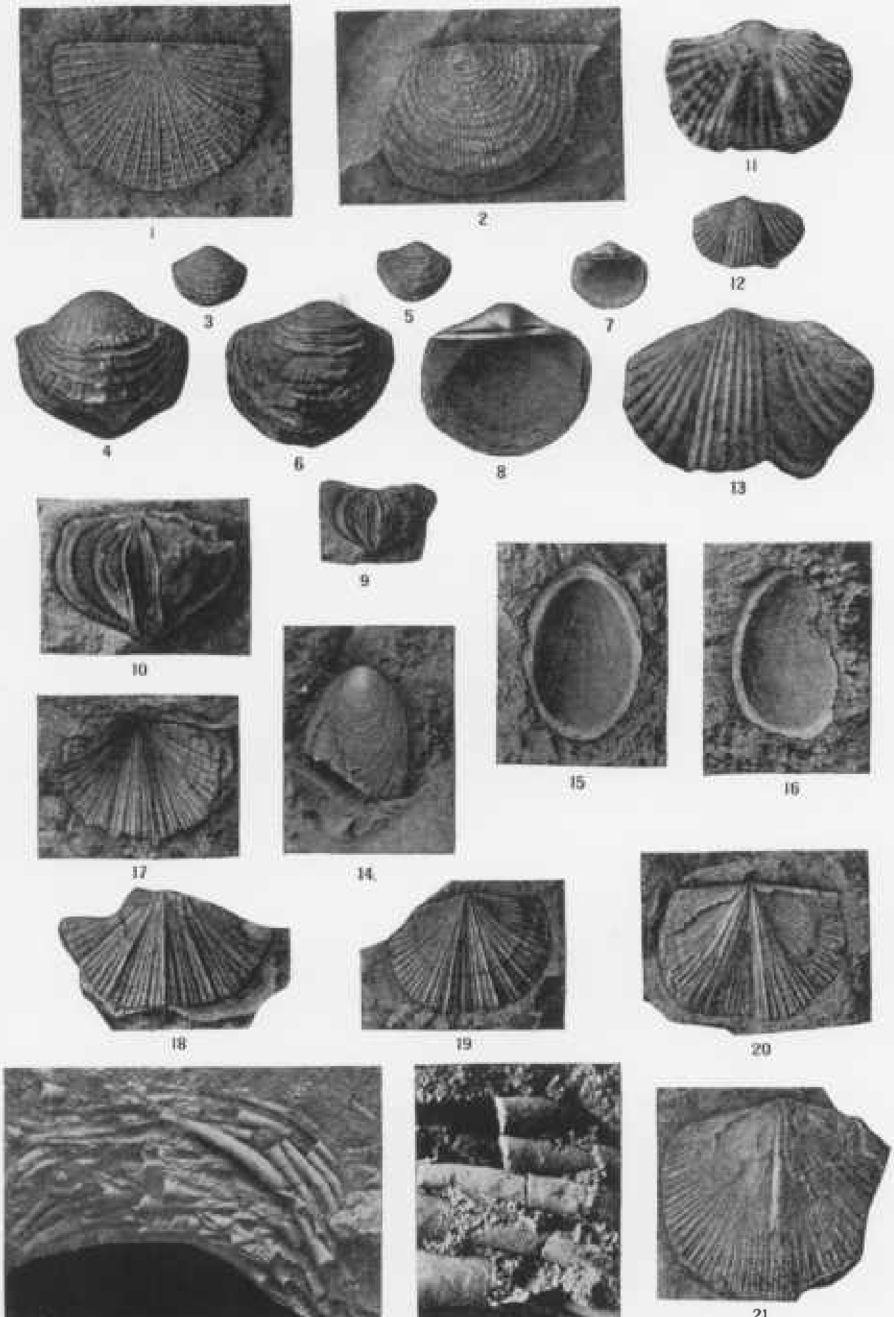

BRACHIOPODA AND MOLLUSCA OF THE MARTINSBURG SHALE (SINUITES BED).

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2. Apical view of the same. The subtriangular posterior slope and its obscurely defined median furrow are visible. × 9.
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Ordovician (Mohawkian). Trenton ls., Trenton Falls, New York.
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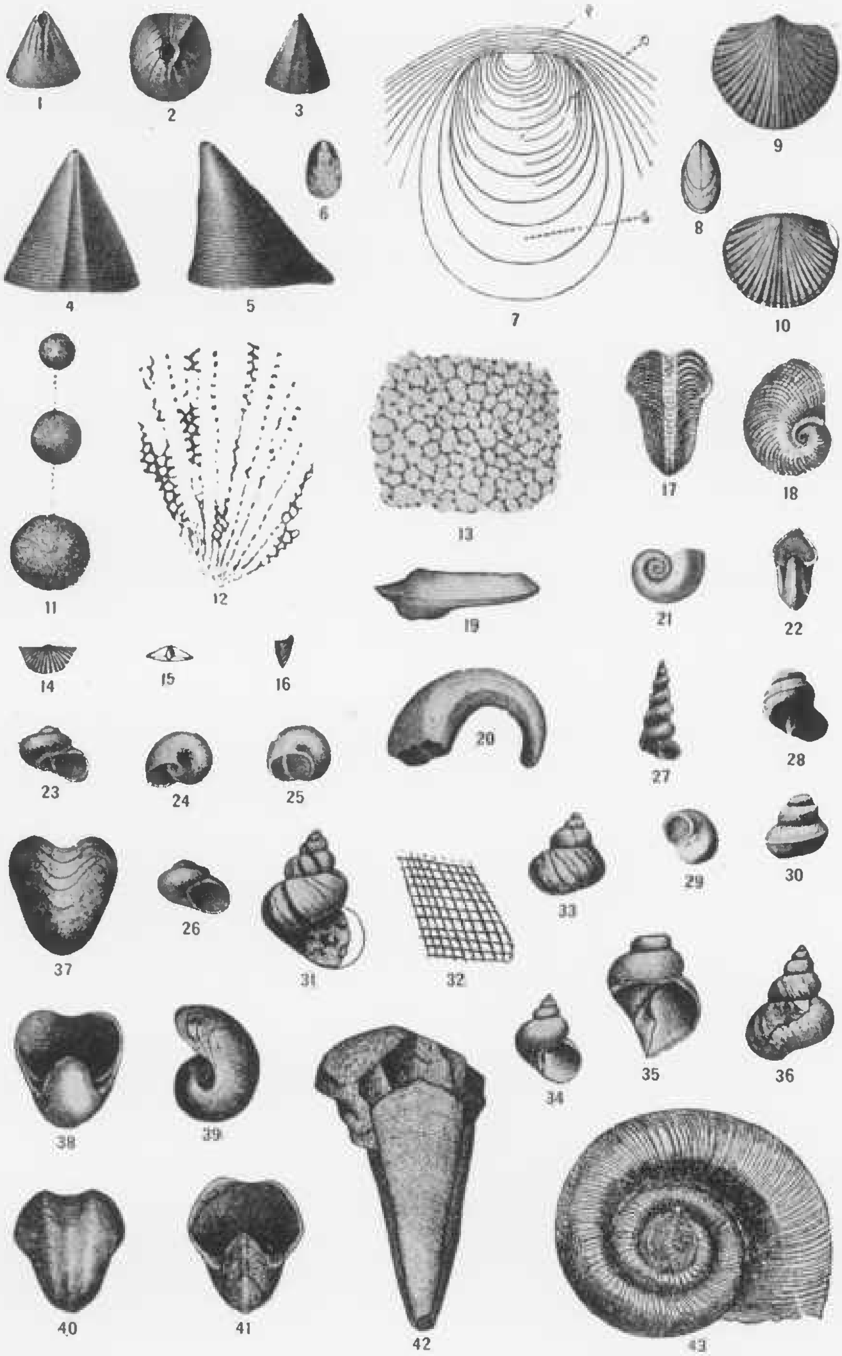
Figs. 1-5 are after Hall and Clarke; 8-10, 19, 20, 42 are after Weller; 6, 7, 11-13 are after Winchell and Schuchert; 14-16 after Billings; 17, 18, 31-41 after Ulrich and Scofield; 21-26 after Meek; and 23 after Miller.



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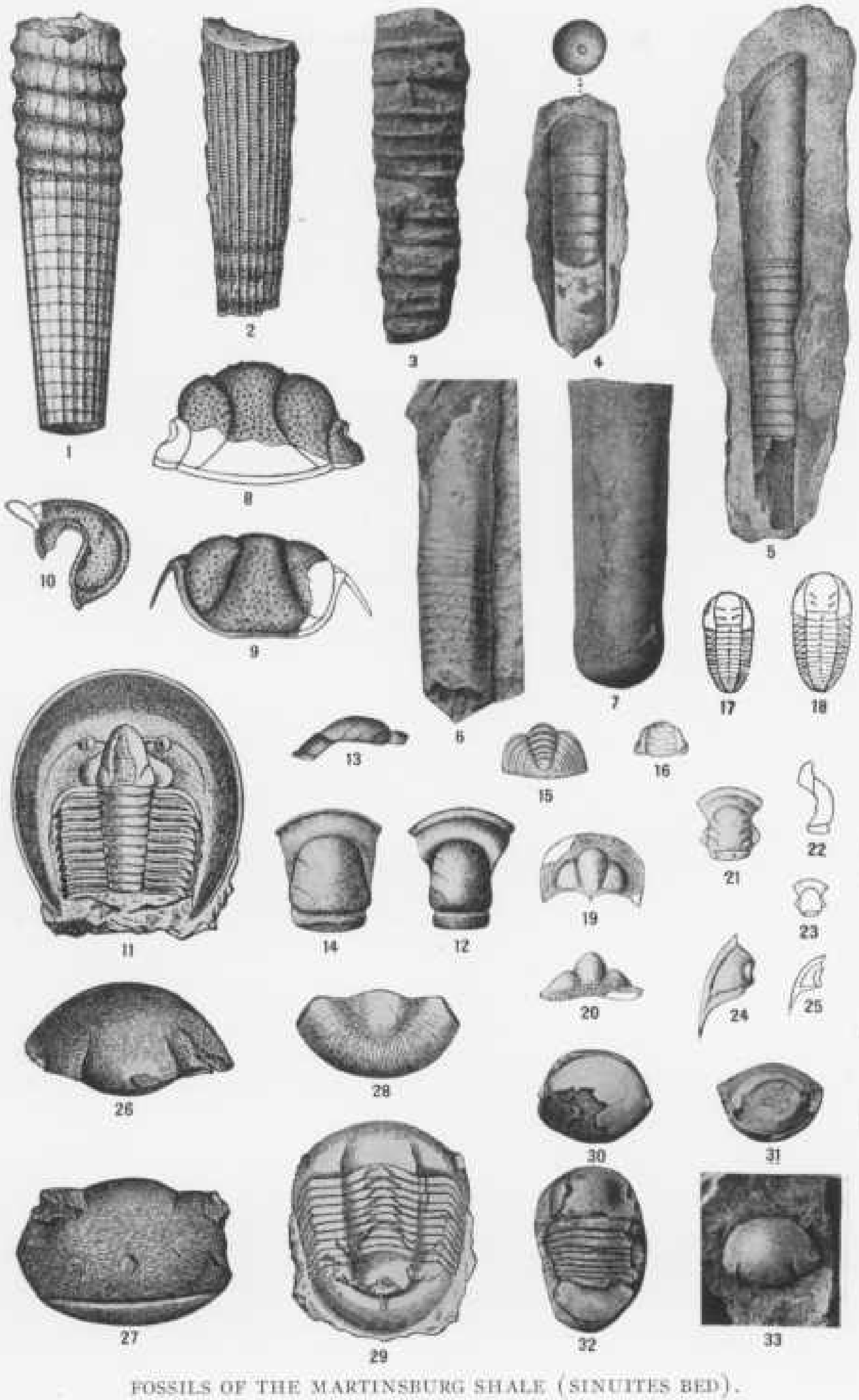
Figs. 1, 2 are after Clarke; 4, 5 after Hall; 8-10, 15, 19-25 after Weller; 11, 16, 26-29 after Billings; 12-14 after Ruedemann.



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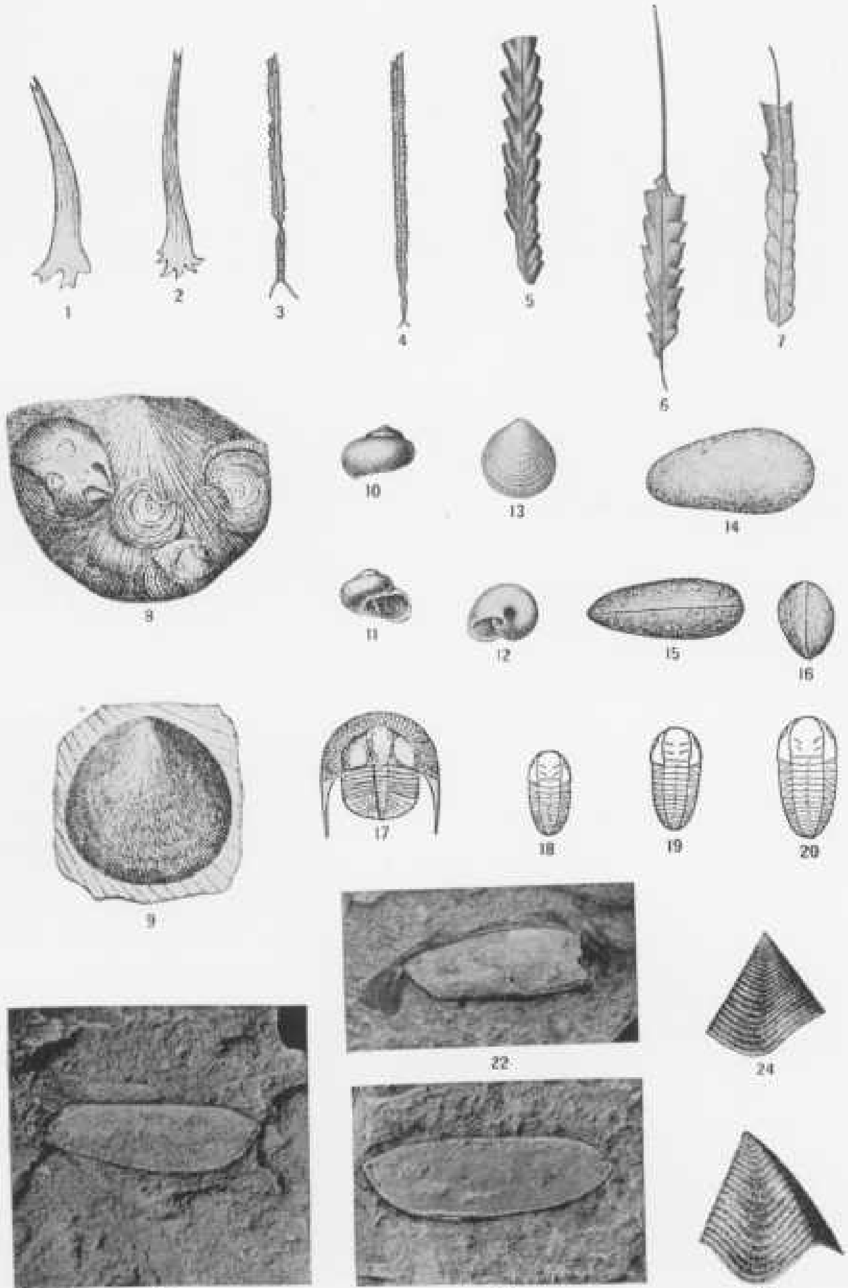

FOSSILS OF THE MARTINSBURG SHALE (CORYNOIDES BED).

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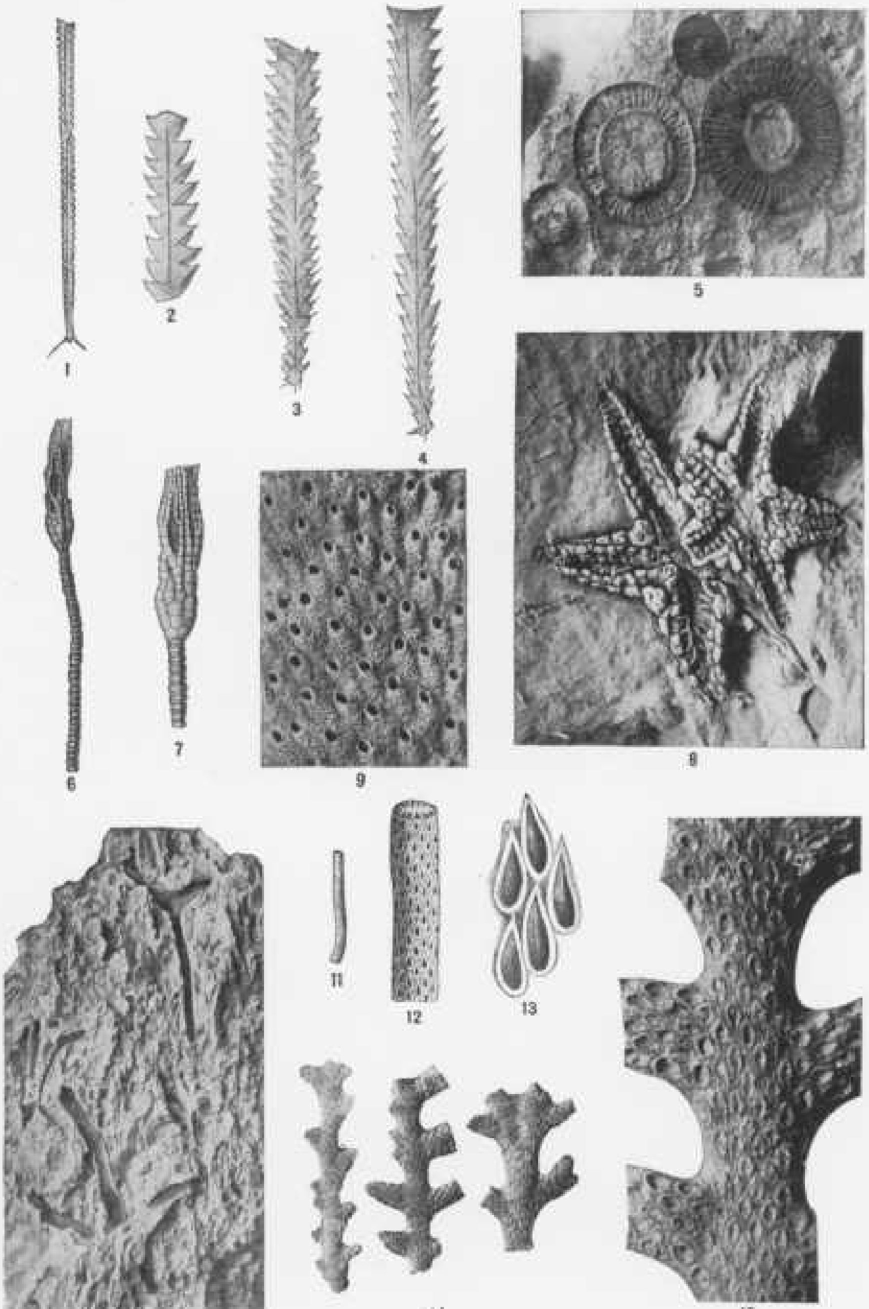
Figs. 1-4 are after Ruedemann; 6, 7, after Meek; and 11-15 after Nicholson.



FOSSILS OF THE MARTINSBURG SHALE (EDEN DIVISION).

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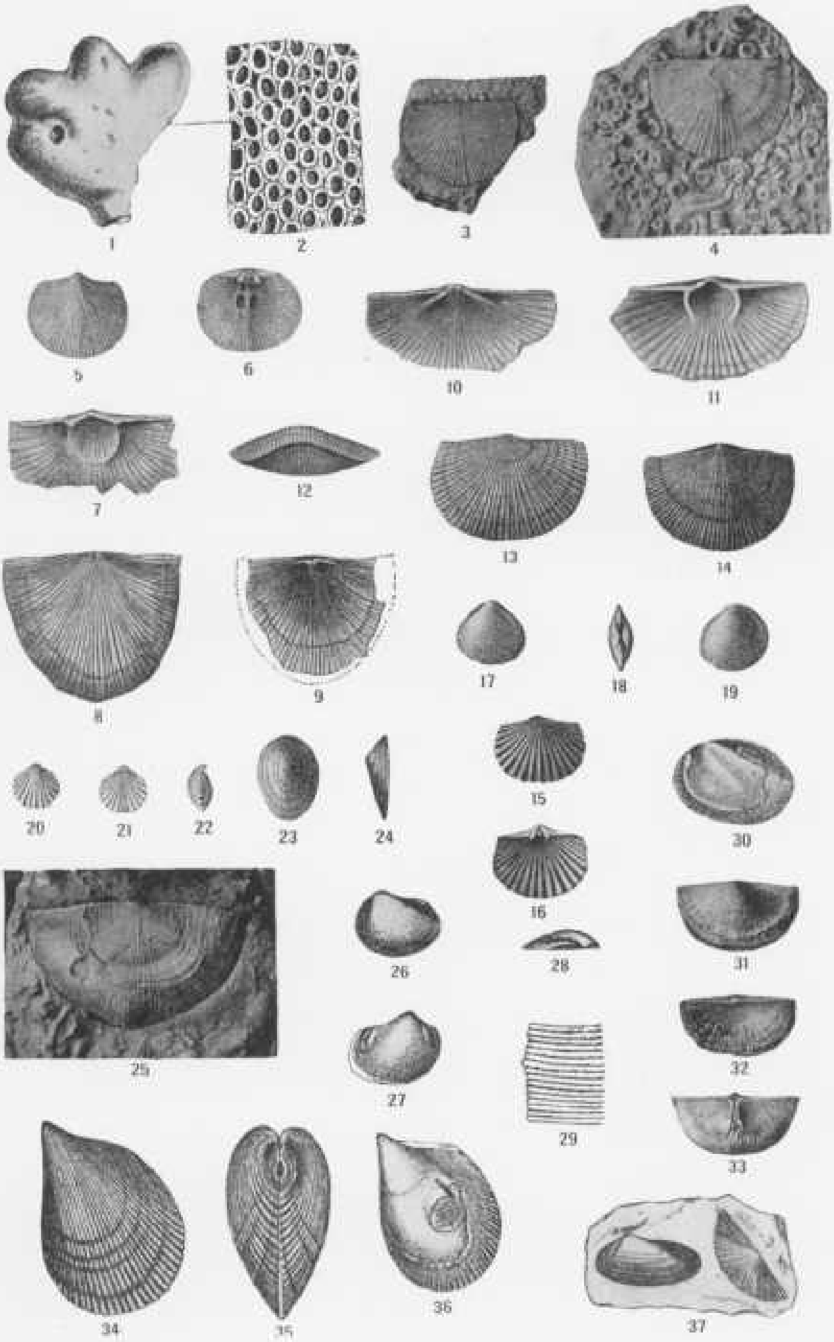

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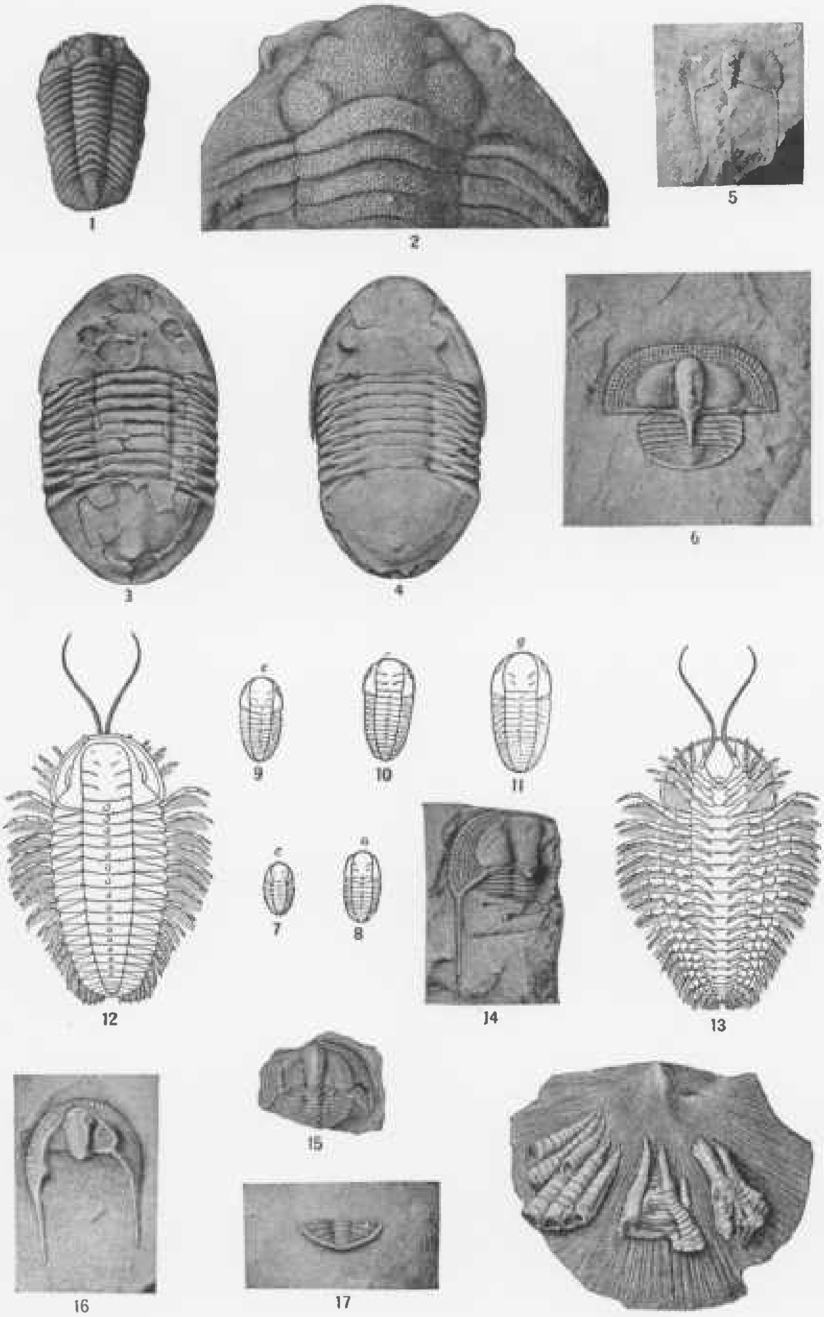

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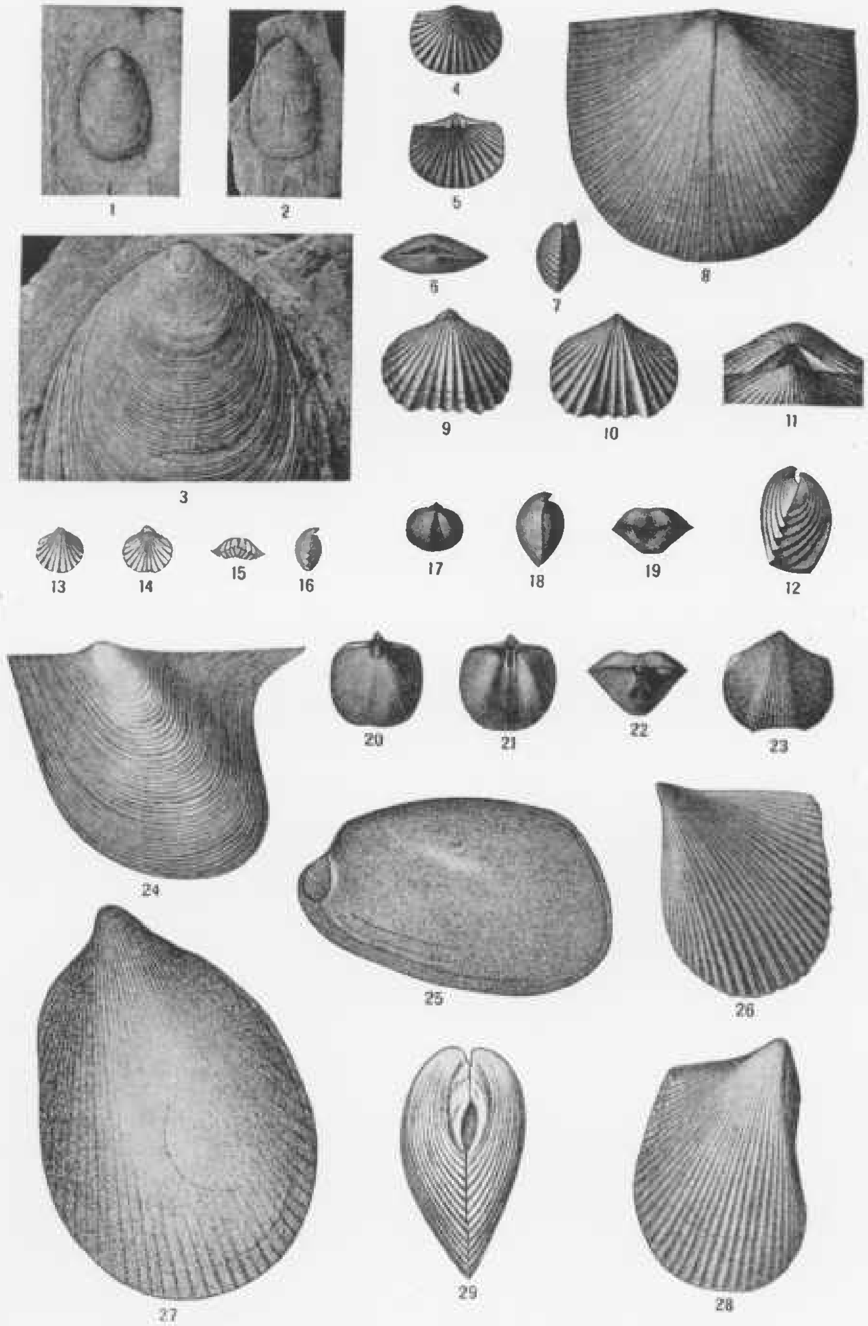

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PLATE LVIII

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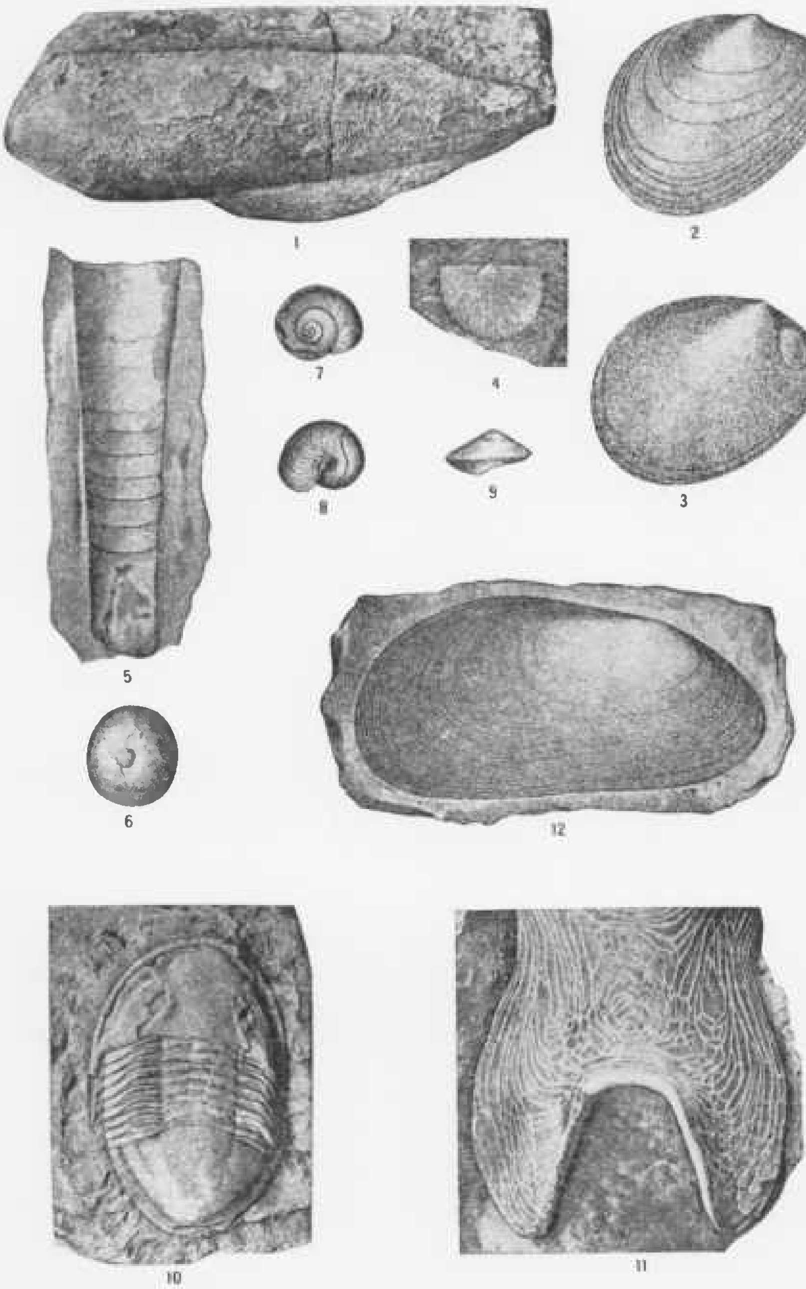
Figs. 2, 3, 7-9 are after Ulrich and 5, 6, 12 after Hall.



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