# THE MIDDLE AND UPPER ORDOVICIAN ROCKS OF MICHIGAN

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STATE OF MICHIGAN
DEPARTMENT OF CONSERVATION
Gerald E. Eddy, Director

GEOLOGICAL SURVEY DIVISION
Franklin G. Pardee, State Geologist

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# THE MIDDLE AND UPPER ORDOVICIAN ROCKS OF MICHIGAN

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PREPARED UNDER THE DIRECTION OF G. E. EDDY, STATE GEOLOGIST, AND IN COOPERATION WITH THE DEPARTMENT OF GEOLOGY, UNIVERSITY OF MICHIGAN. PUBLISHED AS A PART OF THE BIENNIAL REPORT OF THE GEOLOGICAL SURVEY DIVISION IN 1952.

LANSING, MICHIGAN
1952

## FOREWORD

To the Commissioners and Director of the Michigan Department of Conservation:

Gentlemen:

In compliance with Act No. 65 of 1869 as amended by Act No. 179 of 1871 of the Public Acts of Michigan under which the Geological Survey Division of the Department of Conservation operates, and in conformance with the long-time policy of the Geological Survey Division to prepare and publish monographic reports on the geology and economic value of the various rock formations of the State, I have the honor to herewith present a report on the Ordovician rock formations of Michigan prepared by Professor R. C. Hussey of the University of Michigan. I recommend that it be published as Geological Survey Publication 46, Geological Series 39.

This report on the Middle and Upper Ordovician rocks of Michigan is a completion of a report written by Professor Hussey and published as a part of Geological Survey Publication 40, Geological Series 34. It contains detailed descriptions of the outcrop rocks of the formation with lists of the fossils found—material which is essential for study of the buried parts of the formations where it slopes southward under younger rocks of the State and may be a future source of petroleum. Oil has been found around the edges of the Michigan Basin in the Ordovician rock but they await further exploration in the central part of the Basin. This study is an aid to such exploration.

Respectfully submitted,

FRANKLIN G. PARDEE
State Geologist
April 1952

## ACKNOWLEDGMENTS

Gerald Eddy, former director of the Michigan Geological Survey, now director of the Michigan Conservation Department, cooperated with the University of Michigan in furnishing funds which made possible the field work on the Middle and Upper Ordovician rocks of Michigan.

Prof. K. K. Landes, Geology Department of the University of Michigan, accompanied the author during a large part of two field seasons and helped materially with the survey.

Dr. Erwin Stumm, Dr. G. M. Ehlers, and Dr. Robert Kesling gave important help in the identification of fossils and the preparation of plates.

Robert Landes was technical assistant during the first season of field work and was very helpful in collecting fossils and in making stratigraphic sections.

Harry Hardenberg and Rex Grant, of the Michigan Geological Survey, spent several days with the author in the Escanaba region, examining the Middle and Upper Ordovician sections. They made many valuable suggestions involving stratigraphic problems.

Miss Helen Martin, research geologist, Geological Survey Division Department of Conservation, has handled all the details of editing the manuscript and seeing it through the press.

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RUSSELL C. HUSSEY

# CHAPTER I

## THE MIDDLE AND UPPER ORDOVICIAN ROCKS OF MICHIGAN

### INTRODUCTION

The Paleozoic rocks of Michigan are arranged as a great saucer-like structure in which the numerous formations dip towards the center from all sides. The Middle and Upper Ordovician rocks occur in a belt of varying width that extends from the eastern end of the Northern Peninsula of Michigan, westward and then southward past the city of Escanaba. Few outcrops are in the eastern half of this belt but good exposures are numerous from the village of Trenary southward to Escanaba.

The main exposures of Middle Ordovician rocks are found along the meanders of the Escanaba River from the paper mill and abandoned Bichler quarry near the village of Groos to the hydro-electric plant at Bony Falls. New names are given to the four recognizable main divisions of the Middle Ordovician in Northern Michigan. The Black River formation is represented by the Bony Falls member with excellent exposures along the Escanaba River at the locality called Bony Falls. The Trenton formation has three divisions. The Chandler Falls and Groos Quarry members are exposed for several miles along the banks of the Escanaba River beginning at the paper mill near the village of Groos. The highest division of the Trenton is the Haymeadow Creek member which was formerly the basal part of the Bill's Creek beds of Richmond age but these beds are now considered to be of Collingwood age.

These members make up a composite section since they are not all found at the same locality. However no great gaps are in the stratigraphic succession. The members are divided upon the basis of faunal associations but changes in lithology are also important. The lithologic changes that occur in the section are such as might be expected in deposits along the shores of a fluctuating epeiric sea and the evidence of subaerial erosion that is found at several horizons throughout the Middle Ordovician sections is also characteristic of many near-shore deposits.

From the bottom to the top of the complete section certain genera and species of fossils are observed to disappear while other forms appear. The faunal changes are usually gradual and some species have long ranges. Some forms represented by a few individuals at the time of their first appearance may become very abundant at higher levels where they form an easily recognized horizon.

Divisions of the Middle and Upper Ordovician rocks in the Northern Peninsula of Michigan

| | | |
|---|---|---|
| Richmond | Big Hill | |
| | Stonington | |
| | Bill's Creek | |
| Trenton | Haymeadow Creek member | |
| | Groos Quarry member | |
| | Chandler Falls member | Maclurites zone<br>Prasopora zone |
| Black River | Bony Falls member | |

Divisions of the Richmond formation in Ohio

Elkhorn
Whitewater
Saluda
Liberty
Waynesville
Arnheim

## Paleogeography

The Northern Peninsula of Michigan, where Ordovician rocks are exposed, lies close to the southern edge of the Canadian Shield. This ancient land was composed of very resistant, crystalline rocks and stood at such a low elevation that very little sediment was carried by southward flowing streams into the Michigan basin. Some of the higher parts of the Late Proterozoic mountains, called the Killarneys, doubtless stood as islands above the waters of the Trenton sea.

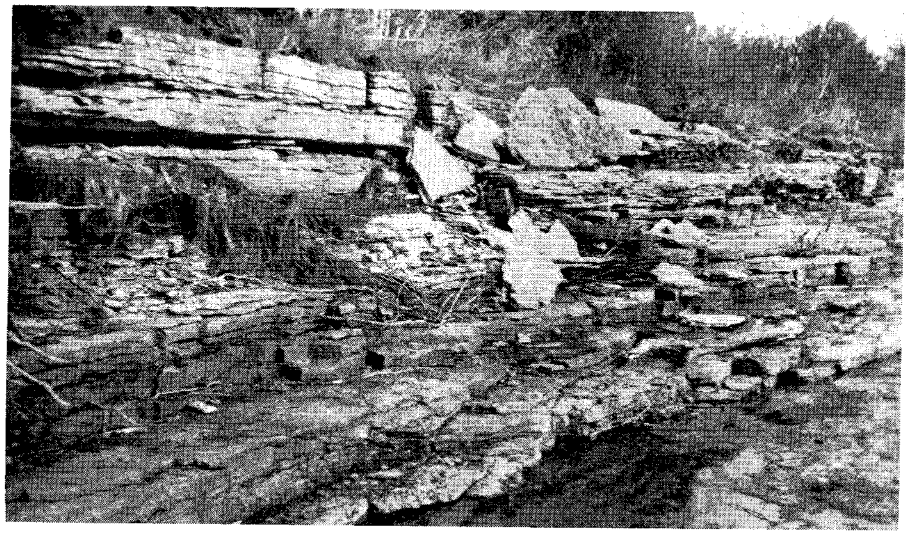
The Ontario Basin lay to the east and southeast of Michigan, extending in a general northeast-southwest direction into Ontario, Canada. Certain faunal elements from this basin, in Ontario



found their way into Michigan; other forms came into the state from the southwest and are related to Minnesota faunas. Fossils from the Trenton of Michigan thus present a mixture of forms from the east and the southwest.

The Ordovician sediments in the Northern Peninsula of Michigan are mostly fine grained and represent near shore deposits which accumulated under fluctuating conditions in shallow water. The extremely fine grained Bill's Creek shales were derived largely from lands to the east. These beds reach a known thickness of 80 feet in northern Michigan. The lower 20 feet of the beds are now correlated with the Collingwood which some authors consider to be Late Trenton. Middle Ordovician sediments thicken to the south towards the deeper parts of the Michigan Basin.

The Coburg (Stewartville) phase of the Trenton saw a widespread submergence of the interior of the North American continent with the Michigan area along the eastern side of the sea. This was one of the great marine invasions.



Ledges of limestone assigned to the Black River, Bony Falls members, at the type locality just below the dam at Bony Falls.

# CHAPTER II

## DESCRIPTIONS OF SECTIONS

### Black River, Bony Falls Member

SECTION AT BONY FALLS ON THE ESCANABA RIVER, DELTA COUNTY
SECTION 1, T. 41 N, R. 24 W.

| Top | of section | Feet | Inches |
|---|---|---|---|
| 10 | Argillaceous limestone, hard, buff colored. | 2 | |
| 9 | Limestone, relatively pure, fine grained. Irregular contact with zone above. | 4 | |
| 8 | Fine grained limestone, very fossiliferous. Upper surface of beds irregular due to weathering. | 2 | |
| 7 | Limestone, similar to zone above, crinoid stems very abundant. | 3 | |
| 6 | Gray limestone, characterized by abundant Fucoid. | 2 | |
| | Disconformity | | |
| 5 | Limestone, irregularly bedded, upper surface pitted and bored by some organism. Erosion on upper surface planed off across borings. Two inch layer of metabentonite at top of this zone. **May be top of Black River.** | 5 | |
| 4 | Argillaceous limestone, layers to to 8 inches thick. Intraformational conglomerate. Ripple marks on some layers | 8 | |
| 6 | Argillaceous limestone, fine grained, gray, irregular bedding | 6 | |
| 2 | Finely crystalline dolomitic limestone. Lower part mottled green and pink. Some beds beveled by erosion | 7 | |
| 1 | Bluish gray limestone below the level of the river. | | |

### The Section at Bony Falls

Bony Falls is located on the Escanaba River in Section 1, T. 41 N., R. 24 W. A hydro-electric power plant is located here and the construction of a dam has diverted the water of the river from a part of its original channel and exposed a rock section about 40 feet thick along the east bank of the stream. It is impossible to trace the rock exposures below the dam for more than a few feet back from the edge of the river on account of the wooded nature of the country.

The rocks at Bony Falls belong to the lowest exposed rocks of the Escanaba River area and dip very gently towards the southeast. The bluish gray beds of the basal zone are below the level of the river but some of this rock has been blasted from the bed of the stream and was built into a wall along the west bank of the river below the dam.

Evidence of subaerial erosion appears at several levels throughout the section and the very obvious erosional disconformity at the top of zone 5 may represent a time break of considerable duration. The upper layer of rock in this zone is deeply pitted as a result of weathering that occurred before the deposition of the succeeding beds. This old erosion surface shows numerous borings by some unknown organism. This is one of the largest of many similar breaks in the various sections along the Escanaba River. *Maclurites bigsbyi* occurs in this zone and a large incomplete specimen of the cephalopod *Endorceras,* three feet long and eight inches in diameter, was observed in place. This genus of cephalopod is fairly common at several localities along the river. A layer or lens of clay, with a maximum observed thickness of two inches, is at the top of zone 5. This clay may be bentonite or metabentonite.

Zone 6 is characterized by numerous Fucoid remains. *Strophomena filitexta* and *Stromatocerium rugosum* are fairly common. A pygidium of the trilobite *Bathyurus (Raymondites)* sp. was found in this zone.

Zone 7 contains great numbers of broken crinoid stems. *Pianodema perveta, Rhynchotrema minnesotense, Hesperorthis tricenaria* and *Lambeophyllum sp.* also occurs in zone 7.

The beds in zone 8 weather with very rough upper surfaces. Occasional specimens of *Eoleperditia fabulites* are found in this zone with fragments of large crinoid stems, Fucoid, *Ctenodonta nasuta, Strophomena incurvata, Orthis* sp., *Pterygometopus* sp., and broken parts of *Illaenus.*

*Foerstephyllum halli* occurs in zone 9. One colony of this coral, measuring five feet in largest diameter, was found on the under side of a rock layer that was in place. The coral obviously grew in this position between the top of zone 9 and the base of zone 10. Some of the laminated layers of fine grained limestone in zone 9 are separated by sandy partings. The buff colored, argillaceous limestone in zone 10 is not very fossiliferous.

Ripple marks are common in the rocks at the top of the section on the west side of the river. In one set the direction of the crests and troughs is north 12 degrees west, but in another set a little lower in the section the direction is almost east and west. The marks vary from eight to ten inches from crest to crest with the steep slope towards the south.



### Relationships of the Black River rocks at Bony Falls

The separation of Black River rocks from the Trenton above presents a difficult problem in many places. The rocks of the two formations are commonly distinguished upon the basis of faunal changes that are not always very significant. Deposition was practically continuous at some localities from Black River into Trenton time and the dividing line between the two formations becomes rather an arbitrary one.

E. O. Ulrich placed the base of the Trenton, in the Escanaba area, at a certain horizon where the small brachiopod *Zygospira recurvirostris* was thought to first appear. Later finds prove that this fossil actually appears at a somewhat lower horizon, below the conglomerate zone, in the *Prasopora* beds. The brachiopod becomes suddenly abundant at the higher level. The conglomerate marks a period of uplift and erosion which is close to the base of the Trenton. The faunal change from the Conglomerate-*Prasopora* horizon to the beds immediately below is abrupt and the lithologic change is from shaly limestone and shale above to dense, hard limestone below.

*Foerstephyllum halli* is found in considerable abundance towards the top of the Bony Falls section and it has not been discovered at any higher level. This coral is a Black River-Trenton form. *Eoleperditia fabulites* also occurs towards the top of the section. This ostracod is common in the Stones River and Black River rocks. Ulrich considered the *Stromatocerium rugosum* from Bony Falls to be a Black River of New York form. He also considered the *Strophomena incurvata* from Bony Falls to be a Lowville form. *Hesperorthis tricenaria,* which appears about three feet from the top of the section, is found in both the Black River and Trenton. Ulrich identified *Lambeophyllum profundum* from the upper beds at Bony Falls. This is a Black River coral. However, the form from Bony Falls is apparently a new species.

The obvious erosion surface at the top of zone 5 at Bony Falls may indicate that considerable of the original section is missing. A two inch layer of metabentonite is at the top of this zone. Another erosion surface is found lower in the section. Zone 4 contains intraformational conglomerate, and ripple marks are found on some of the layers. Black River rocks in other areas are also characterized by numerous breaks in the sequence. The whole section indicates deposition under shallow water conditions comparatively close to the shore.

Trenton limestone and shale belonging to the Chandler Falls member in the Escanaba River area, one quarter of a mile north of the concrete bridge near Cornell, Michigan, along the Escanaba River.

FAUNAL LIST FROM BONY FALLS

*Stromatocerium rugosum* (Hall)
*Foerstephyllum halli* (Nicholson)
*Lambeophyllum* sp.
*Pianodema subaequata perveta* (Conrad)
*Strophomena filitexta* (Hall)
*Strophomena trentonensis* (Winchell and Schuchert)
*Hesperorthis tricenaria* (Conrad)
*Rhynchotrema minnesotense* (Sardeson)
*Ctenodonta nasuta* (Hall)
*Tetranota bidorsata* (Hall)
*Lophospira* sp.
*Sinuites* sp.
*Maclurites bigsbyi* (Hall)
*Endoceras* sp.
*Orthoceras* sp.
*Illaenus* sp.
*Calliops callicephala* (Hall)
*Bathyurus (Raymondites)* sp.
*Eoleperditia fabulites* (Conrad)

Exposure near Whitney, Menominee County, Michigan

A poor exposure in the roadside ditch one mile east of the village of Whitney, Sec. 34, T. 40 N., R. 25 W., yielded several specimens of the brachiopod *Strophemena filitexta.* This exposure is correlated with zone 6 of the Bony Falls section where the same brachiopod is quite common.



SECTION NORTH OF THE CONCRETE BRIDGE ACROSS THE ESCANABA RIVER AT CORNELL, DELTA COUNTY, MICHIGAN
SECTION 32, T. 41 N, R. 23 W.

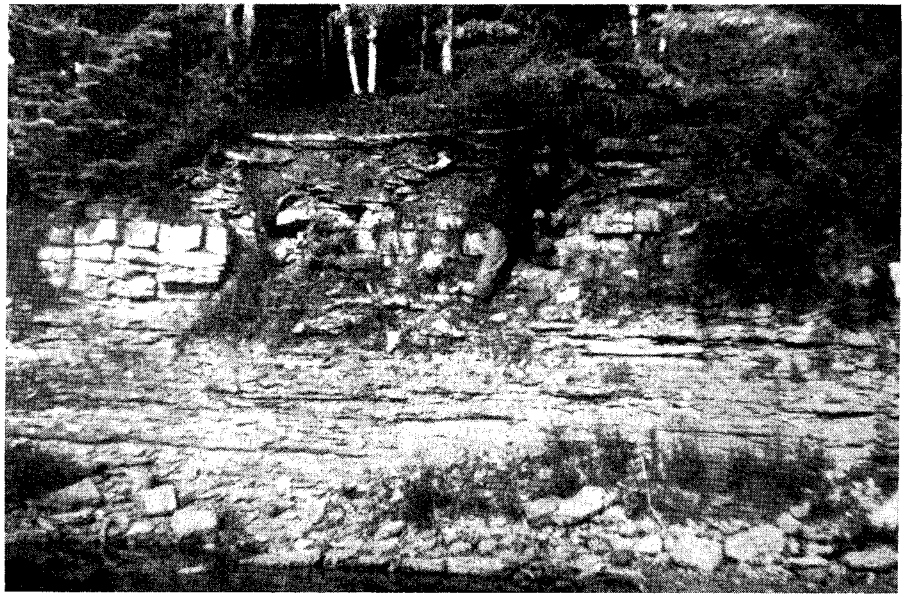
| | Top of section | Feet | Inches |
|---|---|---|---|
| 5 | Argillaceous limestone, thin, irregular bedding. Same as top zone at Chandler Falls. *Maclurites* horizon. | 10 | |
| | Disconformity | | |
| 4 | Argillaceous limestone and shale. Contains same conglomerate as found at Chandler Falls. Several layers of clay. Metabentonite. | 4 | |
| 3 | Argillaceous and dolomitic limestone, bedding irregular. Interbedded lens-like layers gray and green shale in lower half of zone. | 23 | |
| 2 | Argillaceous limestone with interbedded shale. Fucoid numerous. | 5 | 9 |
| 1 | Argillaceous limestone, bedding thin, irregular. | 5 | 4 |

The Section at Cornell, Delta County, Michigan

The shallow Escanaba River flows over Middle Ordovician rocks from the locality at Bony Falls almost to its mouth and exposures of these rocks are nearly continuous along the banks of the river for several miles above and below the concrete bridge across the stream just northeast of Cornell. From this bridge upstream to Bony Falls stratigraphically lower beds are found.

The conglomerate horizon in the Cornell section has been followed upstream for about one-half mile. All the pebbles are well rounded and many of them have been bored by some organism. The pebbles in the conglomerate stand out in prominent relief from the matrix at all localities indicating subaerial erosion before deposition of the succeeding sediments. Some of the pebbles measure one foot in largest diameter and resemble beach shingles. A few of them exhibit a cracked and weathered crust that is reddish brown in color, and one acquired a shiny black siliceous exterior. A well developed erosion surface is at the top of the conglomerate zone indicating a disconformity with the overlying beds. The same disconformity is found at the Chandler Falls locality.

The chief *Maclurites* zone is found about 100 yards above the bridge at Cornell. This zone is 15 feet thick and consists of nodular, argillaceous limestone, irregularly bedded and weathering to a yellowish brown. Rock of this zone is found along the river one and one-half miles southeast of Cornell. Numerous undulations in the rocks along the river cause the same horizons to appear and disappear several times within a distance of twenty miles.

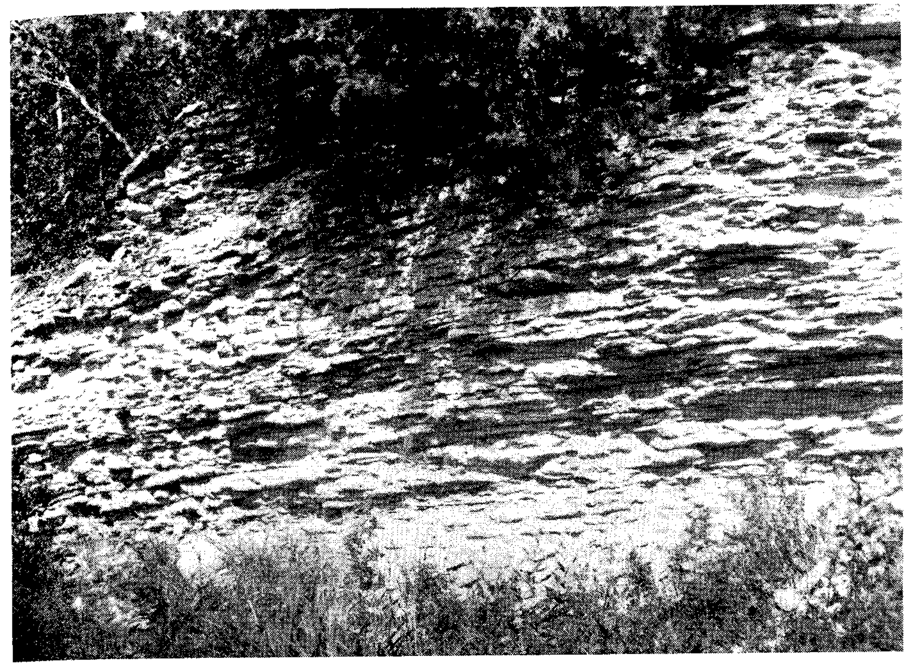


Thicker bed of limestone, just above center of picture, is top of Black River section. Shaly limestones of the Trenton appear just above the Black River. North of the bridge across the Escanaba River at Cornell.

## FAUNAL LIST FROM CORNELL, MICHIGAN

just north of the concrete bridge across the Escanaba River

*Phycodes circinatum* (Rhein. Richter)
*Streptelasma corniculum* (Hall)
*Prasopora selwyni* (Nicholson)
*Prasopora simulatrix* (Ulrich)
*Cornulites flexuosus* (Hall)
*Catazyga uphami* (Winchell and Schuchert)
*Cyclospira bisulcata* (Emmons)
*Plesiomys meedsi* (Winchell and Schuchert)
*Plesiomys pectinella sweeneyi* (N. H. Winchell)
*Leptaena unicostata* (Meek and Worthen)
*Hesperorthis tricenaria* (Conrad)
*Sowerbyella sericeus* (Sowerby)
*Sowerbyella gibbosus* (Winchell and Schuchert)
*Platystrophia trentonensis* (McEwan)
*Rafinesquina minnesotense* (N. H. Winchell)
*Rhynchotrema minnesotense* (Sardeson)
*Strophomena filitexta* (Hall)
*Resserella testudinaria* (Dalman)
*Resserella rogata* (Sardeson)
*Glyptorthis bellarugosa* (Conrad)
*Zygospira recurvirostris* (Hall)
*Clionychia* sp.
*Whitella* cf. *praecipta* (Ulrich)
*Craniops (Pholidops) trentonensis* (Hall)
*Maclurites bigsbyi* (Hall)
*Maclurites crassus* (Ulrich and Scofield)
*Maclurites cuneata* (Whitfield)
*Phragmolites fimbriatus* (Ulrich and Scofield)
*Fusispira nobilis* (Ulrich and Scofield)
*Liospira vitruvia* (Billings)
*Lophospira* sp.
*Tetranota bidorsata* (Hall)
*Hormotoma trentonensis* (Ulrich and Scofield)
*Bellerophon platystoma* (Meek and Worthen)
*Nucania* sp.
*Probillingsites* sp.
*Flexicalymens senaria* (Conrad)
*Ceraurus pleurexanthemus* (Green)
*Illaenus americanus* (Billings)
*Isotelus gigas* (Dekay)
*Calliops callicephala* (Hall)
*Nileus vigilans* (Meek and Worthen)
*Hemiarges paulianus* (Clarke)
*Thaleops ovata* (Conrad)
*Tetralichas staebleri* (Hussey)
*Hystricurus* sp.



Unevenly bedded argillaceous limestone of the Maclurites zone north of the bridge at Cornell, Michigan. This rock forms the top of the Chandler Falls member of the Trenton at Chandler Falls.

## TRENTON CHANDLER FALLS MEMBER

### DETAILED SECTION AT CHANDLER FALLS, T. 39N., 22W. DELTA COUNTY, ON THE ESCANABA RIVER, 3 MILES NORTH OF ESCANABA, MICHIGAN

| | Top of section | Feet | Inches |
|---|---|---|---|
| 6 | Argillaceous limestone with irregular bedding, lens-like in places. Yellowish after weathering. The main *Maclurites* horizon. | 5 | |
| 5 | Argillaceous limestone and shale in thin, lens-like layers. Quantity of shale increases towards bottom of zone, especially in last 5 feet. Shale weathers bluish. Two lens-like layers of bentonite, from 2 to 5 inches thick, found in this zone, about 10 and 12 feet above base of section. | 22 | |
| 4 | Dense, hard limestone, with layers 2 to 3 inches thick, seperated by thin layers of bluish shale. | 1 | |
| | Disconformity | | |
| 3 | Argillaceous limestone and shale with numerous to scattered water-worn pebbles, forming a striking conglomerate. Evidence of uplift and subaerial erosion. Disconformity. Fossils abundant. | 5 | 6 |
| 2 | Bluish shale, thin bedded, bryozoa especially common. *Prasopora* horizon. **May be base of Trenton.** | 3 | 9 |
| 1 | Argillaceous limestone, hard, irregularly bedded. Fossils not abundant. | 8 | |

## The Section at Chandler Falls

Chandler Falls is the site of a hydro-electric power plant located on the Escanaba River, three miles north of Escanaba, in Delta County, Michigan. The best part of the section is found along the west side of the river, below the dam, where 45 feet of rock are exposed in a vertical cliff and in the bed of the river. At the present time the rocks at the top of the section overhang those below to such an extent that it is dangerous to work directly at the foot of the cliff. When the dam was being built large quantities of limestone and shale were blasted from the bed of the river and from the area along the banks. This material was piled upon the eastern side of the stream and was a rich collecting ground for fossils before most of it was swept away by flood waters which broke through the east side of the dam.

The rocks of the Chandler Falls section consist of limestone, dolomite, shale and shaly limestone. The calcareous layers vary in thickness from one inch to eighteen inches and occur chiefly in the lower part of the section. The shale and argillaceous limestone make up the central and upper portions of the exposure. Bryozoa, especially the mound-shaped *Prasopora,* are numerous in the basal parts of the section, in zone 2.

### THE CONGLOMERATE ZONE

The conglomerate found throughout the entire thickness of zone 3 is of special interest because it probably marks the base of the Trenton. The pebbles in this conglomerate vary in their large diameter from a fraction of an inch to more than one foot. Many of them are flat and slab-like. All of them are water worn and most of the pebbles have been bored by some unknown organism, possibly a worm or a mollusk. Weathering frequently loosens the pebbles and since they are commonly harder than the surrounding matrix they stand out in prominent relief. In some places the stones are numerous and lie close together, but in others they are scattered. The pebbles of the conglomerate were apparently derived from the immediately underlying beds to which they are similar lithologically. This would indicate a time interval sufficient for the solidification of the source rock, then uplift, erosion, and later submergence. The conglomerate is found for half a mile below and above the bridge at Cornell and in the exposures at the railroad cut south of Trenary and in the outcrops along the banks of the Whitefish River just southwest of town.



Shallow water conditions are especially evident from the conglomerate zone to the top of the section. Ripple marks, measuring from two to three inches from crest to crest are very common. Some indicate feeble currents, others are of the symmetrical type. One set of current ripples is found at the base of zone 4, on a thin layer of very shaly limestone which forms a crust on a gray, coarsely cystalline, fossiliferous limestone. The direction of the crests and troughs in these ripples is north 22 degrees west. Worm trails are common on the surfaces of some of the rippled layers of rock.

The quantities of shale in zone 3 and 2 greatly increases just above the conglomerate horizon. The shale occurs as lenses and layers between the beds of argillaceous limestone. The general color of the rocks in this portion of the section, after weathering, is bluish. Zone 2 contains two lens-like layers of clay (bentonite or metabentonite), that vary in thickness from two to five inches. This clay is similar to the clay found at Cornell and at Bony Falls, although the clay lenses do not occur at exactly the same horizons in the three sections. Many of the beds in zones 3 and 2 are very fossiliferous but the numerous bryozoa, especially *Prasopora,* are not found above the conglomerate zone.

Zone 1 contains less shale than the underlying beds and consists of moderately hard, irregularly bedded and nodular argillaceous limestone which overhangs the shaly rocks below. Zone 1 is the chief horizon for *Maclurites* although these gastropods are occasionally found down to the conglomerate zone. One huge slab of rock from zone 6, which had fallen from the top of the cliff, shows the flat sides of more than 30 specimens of *Maclurites.* These gastropods are difficult to collect because they do not easily weather out of the matrix.

FAUNAL LIST FROM CHANDLER FALLS

*Phycodes circinatum* (Rheinh. Richter)
*Recaptaculites* oweni (Hall)
*Conularia trentonensis* (Hall)
*Streptelasma corniculum* (Hall)
*Pleurocystites squamosus* (Billings)
*Edrioaster bigsbyi* (Billings)
*Stenaster* sp.
*Hallopora multitabulata* (Ulrich)
*Eurydictya multipora* (Hall)
*Prasopora selwyni* (Nicholson)
*Prasopora oculata* (Foord)
*Prasopora simulatrix* (Ulrich)
*Cornulites flexuosus* (Hall)
*Crania setigera* (Hall)
*Catazyga uphami* (Winchell and Schuchert)
*Plesiomys meedsi* (Winchell and Schuchert)
*Plesiomys pectinella sweeneyi* (N. H. Winchell)
*Glyptorthis bellarugosa* (Conrad)
*Leptaenea unicostata* (Meek and Worthen)
*Sowerbyella gibbosus* (Winchell and Schuchert)
*Plectorthis plicatella trentonensis* (Foerste)
*Rafinesquina deltoidea* (Conrad)
*Rafinesquina minnesotense* (N. H. Winchell)
*Rhynchotrema minnesotense* (Sardeson)
*Strophomena filitexta* (Hall)
*Resserella testudinaria* (Dalman)
*Resserella rogata* (Sardeson)
*Vellamo (Clitambonites) diversus* (Shaler)
*Hesperorthis tricenaria* (Conrad)
*Parastrophia hemiplicata* (Hall)
*Cyclospira bisulcata* (Emmons)
*Zygospira recurvirostris* (Hall)
*Craniops (Pholidops) trentonensis* (Hall)
*Maclurites bigsbyi* (Hall)
*Maclurites crassus* (Ulrich and Scofield)
*Maclurites cuneata* (Whitfield)
*Hormotoma trentonensis* (Ulrich and Scofield)
*Hormotoma bellicincta* (Hall)
*Liospira vitruvia* (Billings)
*Fusispira nobilis* (Ulrich and Scofield)
*Tetranota bidorsata* (Hall)
*Archinacella* sp.
*Endoceras* sp.
*Orthoceras* sp.
*Bumastus trentonensis* (Emmons)
*Flexicalymene senaria* (Conrad)
*Ceraurus pleurexanthemus* (Green)
*Illaenus americanus* (Billings)
*Thaleops ovatus* (Conrad)
*Isotelus gigas* (Dekay)
*Nileus vigilans* (Meek and Worthen)
*Calliops callicelhalus* (Hall)
*Hemiarges paulianus* (Clarke)
*Tetralichas staebleri* (Hussey)

Relationships of the Chandler Falls member of the Trenton

The lower part of the Chandler Falls member of the Trenton has been called the *Prasopora* horizon and it includes the conglomerate zone just above. The shaly nature of this part of the section causes the fossils to weather out in great numbers. This Conglomerate-*Prasopora* horizon is several feet thicker in the section just above the bridge at Cornell than it is at Chandler Falls. A few specimens of *Maclurites* have been found as far down as conglomerate. These gastropods increase in numbers towards the top of the Chandler Falls member and in the upper five feet of the section they occur in great numbers although they do not weather out of the hard, nodular limestone very readily. This upper zone, number six in the section, is called the *Maclurites* horizon.

Ulrich considered the lower part of the section at Chandler Falls and just above the bridge at Cornell to be Glens Falls. These beds can probably be correlated with the upper part of the Hull and the lower Sherman Fall and are equivalent to the Prosser of the Missis-



sippi Valley. *Hemiarges paulianus,* a very common trilobite in the lower shaly beds, is found in the Hull. The Glens Falls, of the Mohawk Valley, New York, is equivalent to the upper part of the Hull and the lower part of the Sherman Fall.

*Glyptorthis bellarugosa* is very common in the shaly zone below the conglomerate horizon, in the Chandler Falls member, both at Chandler Falls and just above the bridge at Cornell. *Plesiomys pectinella sweeneyi* is found in the same beds but is not as common as *Glyptorthis.* These brachiopods occur in considerable numbers in the Decorah of Iowa at several localities. Other fossils found in both the Decorah and the lower part of the Chandler Falls member of the Trenton, especially in the *Prasopora* zone, are,—

*Streptelasma corniculum* (Hall)
*Prasopora simulatrix* (Ulrich)
*Conularia trentonensis* (Hall)
*Crania setigera* (Hall)
*Plesiomys meedsi* (Winchell and Schuchert)
*Platystrophia trentonensis* (McEwen)
*Strophomena filitexta* (Hall)
*Hesperorthis tricenaria* (Conrad)
*Resserella rogata* (Sardeson)
*Zygospira recurvirostris* (Hall)
*Ceraurus pleurexanthemus* (Green)
*Flexicalymeme senaria* (Conrad)
*Isotelus gigas* (Dekay)

Exposure near Bark River, Delta County, Michigan

A poor roadside exposure of rock just east of the village of Bark River, Sec. 5, 38 N., 24 W., is equivalent to the zone immediately above the conglomerate horizon at Chandler Falls.

Waiska River Locality, Chippewa County, Michigan

Middle Ordovician rocks outcrop on the Waiska River, southwest of Brimley, Chippewa County, in the eastern part of the Northern Peninsula of Michigan. The outcrop is found in the northwest quarter of Section 29, T. 46 N., R. 2 W., Chippewa County. The rocks are exposed at a rapids in the bed of the river at the border between sections 29 and 30 and may be seen for about a half mile to the east. Poor exposures are along the banks of the river but soil conceals them in most places. The rocks are hard limestones, with beds up to one foot in thickness, and fossils are rare. The rocks at this locality may be correlated with those below the conglomerate zone at Chandler Falls or with the lower part of the section at Bony Falls.

Exposure at Trenary, Alger County, Michigan

An abandoned quarry one-fourth of a mile south of Trenary, Michigan, exposes 10 feet 8 inches of argillaceous and siliceous limestone in layers that vary in thickness from one inch to one foot. The bedding is irregular and the color of the rock on fresh surfaces varies from gray to bluish gray. The rock in this quarry is correlated with the section just below the conglomerate zone at Chandler Falls. Poor exposures of the overlying rocks are largely concealed by weeds and grass along the west side of the road which leads south from the quarry.

Good exposures of the rocks belonging to the conglomerate zone are a short distance southwest of Trenary, where the bridge on Highway 41 crosses the Whitefish River.

Twenty-one feet of argillaceous limestone and shale, belonging to the conglomerate zone and the one directly above, are exposed in an old railroad cut just south of Trenary. The small brachiopod *Zygospira recurvirostris,* which appears first in the conglomerate zone at Chandler Falls and Cornell, is also found at the same horizon near Trenary.

### Exposures near the Village of Spalding, Menominee County, Michigan

Dolomitic limestone with argillaceous lenses, finely crystalline is exposed three-fourths of a mile east of Spalding on Highway 2. Fresh surfaces yellowish brown, becoming gray after weathering.

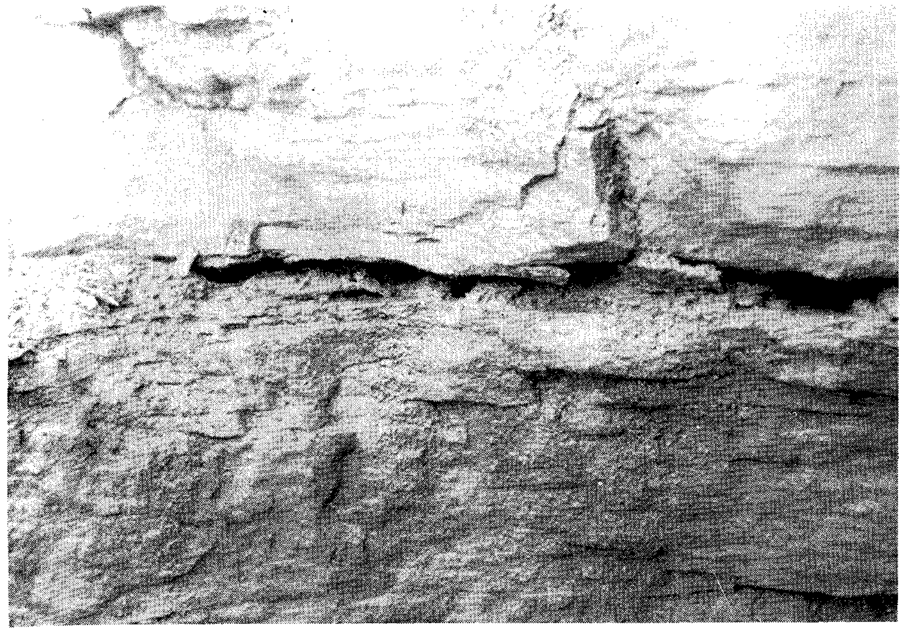
The outcrop occurs in the ditch along the road and extends for about one-fourth mile. Fucoid markings are numerous. Glacial striae run north 45 east. This exposure has no measurable thickness. The rock is correlated with the section in the abandoned quarry just south of Trenary.

Argillaceous limestone with irregular layers, varying in thickness from one to eight inches is exposed seven-tenths of a mile northwest of Spalding near the Fire Tower. Fresh surfaces light gray, brown, mottled. Weathers light gray, brown, greenish. Lenses of dolomite. Total thickness exposed in the ditch about three feet. This exposure is correlated with the top of the section in the abandoned quarry just south of Trenary.

### METABENTONITE

Several lens-like layers of clay (metabentonite) lie directly above the conglomerate zone. Three of these lenses occur within a vertical distance of one foot and they are separated by thin layers of argillaceous limestone varying in thickness from one inch to one and a half inches. Contact between the clay and the limestone is sharp both above and below. Several loose, water worn pebbles,





A layer of metabentonite, from two to three inches thick, may be seen just above the center of the picture. Trenton rock. Chandler Falls member at Chandler Falls.

derived from the immediately underlying conglomerate zone, were found embedded in the clay.

Bentonite (metabentonite) or altered volcanic ash has been found in Ordovician rocks at a number of localities from central and southeastern Ontario to Virginia and as far west as Michigan, Wisconsin and Iowa. E. O. Ulrich, in 1888, reported a bed of plastic clay five feet thick in the Tyrone limestone at High Bridge, Kentucky. This clay and bed of similar material at Singleton, Tennessee, were studied by W. A. Nelson who announced that they were of volcanic origin. Some authors place the Tyrone in the Black River and recently it has been correlated with the Trenton. A bed of bentonite a little more than eight feet thick has been found in Russell County in the southwestern part of Virginia. Beds of bentonite have been found in the Trenton rocks of New York and Vermont.

The location of the volcanoes from which the original volcanic ash was derived cannot be precisely determined. The beds of bentonite decreases in thickness from the locality in southwestern Virginia towards the north and northwest. This would seem to indicate that the volcanoes from which the original ash was derived were located somewhere along the western side of Appalachia from the region of Virginia, possibly as far north as Pennsylvania.

The origin of the clay lenses and layers that have been found at several localities in the Trenton rocks of Michigan is still somewhat obscure. Thin sections of the clay were critically examined by Dr. E. William Heinrich, Professor of Mineralogy at the University of Michigan, and his findings are very interesting. One sample exhibits two phases. The subordinate phase consists of relatively coarse, sub-rounded to sub-angular pieces of rocks and minerals which include orthoclase, some of which is perthitic, quartz, biotite, pieces of intergrown biotite and pale green hornblende, and fragments of moderately coarse grained orthoclase-quartz-hornblende rock which may have been derived from a granite. The biotite is somewhat blanched but quite fresh. All these fragments are set in the material of the second phase which is a very fine grained matrix consisting of calcite, quartz, clay minerals, limonite, hematite, sericite and probably some chlorite and carbonaceous material. Calcite is present both as mineral grains and in small broken pieces of shells. The quartz is very angular, uniform grained, and has the appearance of typical silt. The most abundant minerals in the matrix are quartz and clay.

A sample from a different locality contains somewhat fewer and smaller fragments of rock and mineral fragments. These include orthoclase, chert, micaceous sandstone, quartz, and broken pieces of shells. The matrix contains silty quartz, calcium carbonate, and some clay mineral and also some carbonaceous material and probably chlorite. This portion of the rock has been strongly dolomitized with the formation of small, well-developed dolomite metacrysts. Some coarse grained patches of calcite are present.

Glass shards, which are found in many bentonites, are not present in the material from Michigan, and the matrix is not predominantly clay, although clay may be the single most important mineral.

The lenses and layers of clay in the Trenton rocks of Michigan were deposited along the margin of the sea and Pre-Cambrian rocks are found only a few miles to the west and northwest. Some materials in the clay may have been derived from this nearby land and fragments of shells must have been numerous on the sea bottom throughout the shore zone.

A concentration of fossils was observed in several places immediately below the metabentonite but directly above the clay the rocks were almost barren of fossils. The showers of ash apparently killed off the bottom-living organisms and may have been responsible for some of the faunal changes.



The Land of Appalachia probably consisted of a series of volcanic islands, some large and some small, which were built up by periodic eruptions of the numerous volcanoes. These islands lay some distance off the present Atlantic coast and obviously the location of the many centers of eruption cannot be determined.

The absence of montmorillonite in the various samples of clay from the Michigan localities is interesting since this mineral is commonly a product of the alteration of volcanic ash.

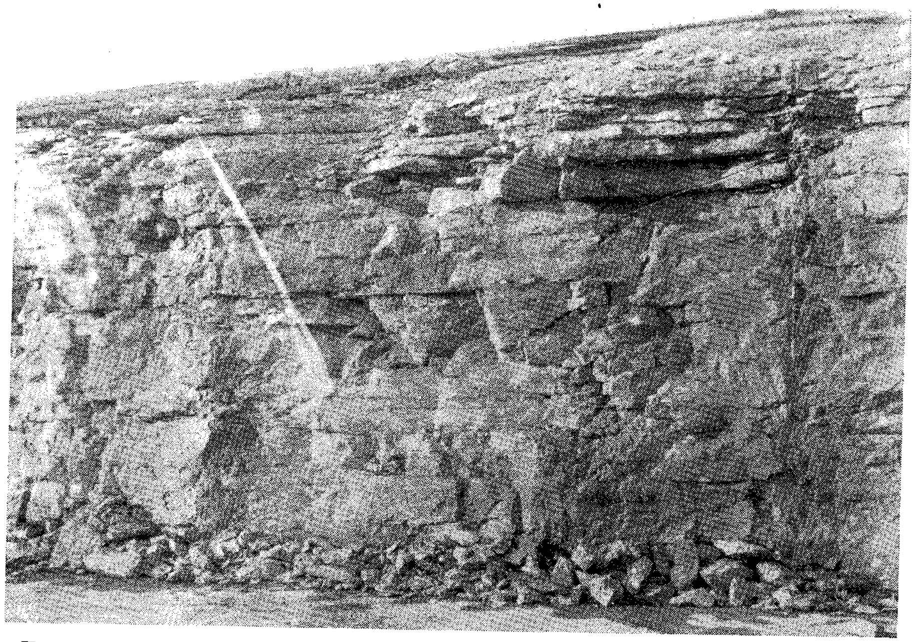
D. F. Hewett discusses the problem of bentonite in Professional Paper 145 of the United States Geological Survey on "Geology and Oil and Coral Resources of the Oregon Basin, Meeteetse, and Grass Creek Basin Quadrangles, Wyoming:"

"Bentonite is doubtless in large measure the alteration product of a volcanic glass but in part may be derived from some mineral that was crystallized in the glass. The alteration probably took place soon after the explosions, when the vapors condensed and gathered mineral particles into drops and produced mud showers. Some mineral particles were blown beyond the region of condensing gases and remained fresh and unaltered. The alteration of most of the material was probably completed when the beds were laid down and covered with overlying sediments.

"The sharp separation of the base of nearly all the beds of bentonite from the underlying material shows that they mark a distinct interruption in the deposition of the normal clay and sand."

Several analyses of bentonite from the Thermopolis shale of the Shoshone River are given. The following minerals were found: biotite, fresh; orthoclase, angular; albite, angular; quartz, angular; biotite, plates; apatite, crystals; andesite, angular; clay, angular; clay aggregates. Some samples of bentonite showed angular glass and others were free from glass.

Clarence S. Ross discusses bentonite in "Bulletin of the American Association of Petroleum Geologists," Volume 12, number 2, pp. 143-44, 1928: "Most of the known volcanic materials of the Paleozoic are highly altered, and the alteration may take several forms. The crystalline feldspathic material may become kaolinized; the glassy fragments and even part of the crystal grains may



Trenton rock, Groos Quarry member, at the type locality in the abandoned Bichler quarry at Groos, Michigan. Thirty feet of rock are shown here.

be replaced by calcite or other carbonate; the tuff may be silicified or the glassy portion may undergo a profound alteration that consists in devitrification and the abstraction of most of the bases and part of the silica, the result being a clay-like material called bentonite."

Although montmorillonite is a common constituent of bentonite or metabentonite at some localities it apparently is not found in all known occurrences of the clay and it may not occur in clays where the ash was blown away immediately from the scene of the volcanic eruption.

The clay from the Trenton of Michigan would probably be called siltstone if it had been found in a consolidated condition. it is heavy and very sticky when wet and clings tenaciously to any object with which it comes in contact. None of the metabentonite from Michigan shows a tendency to expand when placed in water. Bentonite will commonly expand when thoroughly wet. Complete proof is lacking to demonstrate that these lenses and layers of clay in the Escanaba area were originally volcanic ash but it is difficult to see how they could have had any other origin.



## Groos Quarry, Haymeadow Creek

SECTION IN THE ABANDONED BICHLER QUARRY AT GROOS, SEC. 1, 39 N., 3 W., DELTA COUNTY, 5 MILES NORTH OF ESCANABA, MICHIGAN

| Top of Section | | Feet | Inches |
|---|---|---|---|
| 4 | Argillaceous limestone, bedding very irregular, lens-like. Dolomitic phases. Thin layer of black shale at bottom. | 4 | |
| 3 | Limestone, hard, dense, some parts lithographic. Several parting layers of black shale. Pelecypod horizon near top containing *Whitella eardleyi.* | 24 | 8 |
| | Disconformity | | |
| 2 | Shale, dark brown to black, and shaly limestone. The top of this zone forms the main floor of the quarry. Erosion surface at top of zone. | 2 | |
| 1 | Limestone, hard, fine grained, irregular bedding. | 10 | |

### The Bichler Quarry Section at Groos

The abandoned limestone quarry at Groos, five miles north of Escanaba, reveals 40 feet of rock in the upper part of the Middle Orodvician section. The lower six feet of rock in the quarry consist of even bedded dolomite which breaks with a subconchoidal fracture. This grades upward into irregularly bedded, argillaceous limestone towards the top of the zone. Parting lenses and thin layers of black shale are found throughout the section at Groos. One such layer covers the floor of the quarry and it is very fossiliferous. Before the deposition of the shale layer an uplift occurred which exposed the limestone immediately below the thin shale band to weathering. Numerous small solution cracks were formed which were later filled with mud when the region was once again submerged. Evidence of shallow water deposition is found from the floor of the quarry to the top.

Fossils are very irregularly distributed throughout the section. They are found in certain beds, including some of the shale bands, but the hardness of the rock makes it difficult to obtain good specimens. The numerous specimens of the small pelecypod, *Whitella eardleyi,* found at the top of zone three, form a valuable horizon marker since the shells have a very limited vertical range and are found at a number of localities along the Escanaba River and in the bed of the stream just east of Rapid River.

FAUNAL LIST FROM THE BICHLER QUARRY AT GROOS

*Climacograptus pygmaeus* (Ruedemann)
*Climacograptus typicalis* (Hall)
*Cheirocrinus anatiformis* (Hall)
*Conularia trentonensis* (Hall)
*Mesotrypa* sp.
*Pseudolingula (Lingula) iowensis* (Owen)
*Resserella rogata* (Sardeson)
*Rafinesquina* sp.
*Rafinesquina deltoidea* (Conrad)
*Sowerbyella sericeus* (Sowerby)
*Sowerbyella gibbosus* (Winchell and Schuchert)
*Leptaena unicostata* (Meek and Worthen)
*Zygospira recurvirostris* (Hall)
*Platystrophia trentonensis* (McEwen)
*Whitella eardleyi* (Hussey)
*Cuneamya childsi* (Hussey)
*Liospira bachmanni* (Hussey)
*Liospira vitruvia* (Billings)
*Hormotoma trentonensis* (Ulrich and Scofield
*Hormotoma gracilis* (Hall)
*Clathrospira* sp.
*Orthoceras* sp.
*Endoceras proteiforme* (Hall)
*Flexicalymene senaria* (Conrad)
*Isotelus gigas* (Dekay)
*Ogygites* sp.

Relationships of the rocks in the Bichler Quarry at Groos

The black shales exposed above and below the falls on Haymeadow Creek are stratigraphically above the rocks in the Bichler Quarry although the contact has never been seen. The last interval between the top of the Bichler Quarry section and the base of the Haymeadow Creek section cannot be more than three or four feet and the rocks of these two sections are probably somewhere in direct contact.

The lenses and layers of black shale found at many horizons in the quarry section are lithologically like the shale that is found at the falls on Haymeadow Creek. *Ogygites* sp. occurs in many of the shale layers from the top to the bottom of the quarry but it has not been found in the succeeding Bill's Creek beds. This trilobite is not identical with *Ogygites latimarginatus* which is found in the Collingwood of southwestern Ontario, along the shores of Georgian Bay. *Endoceras proteiforme* occurs in the Collingwood and in the rocks at the Bichler Quarry. *Climacograptus pygmaeus* is found in loose slabs of Collingwood shale near Newberry, Michigan, and also in the quarry section. The trilobite *Triarthrus eatoni* is a good index fossil for the base of the Collingwood in Ontario but this form has not been discovered in the Bill's Creek shale, in the section on Haymeadow Creek, or in the Bichler quarry. *Conularia trentonensis, Cheirocrinus anatiformis* plates, *Sowerbyella sericeus* and *Sowerbyella gibbosus* occur in the Bichler quarry section and in blocks of Collingwood shale found near Newberry, Michigan. *Flexicalymene senaria* is found in the upper



part of the Bill's Creek section and also in loose slabs of Collingwood shale near Newberry.

The fauna in the rocks of the Bichler Quarry section show very little significant relationship to the faunas in the sections at Chandler Falls and above the bridge at Cornell.

*Pseudolingula iowensis* is found in the Dubuque of Iowa and in the upper part of the section at the Bichler Quarry. *Conularia trentonensis, Liospira vitruvia, Hormotoma trentonensis,* and *Rafinesquina deltoidea* are Upper Cobourg forms and these fossils also occur at the Bichler Quarry. Plates of *Cheirocrinus* sp. are found in the Dubuque beds at Elkador, Iowa, in the Collingwood shale of Ontario, and are very common in the beds at Rapid River and in the rocks of the Bichler Quarry. However *Cheirocrinus* is not a good index fossil because of its long range.

The relationship of the rocks in the Bichler Quarry and in the bed of the Rapid River near the village of Rapid River, Michigan, is very close to the Stewartville (Upper Cobourg), but some faunal relationship certainly extends into the directly overlying Haymeadow Creek shale.

Exposure in the Escanaba River above the paper mill at Groos

A small island stands in the middle of the Escanaba River a short distance above the paper mill at Groos, Michigan. The rock is well exposed all around the sides of the island and the shallow water of the river makes the locality an easy one to reach. *Whitella eardleyi* is found about six feet above the base of the section. This is the good horizon marker found at several localities.

SECTION AT THE ISLAND

| Top of Section | Feet | Inches |
|---|---|---|
| 2 Argillaceous limestone in thin, irregular layers. Lenses of dolomite. Weathers yellowish brown. | 4 | |
| 1 Argillaceous limestone with lithographic lenses. Thin, irregular beds. Weathers with rough, irregular surface. Specimens of *Whitella eardleyi* numerous about 6 feet from top of zone. | 12 | |

LOCALITY ALONG THE ESCANABA RIVER, SEC. 32, 41 N., 23 W., ONE AND ONE-HALF MILES EAST OF THE VILLAGE OF CORNELL, DELTA COUNTY

| Top of Section | Feet | Inches |
|---|---|---|
| 3 Limestone, dense, massive bedded, gray. Thin layer of dark brown shale at the base, weathering bluish. Similar to shale that covers floor of quarry at Groos. | 6 | 8 |
| 2 Heavy bedded dolomite and limestone. | 8 | 9 |
| 1 Argillaceous limestone, thin, irregular bedding. Weathers yellowish brown. This is the *Maclurites* horizon of the Chandler Falls and Cornell sections. | 14 | 9 |

The rocks in zones 2 and 3 of this section are the same as those that occur below the main floor of the quarry at Groos and they fill in the gap in the general section between the top of the main *Maclurites* horizon at the Chandler Falls locality and the base of the section in the quarry at Groos.

### Quarry Southeast of Cornell

An abandoned quarry seven and six-tenths of a mile southeast of the village of Cornell exposes 12 feet of limestone that is correlated with the middle part of the section in the quarry at Groos.

### Exposure near Shaffer, Delta County

A roadside exposure one-half mile northwest of the village of Shaffer, Sec. 19-20, T. 39 N., 24 W. shows three feet of hard, dolomitic limestone containing numerous *Cheirocrinus* plates. This exposure is correlated with the section in the quarry at Groos.

### Exposure near Harris, Menominee County

A poor roadside exposure one-half mile east of the village of Harris, Sec. 12, 38 N., 25 W., yielded a few specimens of *Whitella eardleyi.* This pelecypod occurs in considerable numbers toward the top of the section in the quarry at Groos.

### Exposure near Perkins, Delta County

Three feet of thin bedded, dolomitic limestone are exposed in an abandoned quarry one-fourth of a mile west of the village of Perkins, Sec.5, T. 41 N., 22W. *Cheirocrinus* plates are common. This rock is correlated with the upper part of the quarry at Groos.

### Exposures on the Ford River

The Ford River, in Sec. 5, T. 38 N., R 23 W., flows over rock for about 200 yards and moderately good exposures are along the banks of the stream. The rock is thin bedded, argillaceous limestone with dolomitic lenses and layers. The color of fresh surfaces is light to dark gray and after weathering the rock is mottled brown, greenish, and yellowish. The bedding is very irregular and the surface is rough after weathering. A thin layer of black or very dark brown shale is near the bottom of the section. The total thickness exposed is about five feet. *Conularia trentonensis, Dictyonema* sp., and *Pseudolingula iowensis* occur here. This exposure is correlated with the basal part of the quarry at Groos.



Exposure of Trenton limestone, Groos Quarry member, just south of the bridge across the Rapid River, east of the village of Rapid River, Michigan. These rocks are equivalent to the top of the section at the Bichler quarry, Groos, Michigan.

One and one-fourth miles north of the village of Hyde, Delta County above and below the bridge across the Ford River, Sec. 31, 39 N. 23 W. moderately good exposures of rock are in the south bank of the stream. The total thickness is about seven feet. This rock is correlated with the section in the quarry at Groos.

### Locality at Rapid River, Delta County

Rapid River flows southward just east of the town of Rapid River, in Delta County, Michigan. Eight feet of irregularly bedded, argillaceous limestones are exposed in the bed of the stream and in the banks, both below and above the bridge. The color varies from dark to light gray on fresh surfaces and after weathering the dominant color is brownish. Fossils are numerous but good specimens are difficult to obtain because the rock is hard and dolomitic and lithographic lenses and layers are common. *Whitella eardleyi* occurs in abundance near the bottom of the section. This fossil is a good horizon marker and the rocks at Rapid River are correlated with the upper part of the Bichler Quarry section at Groos where the same pelecypod occurs.

### Abandoned Quarry at McFarland, Marquette County

An abandoned quarry at McFarland, Michigan, Sec. 25, 44 N., 24 W., shows 20 feet of argillaceous limestone and dolomite which weathers brownish yellow and greenish gray. Fossils are not common and since the quarry is partly filled with water collecting is difficult.

The rocks here are correlated with the zone just above the conglomerate-bearing zone at Chandler Falls and Cornell.

### Exposure near Wilson, Menominee County

A roadside exposure of hard, argillaceous limestone, irregularly bedded and having lenses of dolomite is two miles east and one mile south of the village of Wilson, in Menominee County, Michigan. The outcrop is 13 feet 5 inches thick and the beds dip to the south at an angle of four degrees. This exposure is correlated with the upper part of the section at Chandler Falls which is the chief *Maclurites* horizon.

### Exposures near Bark River, Delta County

The *Maclurites* horizon is represented by five feet four inches of rock exposed along the road two miles north of Bark River, in Delta County, Michigan. Three feet of rock belonging to this horizon are found just east of Bark River, on Highway 2.

### Exposures near Schaffer, Delta County

Three miles east of Schaffer, on Highway M-69, and also one-half mile west of the town, roadside exposures of argillaceous limestone are correlated with the upper part of the section exposed in the Bichler Quarry at Groos, Michigan.

### Days River Exposure, Delta County

Rocks of the same horizon as those found in the upper part of the Bichler Quarry at Groos, are found at the bridge where Highway 2 crosses the Days River, between Escanaba and Rapid River. Sec. 3, 4N., 22W.



### Exposures along the Ford River

Thin bedded, argillaceous limestone with dolomitic and lithographic layers and lenses outcrops along the banks of the Ford River, two miles southeast of Hyde, in Delta County, Michigan. The bedding is very irregular and weathering produces nodular surfaces on many of the layers. Thin layers of dark brown and black shale are found at several horizons in the section which measures five feet four inches in thickness. This exposure is correlated with the upper part of the Bichler Quarry section which contains the pelecypod *Whitella eardleyi.*

### Exposure at Brampton, Delta County

A roadside exposure on M-35, at Brampton, in Delta County, Michigan, is correlated with the upper part of the section in the Bichler Quarry at Groos, Michigan.

### Exposure near Perkins, Delta County

In an abandoned quarry along Highway M-35, one-fourth of a mile west of Perkins, in Delta County, Michigan, the rocks consist of four feet of thin bedded, argillaceous limestone, with dolomitic and lithographic layers and lenses. This exposure is correlated with the upper part of the Bichler Quarry section, at Groos, Michigan.

### Roadside exposure, Marquette County

Twelve miles northeast of Cornell, in Marquette County, the rocks in a roadside exposure are correlated with the chief *Maclurites* horizon as it is found in the upper part of the Chandler Falls section.

### Exposure near Faunus, Menominee County, Michigan

Six feet of dolomitic limestone are exposed along Highway 69, Sec. 35, T 41, N. R. 26 W., eight-tenths of a mile northwest of the village of Faunus. Fresh surfaces of this rock are light gray to brown, weathering to dark gray and dark brown. This exposure is correlated with the rock in the base of the section at Bony Falls.

## AN OCCURRENCE OF CONGLOMERATE SOUTH OF SAULT STE. MARIE, CHIPPEWA COUNTY

Nine miles directly south of Sault Ste. Marie, on the road towards Pickford, Michigan, a number of large boulders lie at the foot of a northward facing terrace slope. These boulders are not in place but have probably been derived from some nearby source. These rocks consist of fragments of quartzite, hard gray limestone, and dolomite, embedded in a matrix of fine grained sandstone. Some of the fragments are quite angular, others are sub-angular, and they vary from one-fourth inch to 12 inches in length. This conglomerate is unlike that which occurs near the base of the section at Chandler Falls but both conglomerates may occur at about the same stratigraphic level.

### The Collingwood Formation

Typical exposures of the Collingwood occur in southwestern Ontario, along the shore of Georgian Bay. The formation here consists of alternate beds of shale and limestone. The fauna of the shale includes the following forms:

*Ogygites canadensis* (Chapman)=*O. latimarginatus* (Hall)
*Triarthrus eatoni* (Hall)
*Triarthrus canadensis* (Smith)
*Climacograptus prolificus* Parks
*Glossograptus quadrimucronatus* (Hall)
*Leptograptus flaccidus* (Hall)
*Leptobolus insignis* (Hall)
*Resserella emacerata* (Hall)
*Endoceras proteiforme* (Hall)
*Lingula coburgensis* (Billings)
*Lingula progne* (Billings)

Dr. August F. Foerste describes an exposure of Collingwood at Little Current on Manitoulin Island, Ontario. Many blocks and slabs of Collingwood shale and limestone occur in the extensive gravel deposits around Newberry, Michigan. The lithology of these loose blocks is similar to that of the Collingwood in Ontario. Ruedemann and Ehlers report the following fauna from this drift material at Newberry.

From blocks of shale:

*Climacograptus pygmaeus* (Ruedemann)
*Diplograptus amplexicaulis uticanus* (Ruedemann)
*Leptobolus insignis* (Hall)
*Triarthrus eatoni* (Hall)
*Ogygites latimarginatus* (Hall)
*Primitiella unicornis* (Ulrich)

From blocks of light, grayish-brown limestone:

*Climacograptus pygmaeus* (Ruedemann)
*Cheirocrinus* sp.
cf.*Oxoplecia calhouni* (Wilson)

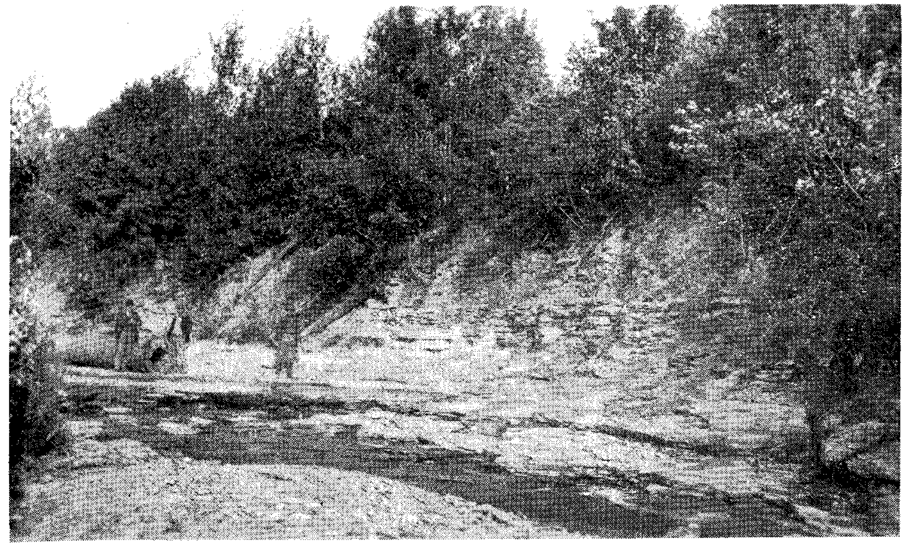
From dark, grayish-brown limestone:

*Diplograptus amplexicaulis uticanus* (Ruedemann)
*Lingula* cf. *whitfieldi* (Ulrich)
*Lingula coburgensis* (Billings)
*Dalmanella emecerata* (Hall) var.
*Conularia trentonensis* var. latior (Ruedemann)
*Sowerbyella sericeus* (Sowerby) var.
*Sinuites* sp.
*Isotelus* sp.
*Flexicalymene senaria* (Conrad)
*Primitiella* sp.
*Tetradella subquadrans* (Ulrich) var.

### Richmond, the Bill's Creek Beds

Bill's Creek rises in the northern part of Sec. 5, T. 41 N., R. 20 W., Delta County, and flows for about six miles in a southwesterly direction, finally emptying into Whitefish River Sec. 15, 41 N., 21 W. The Bill's Creek shale is exposed along the banks of the stream in the eastern part of Sec. 12, T. 41 N., R. 21 W., and the





Typical appearance of the Bill's Creek shale at the type locality along the banks of Bill's Creek, five miles northeast of Rapid River, Michigan.

western part of Sec. 7, T. 41 N., R. 20 W. The rock consists mostly of thin-bedded shale, with occasional layers six inches thick that break with a conchoidal fracture. The color of fresh surfaces is dark, chocolate brown, and after weathering the prevailing color is light bluish. The thickness of the beds along Bill's Creek is 67 feet with numerous alternations of shale and argillaceous limestone towards the top of the section. The shale and limestone in places grade both vertically and horizontally into each other. These alternations towards the top of the Bill's Creek beds are especially well shown in the section exposed along the western side of the Stonington Peninsula across Little Bay de Noc from the city of Escanaba. In some places the change from limestone to shale to limestone is abrupt and the contact surfaces are irregular as though erosion had occurred. In some beds the transitional phases are less abrupt. Great numbers of small pelecypods, belonging to the genus *Clidophorus*, occur in the limestone layers and in shaly partings between the layers.

Haymeadow Creek rises near the center of Sec. 34, T. 43 N., R. 20 W., and flows for eight miles in a southwesterly direction, to the Whitefish River. The Bill's Creek shale is exposed along the banks of Haymeadow Creek in the northern part of Sec. 19, T. 42 N., R. 20 W. The section is 14 feet thick just below the falls. The shale is mostly thin-bedded, with occasional layers six inches thick.

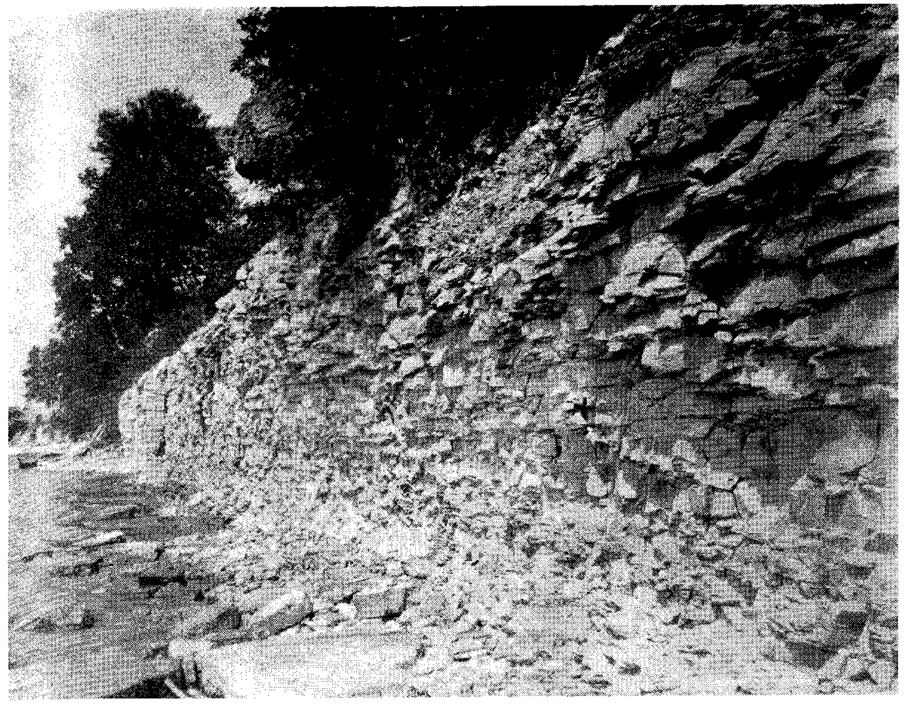
The color of fresh surfaces is dark, chocolate brown and even after weathering the color is only slightly lighter.

The following fossils have been identified from the Bill's Creek beds:

*Glossograptus (Orthograptus) quadrimucronatus* (Hall)
*Cornulites corrugatus* (Nicholson)
*Lichenocrinus tuberculatus* (Miller)
*Arthropora shafferi* (Meek)
*Bythopora striata* (Ulrich)
*Rhombotrypa quadrata* (Rominger)
*Cornulites flexuosus* (Hall)
*Resserella* sp.
*Pseudolingula (Lingula) changi* (Hussey)
*Leptobolus insignis* (Hall)
*Rafinesquina alternata* (Emmons)
*Zygospira* cf. *modesta* (Hall)
*Cleidophorus noquettensis* (Foerste)
*Cleidophorus hayesi* n. sp.
*Pterinea (Caritodens) demissa* (Conrad)
*Pterinea* aff. *insueta* (Emmons)
*Cyclora minuta* (Hall)
*Acidaspis* sp.
*Flexicalymene senaria* (Conrad)
*Isotelus gigas* (Dekay)
*Bythocypris cylindrica* (Hall)
*Primitia cincinnatiensis* (Miller)
*Primitiella stoningtonensis* (Hussey)
*Tetradella regularis* (Emmons)

The base of the shale exposed above and below the falls on Haymeadow Creek must be very close to the top of the Trenton limestone that is found in the Whitefish River a short distance west of the bridge across Haymeadow Creek. The contact between the shale and the limestone is not exposed at any of the localities known at present. The contact between the top of the Bill's Creek shale and the overlying Stonington beds of Richmond age is a disconformable one. A clearly defined and persistent bed of fine-grained argillaceous limestone, varying in thickness from three to six inches is at the top of the shale exposed along the eastern side of Little Bay de Noc. The upper surface of this limestone is irregular and is clearly the result of subaerial erosion. Immediately above the disconformity a layer of coarsely crystalline, argillaceous limestone with a conglomerate forms the basal part of the bed. This conglomerate is composed of water-worn fragments of the immediately underlying, fine-grained, argillaceous limestone. The position of the disconformity is further marked by a great faunal break between the Bill's Creek shale and the Stonington beds, just above.

The fossils towards the top of the Bill's Creek beds are found almost exclusively in the argillaceous limestone layers and very few of these fossils occur in the lower parts of the section. Graptolites are numerous in the shale at the falls on Haymeadow Creek but they are not very common higher up in the section. The Ostracod, *Tetradella regularis,* is exceedingly abundant in certain layers of shale, especially the thin ones, but it has not been found towards the base of the section. *Tetradella regularis* occurs in the basal part of the Waynesville member of the Richmond and is associated



Bill's Creek shale exposed along the eastern shore of Little Bay de Noc, on the western side of the Stonington Peninsula. In the upper left hand corner, between the break in the trees, may be seen the basal portion of the Stonington beds of Richmond age, lying just above the disconformity separating the Bill's Creek beds from the Richmond.

with *Primitia cincinnatiensis* both in Michigan and Ohio. *Bythopora striata,* from the higher Bill's Creek beds, is found in the Arnheim and Waynesville of Ohio, Indiana, and Kentucky. The very abundant *Arthropora shafferi* from the higher Bill's Creek beds is quite similar to a form from the Lower Waynesville, and is unlike any species from the Eden. *Cleidophorus neglecta* is common in the basal beds of the Maquoketa shale at Dubuque, Iowa, and a related form is very abundant in upper part of the Bill's Creek beds. The *Lingulae* from the higher Bill's Creek beds are identical with species from the Maquoketa shale at Graf, Iowa. *Lingula changi,* from the Bill's Creek beds, has been found in drift specimens of Collingwood shale near Newberry, Michigan.

A paper by the author on the Richmond Formation of Michigan, published in 1926, correlates the upper part of the Bill's Creek beds with the Maquoketa of Iowa, but the paper also states that the lower Bill's Creek beds, exposed at the falls on Haymeadow Creek, may not belong to the Richmond. It now seems best to

The falls on Haymeadow Creek ten miles northeast of Rapid River, Michigan. These beds represent the lowest exposed part of the Bill's Creek shale and are correlated with the Collingwood.

The hammer rests upon the erosion surface which marks the disconformity between the Bill's Creek shale and the Stonington beds of Richmond age. East side of Little Bay de Noc along the west side of the Stonington Peninsula.



correlate these lower beds, at least, with the Collingwood, in spite of the fact that many of the typical Collingwood fossils have not been found in shale at the Haymeadow Creek locality. This shale differs lithologically from the beds of the typical Bill's Creek section. It is darker in color and does not weather with a light gray surface.

The Eden and Maysville formations of the Ordovician, as well as the Waynesville member of the typical Richmond section, are not present in the Escanaba region of Michigan. These rocks have been identified on Manitoulin Island and their absence from the Michigan section may be due to the fact that they were never there or they may have been removed by erosion. The disconformity at the top of the Bill's Creek beds is evidence of an erosion interval that may thus be very significant.

SECTION OF THE BILL'S CREEK BEDS AT THE TYPE LOCALITY ON BILL'S CREEK. SEC. 7, T. 41 N. R. 20 W., SEC. 12 T. 41 N. R. 21 W.

| | Top of Section | Feet | Inches |
|---|---|---|---|
| 13 | Argillaceous limestone, dark brown on fresh surfaces, light to dark brown after weathering. Hard, coarsely crystalline. Fossils unevenly distributed. | 4 | |
| 12 | Shale, thin-bedded, fissile. Chocolate brown on fresh surfaces, light gray after weathering. | 3 | 8 |
| 11 | Argillaceous limestone, soft to hard, dark brown on fresh surfaces, light brown after weathering. Lenses of shale. Limestone and shale layers grade horizontally into each other. | 3 | 8 |
| 10 | Shale, dark gray, fissile, interbedded with indurated, buff-colored shale. | 3 | 2 |
| 9 | Argillaceous limestone, dark gray. | | 1 |
| 8 | Dark gray shale. | | 1 |
| 7 | Argillaceous limestone, dark gray. | | 2 |
| 6 | Shale, dark gray. | | 1 |
| 5 | Argillaceous limestone, dark gray, moderately hard to hard. Bryozoa abundant. | | 2 |
| 4 | Shale, light gray to dark brown on fresh surfaces, light gray after weathering. This is the main horizon for *Lingulae*. Numerous water-worn specimens of *Cleidophorus* 3 feet 8 inches from bottom of layer. | 15 | |
| 3 | Shale, thin-bedded, grayish brown on fresh surfaces, light gray after weathering. | 10 | |
| 2 | Shale, breaking into angular fragments, fissile after weathering. Mud lumps numerous. | | |
| 1 | Shale, grayish-brown on fresh surfaces, light gray after weathering. Much softer after weathering. *Resserella* sp. abundant. | 22 | |

## The West Neebish Channel

The West Neebish Channel is located at the eastern end of the Northern Peninsula of Michigan, south of Sault Ste. Marie, Chippewa County connecting Hay and Munuscong lakes west of Neebish Island. Argillaceous limestone and shale were blasted from the bottom of this channel in order to make an improved passage for boats. This rock is now piled in a long row along the side of the channel and has yielded the following fauna:

*Hindia* sp.
*Streptelasma corniculum* (Hall)
*Amecystis* sp.
*Anolotichia impolita* (Ulrich)
*Batostoma* sp.
*Dekayella* sp.
*Eridotrypa* sp.
*Homotrypa minnesotense* (Ulrich)
*Pachydictya* sp.
*Phaenopora* cf. *incipiens* (Ulrich)
*Rhinidictya* cf. *neglecta* (Ulrich)
*Craniella* sp.
*Dinorthis pectinella sweeneyi* (N. H. Winchell)
*Hesperorthis tricenaria* (Conrad)
*Pianodema subaequata perveta* (Conrad)
*Platystrophia trentonensis* (McEwan)
*Rafinesquina* sp.
*Rhynchotrema minnesotense* (Sardeson)
*Rhynchotrema* sp.
*Strophomena filitexta* (Hall)
*Trematis ottawaensis* (Billings)
*Zygospira recurvirostris* (Hall)
*Conularia trentonensis* (Hall)
*Endoceras* sp.
*Acidaspis* sp.
*Bumastus* sp.
*Ceraurus pleurexanthemus* (Green)
*Isotelus gigas* (Dekay)
*Pterygometopus* sp.

The argillaceous limestone of the Neebish Channel belongs to the Lower Trenton or Hull formation. *Hesperorthis tricenaria* does not occur above the Hull and the genus *Platystrophia* appears for the first time in this formation although it is rare. *Strophomena filitexta* is abundant in the Hull and it is common in the beds of the Neebish Channel.

## Encampment d'Ours Island, Ontario

Pre-Cambrian slates and quartzites form bold cliffs along the shores of Encampment d'Ours Island in the North Channel, St. Mary's River, north of St. Joseph Island. In the northeastern part of the Island the Pre-Cambrian rocks are overlaid by dark brown sandstone, conglomeritic in places, which is about 100 feet thick.

A detailed section was measured in the steep cliff above the old sandstone quarry, on the northeastern part of the island.



SECTION ON ENCAMPMENT D'OURS ISLAND, ONTARIO

| Top of Section | | Feet | Inches |
|---|---|---|---|
| 13 | Limestone and black shale in alternate layers. | 10 | |
| 12 | Limestone, hard, dark brown. | | 2 |
| 11 | Black shale, thin bedded. | 4 | |
| 10 | Limestone, dark brown, hard. | | 2 |
| 9 | Brown sandstone, soft. | 1 | 7 |
| 8 | Black shale, thin bedded. | 2 | 10 |
| 7 | Limestone, soft, dark brown. | | 2 |
| 6 | Black shale, thin bedded. | 8 | 8 |
| 5 | Sandy limestone. | | 6 |
| 4 | Sandstone, soft, dark brown. | 5 | |
| 3 | Black shale, thin bedded, fissile. | | 6 |
| 2 | Sandstone, dark gray to brown, hard. | 4 | |
| 1 | Sandstone, light to dark brown, massive bedded. | 100 | |

Above this continuous section a long, gentle slope, covered with soil, has two poor exposures of thin-bedded, hard nodular limestone. One exposure is about 12 feet from the top of the measured section below and the other exposure is at the top of the slope. The entire covered interval is 25 feet thick.

FAUNA FROM ENCAMPMENT D'OURS ISLAND

*Columnaria alveolata* (Goldfuss)
*Tetradium fibratum* (Safford)
*Eurydictya multipora* (Hall)
*Stictopora ramosa* (Hall)
*Rafinesquina alternata* (Emmons)
*Strophomena septata* (Winchell and Schuchert)
*Zygospira recurvirostris* (Hall)
*Rhynchotrema* sp.
*Cyrtodonta huronensis* (Billings)
*Whitella suntruncata* (Hall)
*Matheria tenera* (Billings)
*Vanuxemia inconstans* (Billings)
*Ambonychia amygdalina* (Hall)
*Endodesma gesneri* (Billings)
*Clathrospira subconica* (Hall)
*Pleurotomaria quebecensis* (Billings)
*Lophospira biconcta* (Hall)
*Tetranota bidorsata* (Hall)
*Trochonema umbilicatum* (Hall)
*Orthoceras huronense* (Billings)
*Endoceras proteiforme* (Hall)
*Bathyurus spiniger* (Hall)
*Isotelus gigas* (Dekay)
*Ceraurus pleurexanthemus* (Green)
*Illaenus americanus* (Billings)

White, friable sandstone is found in the ship channel between Sugar Island and Neebish Island. According to Rominger this rock is found directly beneath the Lower Black River on Encampment d'Ours and it may be Black River. Poorly preserved specimens of *Lingula* are found in the sandstone.

## Sulphur Island, Ontario

Sulphur Island is located in the North Channel of Lake Huron two and three-fourth miles north and about one mile east of Poe Point, Drummond Island, Michigan, Sec. 24 T. 43 N, R. 6 E. A prominent, steep ledge of Pre-Cambrian quartzite outcrops along the east side of Sulphur Island and rises 15 to 20 feet above the level of the lake.

Weathering and erosion loosened large and small blocks of the quartzite and these accumulated at the foot of the ledge where they form a prominent conglomerate with the various blocks tilted at different angles. Some of the quartzite was eventually reduced to sand. When the Middle Ordovician sea invaded the area Sulphur Island was submerged and became a reef. Argillaceous limestone, mixed with some of the sand, was deposited unconformably upon the quartzite conglomerate. These Ordovician rocks may still be seen, especially along the eastern side of Sulphur Island, dipping at various angles from the blocks of quartzite. Later eperic seas doubtless invaded the region but no rocks of Upper Ordovician, Silurian, or Devonian periods have been found on Sulphur Island. Erosion has probably removed all marine deposits that were made after the Middle Ordovician. The fossils from the Middle Ordovician rocks on Sulphur Island are of Black River (Decorah) age.

FAUNA FROM THE MIDDLE ORDOVICIAN OF SULPHUR ISLAND

*Lambeophyllum* sp.
*Heterocrinus* sp.
*Lichenocrinus* sp.
*Arthroclema* sp.
*Bythopora* sp.
*Dekayella* sp.
*Eridotrypa aedilis* (Eichwald)
*Escharopora confluens* Ulrich
*Hallopora multitabulata* (Ulrich)
*Mesotrpya spinosa* Ulrich
*Pachydictya occidentalis* Ulrich
*Phyllodictya* sp.
*Prasopora simulatrix* Ulrich
*Rhinidictya mutabilis* major (Ulrich)
*Stictoporella* sp.
*Trigonodictya conciliatrix* (Ulrich)
*Resserella rogata* (Sardeson)
*Plesiomys meedsi* (Winchell and Schuchert)
*Dinorthis pectinella* (Emmons)
*Glypthortis bellarugosa* (Conrad)
*Pianodema subaequata circularis* (N. H. Winchell)
*Platystrophia* sp.
*Sowerbyella sericeus* (Sowerby)
*Favistella alveolata* (Goldfuss)
*Streptelasma corniculum* Hall
*Rafinesquina minnesotense inquassa* (Sardeson)
*Rhynchotrema increbescens* (Hall)
*Strophomena filitexta* (Hall)
*Strophomena trentonensis* Winchell and Schuchert
*Hesperorthis tricenaria* (Conrad)
*Zygospira recurvirostris* (Hall)
*Vanuxemia* sp.
*Cyrtodonta subcarinata* Billings
*Bumastus* sp.
*Tetralichas* sp.



SECTION ON ST. JOSEPH ISLAND, ONTARIO, AT THE WESTERN END OF THE NORTH CHANNEL IN LAKE HURON

The top of the section begins at Quarry Point, on the northeast side of the Island, and continues northward to Gravel Point, and then westward for about two miles, along the north shore of Landspur.

| Top of section | | Feet | Inches |
|---|---|---|---|
| 8 | Sandy limestone, brown, hard. Contains large *Endoceras*. | 3 | |
| 7 | Limestone, gray, hard. Contains *Columnaria* and *Endoceras*. | 5 | |
| 6 | Limestone, gray, thin bedded, irregular weathering. | 8 | |
| 5 | Argillaceous limestone. Large *Endoceras*. | 3 | |
| 4 | Limestone, hard, brown. | 2 | 6 |
| 3 | Argillaceous limestone, gray to brown. Fossils very abundant. *Vanuxemia* sp. common. | 12 | |
| 2 | Covered interval | 3 | |
| 1 | Argillaceous limestone, brown, hard. *Vanuxemia*. | 3 | |

The *Endoceras* found in zone 8 was 33 inches long and 5.33 in diameter at the larger end.

The rocks of this section have been correlated with the Lower Black River, below the Pauquette River section.

Raynolds Point on Drummond Island, Sec. 29, T. 43 N., R. 3 E.

The Whitewater member of the Richmond is exposed three-fourths of a mile south of Raynolds Point. A great *Stromatocerium* reef extends out under the water and is equivalent to the Gore reef on Manitoulin Island. Seven feet of sandy and dolomitic limestone with beds from one to three inches thick are above the reef zone. Above this zone lies another great reef containing *Stromatocerium huronense* and *Tetradium*. This is equivalent to the Kagawong reef on Manitoulin Island.

The following extensive fauna is found in the middle zone:

*Girvanella richmondensis* (Miller)
*Heterospongia sp.*
*Protarea richmondensis* Foerste
*Streptelasma rusticum* (Billings)
*Tetradium* minus Safford
*Stromatocerium huronense* (Billings)
*Inocaulis* sp.
*Homotrypa ramulosa* Bassler
*Hebertella occidentalis* Hall
*Platystrophia* sp.
Starfish, not identified
*Byssonychia* sp.
*Ctenodonta inpigenia* (Billings)
*Cyrtodonta* sp.
*Ischyrodonta miseneri* Ulrich
*Ischyrodonta truncata* Ulrich
*Modiolopsis valida* Ulrich
*Opisthoptera casei* (Meek and Worthen)
*Ortonella hainesi* (Miller)
*Helicotoma brocki* Foerste
*Lophospira bowdeni* (Safford)
*Lophospira trophidophora* (Meek)
*Scenella* sp.
*Vallatotheca manitoulini* Foerste
*Isotelus* sp.
*Technophorus* sp.

## Three-Fourths of a Mile West of Raynolds Bay on Drummond Island

### FAUNAL LIST FROM THE WHITEWATER MEMBER OF THE RICHMOND

| | |
|---|---|
| *Calapoecia cribriformis* (Nicholson) | *Rhombotrypa subquadrata* (Ulrich) |
| *Favistella (Columnaria) alveolata* (Goldfuss) | *Hebertella occidentalis* Hall |
| *Favistella calicina* (Nicholson) | *Platystrophia acutilirata* (Conrad) |
| *Protarea richmondensis* Foerste | *Rafinesquina alternata* (Emmons) |
| *Streptelasma rusticum* Billings | *Rhynchotrema capax* (Conrad) |
| *Batostoma variabile* Ulrich | *Strophomena planumbona* Hall |
| *Bythopora meeki* (James) | *Strophomena vetusta* (James) |
| *Ceramoporella ohioensis* var. | *Zygospira modesta* (Say) |
| *Homotrypa wortheni* (James) | *Byssonychia* sp. |
| *Homotrypella rustica* Ulrich | *Pterinea (Caritodens) demissa* (Conrad) |
| *Ptilidictya plumaria* James | |
| *Rhombotrypa quadrata* (Rominger) | *Isotelus* sp. |

## Raynolds Point, Immediately East of Raynolds Bay, Drummond Island

### FAUNA FROM THE WHITEWATER MEMBER OF THE RICHMOND

| | |
|---|---|
| *Stromatocerium huronense* (Billings) | *Ptilodictya plumaria* James |
| *Calapoecia cribriformis* (Nicholson) | *Rhombotrypa quadrata* (Rominger) |
| *Columnaria alveolata* Goldfuss | *Rhombotrypa subquadrata* (Rominger) |
| *Streptelasma rusticum* (Billings) | *Hebertella occidentalis* Hall |
| *Batostoma variabile* Ulrich | *Platystrophia acutilirata* (Conrad) |
| *Bythopora meeki* (James) | *Rafinesquina alternata* (Emmons) |
| *Ceramoporella ohioensis* var. | *Rhynchotrema capax* (Conrad) |
| *Homotrypa wortheni* (James) | *Strophomena planumbona* Hall |
| *Homotrypella rustica* Ulrich | *Strophomena vetusta* (James) |
| *Ptilodictya magnifica* Miller | |

## Chippewa Point on Drummond Island, Sec. 19, T. 43 N., R. 6 E.

The Whitewater member of the Richmond is exposed along the north side of Chippewa Point. The following fossils have been identified from this locality:

| | |
|---|---|
| *Beatricea undulata* (Billings) | *Bythopora meeki* (James) |
| *Calapoecia cribriformis* (Nicholson) | *Hebertella occidentalis* Hall |
| *Columnaria alveolata* Goldfuss | *Platystrophia* sp. |
| *Streptelasma rusticum* (Billings) | *Helicotoma brocki* Foerste |
| *Tetradium minus* Safford | *Byssonychia* sp. |
| *Stromatocerium huronense* (Billings) | *Orthoceras* sp. |

Argillaceous limestone and shale of the Whitewater member of the Richmond are exposed at Poe Point on Drummond Island, Sec. 24, T. 43 N., R. 6 E.

The beds in the basal part of the section extend out under the water with one foot of hard, dark gray limestone exposed above the level of the lake. Zone 2 consists of 28 feet of shaly limestone and shale, varying from soft to hard and weathering to a light gray. This zone contains a large fauna with *Streptelasma rusticum* especially abundant. Two feet of hard, dark gray limestone form a prominent overhanging ledge at the top. The following fauna has been identified from this locality:



| | |
|---|---|
| *Calapoecia cribriformis* (Nicholson) | *Hebertella occidentalis* Hall |
| *Columnaria alveolata* Goldfuss | *Platystrophia acutilirata* (Conrad) |
| *Protarea richmondensis* Foerste | *Rafinesquina alternata* (Emmons) |
| *Streptelasma divaricans* (Nicholson) | *Rhynchotrema capax* (Conrad) |
| *Streptelasma rusticum* (Billings) | *Strophomena planumbona* (Hall) |
| *Cyclocystoides* sp. | *Strophomena vetusta* (James) |
| *Bythopora meeki* (James) | *Zygospira modesta* (Hall) |
| *Bythopora striata* Ulrich | *Clathrospira subconica* (Hall) |
| *Ceramoporella ohioensis* (Nicholson) | *Salpingostoma richmondensis* Ulrich |
| *Homotrypa ramulosa* Bassler | *Schizolopha moorei* Ulrich |
| *Homotrypa wortheni* (James) | *Byssonychia* sp. |
| *Monticulipora epidermata* Ulrich and Bassler | *Pterinea (Caritodens) demissa* (Conrad) |
| *Proboscina auloporoides* (Nicholson) | *Vanuxemia* sp. |
| *Rhombotrypa quadrata* (Rominger) | *Amphilochas* sp. |
| *Rhombotrypa subquadrata* (Ulrich) | *Flexicalymene* sp. |
| *Crania scabiosa* Hall | *Ceraurus* sp. |
| *Hebertella alveata* Foerste | *Isotelus* sp. |

## Comparison of the Richmond in Michigan and on Manitoulin Island

The Richmond rocks in the Escanaba region of Michigan are related to those in Ontario, especially on Manitoulin Island, but the Stonington beds of the Michigan section are closely related to the Whitewater of the typical southwestern Ohio section whereas the Richmond of Manitoulin Island is closer to the Waynesville. The Big Hill beds which form the top of the Richmond section in Michigan are probably Whitewater-Elkhorn.

The following fossils are found in both Michigan and on Manitoulin Island:

| | |
|---|---|
| *Streptelasma rusticum* (Billings) | *Strophomena huronensis* Foerste |
| *Tetradium huronense* Billings | *Rafinesquina alternata* (Emmons) |
| *Columnaria alveolata* Goldfuss | *Platystrophia clarksvillensis* Foerste |
| *Portarea richmondensis* Foerste | *Pterinea (Caritodens) demissa* (Conrad) |
| *Rhombotrypa quadrata* (Rominger) | |
| *Petrocrania scabiosa* Hall | *Cyrtolites ornatus* Conrad |
| *Hebertella occidentalis* Hall | *Billingsites newberryi* (Billings) |
| *Strophomena planumbona* Hall | *Bythocypris cylindrica* (Hall) |

The following are some typical forms from the Richmond of Manitoulin Island that have not been found in Michigan.

| | |
|---|---|
| *Columnaria calycina* Nicholson | *Rhytima kagawongensis* Foerste |
| *Stromatocerium huronense* (Billings) | *Ctenodonta iphigenia* Billings |
| | *Opisthoptera fissicosta* (Meek) |
| *Constellaria polystomella* Nicholson | *Clathrospira subconica* (Hall) |
| *Hebertella insculpta* (Hall) | *Liospira helena* (Billings) |
| *Hebertella sinuata* (Hall) | *Cyclonema bilix* (Conrad) |
| *Zygospira kentuckiensis* James | *Endoceras* sp. |
| *Cyrtodonta ponderosa* Billings | *Spyroceras hammelli* Foerste |
| *Ortonella hainesi* (Miller) | *Oncoceras* sp. |

Species of the genus *Platystrophia* are very abundant in the Richmond whereas they are not common in the exposure at Clay Cliff on Manitoulin Island.

The rocks at both localities were formed from sediments deposited in shallow water and probably not far distant from the shore. Ripple marks are common in the Michigan beds and at both localities alternation between very fossiliferous and almost unfossiliferous strata is common. Sandy clays containing a few fossils are found at many horizons in the Clay Cliffs section but in the Michigan beds argillaceous limestones predominate in the Stonington beds of the Richmond. The waters at both localities must often have been muddy. Bryozoans are more abundant in the Michigan area. No coarse sediments are found at either locality and the neighboring lands must have been fairly low with streams of moderate velocities. The shale in the Richmond was, of course, derived from nearby lands but it may have been carried into the nearby seas chiefly at times of heavy rains.

The Ogontz beds, which lie above the Stonington, consist of irregular bedded limestone with both argillaceous and cherty layers, although the quantity of argillaceous material in the Ogontz is not very great. It is obvious that this member was deposited under relatively clear water conditions.

The Big Hill beds, which lie at the top of the Richmond section in the Escanaba region of Michigan, represent the late Arctic invasion and contain the typical corals *Halysites gracilis* and *Paleophyllum stokesi*. These are not found in any of the lower Richmond rocks in Michigan. These corals also occur in the Fremont limestone at Cañon City, Colorado.

Waynesville rocks are exposed along a road that runs east and west, about 3 miles south of Little Current on Manitoulin Island, and also on the Bass Lake road which leads southward from Little Current. The basal part of the Waynesville is exposed at the second locality and contains the typical fossils *Hebertella insculpta* and *Catazyga headi*. The *Stromatocerium* reef exposed at Gore Bay on the northwest side of Manitoulin Island is found both at the Clay Cliffs locality and in the exposures along the road south of Little Current.

Two layers of fine grained, argillaceous limestone occur near the bottom of the Bay de Noc member of the Stonington beds in the Escanaba region of Michigan. These beds contain numerous specimens of *Whiteavesia (Pholadimorpha) pholadiformis* and *Modiolopsis valida*. *Whiteavesia pholadiformis* occurs in what Foesrste has called Lorraine-like strata on Manitoulin Island. These beds lie directly below the section that has been correlated with the Waynesville.

# CHAPTER III

## DESCRIPTIONS OF ORDOVICIAN FOSSILS

### Genus PHYCODES Reinh. Richter

**PHYCODES OTTAWAENSE** Billings
**(LICROPHYCUS OTTAWAENSE** Billings)
Plate 8, Fig. 2

Von Reinhard Richter described and figured *Phycodes circinatum* in 1850 as a possible form of alga. Billings, in 1865, described the some form under the generic name of *Licrophycus* with the species *ottawaense* and *minor*.

The plant grows from a single root and has numerous slender stems that were probably quite flexible in life. Some of the branches bifurcate and diverge from the root at acute angles. The branches taper very slightly in the specimen from Michigan and their width varies from one to three millimeters. The specimen as preserved is 10.5 cm. wide and 11 mm. high. The stems are now solid and vary in cross section from cylindrical to oval. Some of the stems show obscure markings like longitudinal ridges, and one broken stem appears to be made up of concentric layers.

Horizon and locality: Trenton. Chandler Falls and Cornell.

*Phychodes circinatum* Reinh. Richter. Neues Jahrbuch für Mineralogie, Geologie und Paläeontologie. 72. Beilage-Band. Abteilung B. 1934.

*Licrophycus ottawaense* Billings, Pal. Foss. Canada, 1, 1865, p. 99, fig. 87.

## Phyllum ECHINODERMATA

### *Class* CYSTOIDEA Von Buch

### Genus PLEUROCYSTITES Billings

**PLEUROCYSTITES SQUAMOSUS** Billings
Plate 7, Fig. 14

The specimen shows only the antanal side, the opposite side being embedded in the hard limestone matrix. The calyx has been somewhat distorted by crushing but nearly all the plates are well shown and the sutures can easily be traced. The column is round, tapering distally, with the projecting edges of the segments vertically striated; the segments are separated from each other by deep grooves which become shallow distally where the segments are also thicker. The surface of the plates is granular. On a few plates there are traces of concentric lines running parallel to the margin.

Basal pectinorhomb narrow, about 1.5 mm. wide and 5 mm. long, with the longer axis running in the same direction as the length of the calyx. The longer axes of the two upper pectinorhombs are transverse to the length of the calyx. The chief distinction between *Pleurocystites filitextus* and *P. squamosus* is in the number of plates on the anal side. In the former species the anal area is covered with forty or fifty plates; in the latter species the area is covered with several hundred very small plates.

Horizon and locality: Trenton. Chandler Falls. Conglomerate zone.

### GENUS PSEUDOLINGULA Mickwitz
### PSEUDOLINGULA IOWENSIS (Owen) Winchell and Schuchert
**(LINGULA IOWENSIS Owen)**

Plate IX, Fig. 28

*Lingula iowensis* Owen, 1844, Geol. Rept. Iowa, Wis. and Ill., p. 70, pl. 15, fig. 1.

Shells reach large size. Elongated oval, widest about the middle or slightly anterior to the middle. Sides gently, evenly convex. Anterior margin broadly rounded. Beak blunt. Median septum in the brachial valve narrow towards the beak, broadening and deepening towards the anterior end which extends beyond the mid-line of the shell. Moderately strong concentric lines on the surface and in the cast moderately strong radiating lines towards the front margin. Shell, where preserved, glossy brown.

The genus *Pseudolingula* of Mickwitz is distinguished from *Lingula* largely by the paired umbonal muscles instead of the single muscle. Those muscles have not been observed in American species. In a recent publication, Memoir 42, of the Geological Society of America, on Maquoketa Brachiopoda of Iowa, Y. Wang retains the genus *Lingula* for the species *iowensis*.

Found in the upper thirty feet of the Bichler Quarry at Groos, Michigan. These beds may be Collingwood.

## Phylum BRACHIOPODA
### GENUS CRANIA Retzius
**CRANIA SETIGERA Hall**

Plate IX, Fig. 3

*Crania setigera Hall.* Descriptions new species Crinoidea and other Fossils, 1866, p. 12. 24th Rep. New York State Cab. Nat. Hist., p. 220, pl. 7, fig. 13. 1872

In some specimens the surface pustules are so strongly developed that they may be called spines. In some specimens the spines are broad and oblique and give the appearance of ridges radiating from the beak to the margin.



Chandler Falls member of the Escanaba River group. Chandler Falls locality.

### GENUS MICROTRYPA WILSON
**MICROTRYPA WARMINGTONI, new species**

Plate 4, Figs. 8, 10, 11

*Microtrypa altilis* Wilson. Transactions Royal Soc. Canada. Third Series, Sec. 4, Vol. 39, 1945. Plate 2, Figs. 10-12.

Shell sub-triangular to semicircular in outline. Cardinal extremities extended. Cardinal process strong with two triangular branches. Brachial valve moderately and evenly convex. The septal system begins with three ridges between the brachiopores. After a short distance the central ridge bifurcates and the four extend a little more than half the distance to the anterior margin. The central ridges are somewhat longer than the lateral ones and all become stronger towards the anterior margin. In one specimen the anterior ends of the lateral septae are bent slightly outwards. The septal system resembles that of *Opikinella* which belongs to the *Rafinesquina* group. Interior of the brachial valve pustulose. Punctae small and irregularly arranged.

Trenton. Lower part of the Chandler Falls member at Chandler Falls.

### GENUS TRIGRAMMARIA WILSON
**TRIGRAMMARIA DUCHAINEI, new species**

Plate 3, Figs. 1, 2, 14

*Trigrammaria trigonalis* Wilson. Transactions Royal Society of Canada. Third Series, Section 4, Vol. 39., 1945. Pl. 2, figs, 7-9.

Outline of shell triangular with the greatest width across the hinge line. Dorsal valve flattened in the beak area and with a strong but not sharply abrupt geniculation. Concentric wrinkles on the dorsal valve moderately strong where the geniculation begins. Slightly oblique wrinkles at the hinge line. Surface of the dorsal valve covered with moderately strong to strong striations with 1 to 6 weaker striae between the stronger ones. From the geniculation to the front margin some of the weaker striae become stronger and alternate with 1 to 3 weaker ones. A broad, rounded fold on the dorsal valve begins at the geniculation and is prolonged beyond the margin into a nasute projection. The striations are crossed by very fine concentric striae. The irregular arrangement of the punctae in *Trigrammaria* help distinguish this genus from *Strophomena*.

The interior of a ventral valve assigned to this genus and species has a moderately small but sharply defined scar with one strong median septum, prolonged beyond the area of the scar, and two slightly weaker ones parallel or subparallel to the median one. Strong radiating wrinkles towards the front of the interior of the pedicle valve.

Trenton. Lower part of the Chandler Falls beds at Chandler Falls and above the concrete bridge at Cornell.

**TRIGRAMMARIA STUMMI** n. sp.
Plate X, Figs. 6, 7

Shells uniformly small, triangular in outline, wider than long, with the greatest width across the hinge line. Posterior half of the brachial valve flattened, with a broad, shallow sinus starting at the beak and extending to the line of geniculation. Sinus widens towards the front. Moderately strong crenulations near the hinge line. Irregular but strong, roughly concentric wrinkles cover the posterior portion of the valve and fine radiating lines, of about equal strength cover the same portion of the valve and extend to the front margin in specimens that are not exfoliated. Anterior to the geniculation widely separated ridges have finer striae between the ridges. The abruptly rounded geniculation begins anterior to the medial line of the shell. A very prominent fold is present on the downward bent portion of the valve. This fold is sharp to strongly rounded and in one specimen it is slightly to one side of the mid-line. Punctae closely spaced and irregularly arranged. Only one valve of this species is known.

Trenton. Escanaba River Group. Gross Quarry member. Moderately common at several localities.

## GENUS VELLAMO ÖPIK

**VELLAMO TRENTONENSIS** (Raymond)
Plate III, Figs. 3, 6, 7, 8, 9, 10, 11, 12, 13, 15

*Clitambonites diversa* Winchell and Schuchert. Geol. Minn., 3, 1893, p. 378, pl. 30, figs. 11-17.

The specimens of *Vellamo trentonensis* from the Trenton of Michigan are somewhat variable. The greatest width may be along the hinge line or across the middle of the shell. The shells are all wider than long. The cardinal area of the ventral valve is high and may be quite flat, slightly convex, or even warped. The area may be almost vertical or slope forwards. In some individuals the beak is inconspicuous and sharp and in others it is blunt and twisted slightly to one side. The cardinal area is covered with fine, crowded, vertical striations and coarser, irregularly spaced transverse striations. The ventral valve is seldom symmetrical but usually warped. The dorsal valve may be flat, slightly concave, or warped. The surface of both valves covered with coarse, radial striae which are increased both by bifurcation and interpolation. These striae are subangular or somewhat tubulose, and are nodular in places. The striations are crossed by fine, crowded striae. A shallow median depression is developed in the dorsal valve.



Rare in the Chandler Falls member of the Escanaba River group, at both Chandler Falls and Cornell.

## GENUS ZYGOSPIRA HALL

**ZYGOSPIRA RECURVIROSTRIS** (Hall)
Plate X, Figs. 3, 3, 21

*Atrypa recurvirostris* Hall. Pal. New York, 1, 1847, p. 140, pl. 33, fig. 5.

Some of the specimens have the dorsal valve inflated just below the beak, and approach, in this respect, *Zygospira recurvirostris turgida* from the Richmond of Michigan. The median depression in the dorsal valve is shallow. In some individuals a striation, stronger than any of the others, runs down the middle of the depression. Ventral valve gibbous and often narrowly rounded along the median line. Plications on each valve usually number about 24.

Very abundant in some layers of the Lower Trenton beginning with the conglomerate zone. Chandler Falls member of the Escanaba River group. Many localities.

Ulrich placed the base of the Trenton at beds a little above the conglomerate zone where Zygospira recurvirostris suddenly becomes very abundant.

## GENUS CATAZYGA HALL AND CLARKE

**CATAZYGA UPHAMI** (Winchell and Schuchert)
Plate IX, Figs. 7-9

*Zygospira uphami* Winchell and Schuchert. Amer. Geol., 9, 1892, p. 291.

Some of the Michigan forms attain a width of a little over 11 mm. Ventral valve gibbous with a tendency towards the development of a very low, narrow fold, which can be traced three-fourths of the way from the front margin to the umbo. Striations fine, numerous, regularly spaced, and in some individuals becoming heavier towards the middle of the valve. Dorsal valve with a shallow sinus. In some specimens a heavy striation runs down the center of the sinus from about the middle point of the valve to the front. This striation is produced by the partial or nearly complete fusion of two striae.

Found chiefly in the conglomerate zone of the Chandler member at Cornell and Chandler Falls.

### GENUS PLATYSTROPHIA KING

**PLATYSTROPHIA TRENTONENSIS** McEwan

Plate II, Figs. 1-8

*Platystrophia biforata* Grabau and Shimer. North American Index Fossils, vol. 1, 1903, p. 258.

McEwan, Proceedings U. S. Nat. Mus. No. 2297. Vol. 56, p. 407.

The width across the hinge in the most typical specimens from the Trenton of Michigan varies from shorter to longer than the greatest width across the middle of the shell. The fold is slightly elevated, with four plications, the two inner ones being the strongest. In one specimen an outer plication originates by bifurcation. The sinus is well developed, with three plications, of which the central one is the strongest. The lateral slopes have from nine to thirteen plications.

Platystrophias are not common in the Trenton rocks of Michigan but they become exceedingly abundant in the Richmond rocks on the Stonington Peninsula of Michigan, only a short distance from the Trenton outcrops.

**PLATYSTROPHIA BOWLESI,** new species

Plate VII, Figs. 6, 8, 9

The same beds that contain specimens of typical *Platystrophia trentonensis* have yielded a few individuals of an entirely different species of *Platystrophia.*

*Platystrophia duchainei* is a small, thin form with extended hinge extremities. The fold is slightly developed and has two strong plication and a third weak one that originates by bifurcation. Ten to eleven plications are on the slopes of the pedicle valve. The sinus is moderately deep, and has two plications of unequal strength, the weaker one originating by intercolation. Twelve plications are on the slopes of the brachial valve.

A second individual has a fold with four plications, the lateral ones being weak and originating by bifurcation. The sinus of this individual has three plications, the lateral ones being weak and originating by bifurcation. The slopes of the brachial valve have nine to ten plications and the slopes of the pedicle valve have nine to eleven plications.



The general shape of *Platystrophia duchainei* is similar to *Platystrophia acuminata* from the Arnhein formation of the Richmond.

Platystrophias are not common in the Trenton rocks of Michigan but are exceedingly abundant in the Richmond formation which outcrops near the Trenton exposures.

Trenton, the Chandler Falls member at Chandler Falls and Cornell.

The earliest known species of the genus *Platystrophia* have been found in The Black River group near Fennemore, Tennessee. This group has been correlated with the Decorah Shale. This form, *Platystrophia extensa,* with 9 to 13 plications on the lateral slopes, belongs to the Triplicate group. The hinge line may be almost as great as or somewhat greater than the width across the middle.

No species of the genus *Platystrophia* have been found in Michigan below the conglomerate zone of the Lower Trenton and no uniplicate forms have been discovered.

### GENUS SOWERBYELLA JONES

**SOWERBYELLA SERICEA** (Sowerby)

Plate IX, Fig. 17-22, 32

*Leptaena sericea* Sowerby. Murchison's Sil. Sys., 1839, pl. 19, figs. 1, 2.

The forms from the Trenton of Michigan vary from semi-oval to quadrate. In some forms the hinge line is extended but in others the greatest width of the shell is across the middle. The costellae are of unequal strength but all are fine. In some specimens strong oblique wrinkles are just anterior to the posterior margin, but in others the wrinkles are weak. In some individuals blunt spines are found on the costellae. Anterior margin often roughened by crowded lamellae. This species is abundant throughout the Trenton at all localities.

### GENUS CYCLOSPIRA HALL

**CYCLOSPIRA BISULCATA** (Emmons)

Plate X, Figs. 20, 23

*Orthis bisulcata* Emmons. Geol. New York, Rep. 2nd Dist., 1842, p. 396, fig. 4.

Shell small, profile biconvex, ventral valve deep with a shallow mesial sinus usually extending more than half the length of the valve but in some individuals present only near the front. Sinus bordered on each side by a well-defined ridge. Dorsal valve with a shallow sinus divided into two parts near the front by a broad, flat ridge. Beak of ventral valve curved over that of the dorsal valve. Surface covered with fine radiating lines. A few weak growth lines are present.

Trenton at Chandler Falls and Cornell.

### Genus STROPHOMENA Blainville

**STROPHOMENA FILITEXTA** Hall

Plate IV, Figs. 5, 6, 7, 9

*Strophomena filitexta* Billings. Canadian Nat. Geol., 1, 1856, p. 203, figs. 1, 2.

Many well preserved interiors and exteriors of this form are found in the Trenton rocks of Michigan. The muscle scars are well defined and on the ventral valve they vary from oval to nearly circular. The papillae on the interior of the ventral valves are often numerous and crowded, and are arranged in radiating rows separated by shallow grooves. The hinge line is slightly wider or considerably wider than the greatest width across the middle of the shell.

Lower Trenton, Bony Falls, Cornell, and Chandler Falls.

## Phylum MOLLUSCA

### Class Pelecypoda Goldfuss

**WHITELLA** sp. aff. **PRAECIPTA** Ulrich

Plate VI, Figs. 10, 11

*Whitella praecipta* Ulrich. Amer. Geol., 6, 1890, p. 386. Geol. Minn., 3, pt. 2, 1894. p. 574, pl. 41, figs. 15, 16.

Shell elongate-oval in outline. Anterior end narrowly rounded. Pallial line faint, running parallel with margin. Umbonal ridge slightly angular. Only one specimen of this pelecypod was found and it is preserved as a cast of the interior.

Trenton, Chandler Falls member in the conglomerate zone at Cornell.

### Genus CLEIDOPHORUS Hall

**CLEIDOPHORUS HAYESI** n. sp.

Plate IX, Fig. 10

Shells all very small, about 4 or 5 millimeters in length. Shape of valves sub-elliptical with moderately strong convexity. Anterior end more narrowly rounded than posterior end. Furrow deep, extending more than half way to the basal margin.

Beaks moderately prominent situated about one-third of the distance towards the anterior end.

Not as elongate-elliptical as *C. neglectus* and posterior end is more broadly rounded.



Occurs in great numbers in certain layers near the top of the Bill's Creek shale in the section exposed along the west side of the Stonington Peninsula and the east side of Little Bay de Noc.

**CLEIDOPHORUS NOQUETTENSIS** n. sp.

Plate IX, Fig. 15

Shells very small, about 3 to 5 millimeters in length. Anterior end strongly rounded, nasute. Posterior end strongly, evenly rounded. Dorsal margin straight, sloping strongly downwards from just back of beak. Basal margin broadly rounded, sloping up strongly to the anterior end. Furrow strong, extending over half the distance to the basal margin.

Differs from *C. hayesi* in the curvature of the anterior end and in the strong downward slope of the dorsal margin posterior to the beak.

Very abundant in certain layers near the top of the Bill's Creek shale in section exposed along the west side of the Stonington Peninsula and the east side of Little Bay de Noc.

### Genus VANUXEMIA Billings

**VANUXEMIA CALVERI**, sp. nov.

Plate VII, Figs. 18, 20, 21

Shell moderately large, ventricose. Umbones prominent, blunt, concave on the inner sides. Beaks widely separated. Anterior end short, blunt, extending but a short distance in front of the beaks. Posterior end strongly rounded. Ventral margin broadly, evenly rounded. Anterior muscle scars small, well-defined, excavated out of the anterior margin of the hinge plate. Posterior scars large, faintly impressed.

Trenton. Bridge at Cornell, conglomerate zone.

### Genus WHITELLA Ulrich

**WHITELLA EARDLEYI** Hussey

Plate VII, Figs. 4-5

Shell small, oblique, elongate. Anterior end extended only slightly in front of the beaks, curving very gradually into the ventral margin. Umbones broad, prominent. The strong umbonal ridge, slightly rounded near the beaks, extends almost to the posterior extremity. Hinge line short, extending less than half the length of the shell. Surface markings, where preserved, consist of low, rather widely spaced ridges.

Trenton. Common at several localities, especially at Rapid River and the quarry at Groos.

## *Class* GASTROPODA

### GENUS LIOSPIRA Ulrich and Scofield

**LIOSPIRA BACHMANNI** sp. nov.

Plate VII, Figs. 16, 19

Shell large, low spired, three volutions preserved. Periphery of last volution sharply angular; periphery of other whorls less angular. The slope above the periphery towards the suture is flat or very slightly concave. A low ridge borders the deeply impressed suture. The shell below the periphery slopes strongly and evenly towards the umbilicus, which is moderately large.

Trenton. Towards top of quarry at Groos.

### GENUS FUSISPIRA HALL

**FUSISPIRA NOBILIS** Ulrich and Scofield

Plate VI, Figs. 12, 14

*Fusispira nobilis* Ulrich and Scofield. Geol. Minn., 3, Part 2, 1897, p. 1078, pl. 80, figs. 2-4.

The thinness of the shell, which is partly preserved on a specimen from St. Joseph Island, is one of the characteristics that distinguishes this species from *F. schucherti.* Three prominent revolving lines are preserved on the living chamber.

Commonest in the lower part of the conglomerate zone at Chandler Falls and the bridge at Cornell. Found at Gravel Point on St. Joseph Island.

### GENUS BUCANIA HALL

**BUCANIA BUCKWALTERI**, sp. nov.

Plate VII, Figs. 10-11

Shell moderately large, high. Slit band bordered on each side by a delicate ridge. On either side of the band the surface is covered by a sharply defined network, with the meshes arranged in rows running in two main directions; one row runs across the volutions somewhat obliquely; the other runs at a strongly oblique angle backward and inward towards the slit.

Trenton. Bridge at Cornell. Conglomerate horizon.

### GENUS HOLOPEA HALL

**HOLOPEA WEAVERI** Hussey

Plate VIII, Figs. 16, 17

Shell large, low-spired, volutions expanding rapidly. Top of the last whorl very slightly rounded, flattened in places, sloping down to the suture, which is deeply impressed in the cast. Sides of the last whorl broadly convex. Umbilicus very small.

Trenton. Conglomerate horizon. Trenary, Michigan.



### GENUS MACLURITES ULRICH AND SCOFIELD

**MACLURITES CUNEATA** Whitfield

Plate I, Figs. 4-5

*Maclurea cuneata* Whitfield. 1878, Ann. Rep. Geol. Surv. Wis., p. 75. 1882, Geol. Wis., Vol. 4, p. 246, pl. 9, figs. 5-6.

Interior casts of *Maclurites cuneata* look very much like those of *Maclurites manitobense.* The latter is usually a large species whereas *M. cuneata* is rarely more than 3 inches in diameter and the umbilical opening is small.

Chief localities in Michigan are Chandler Falls and north of the bridge at Cornell. Found only above the conglomerate zone, and at Chandler Falls chiefly in the limestone at the top of the section. No. 12093, Museum of Paleontology, University of Michigan.

**MACLURITES BIGSBYI** Hall

Plate I, Figs. 6-7

*Maclurea bigsbyi* Hall. 1861, Geol. Rep. Wis., p. 37; Whitfield, 1882, Geol. Wis., Vol. 4, p. 222, pl. 6, figs. 17 and 18.

The lower surface is flat and the outer edge is angular. Umbilicus large, descending abruptly, and exposing at least half of the inner whorls. This species may be distinguished from *Maclurites crassus* by the flat lower surface and the thinner shell. A slab was found at Chandler Falls with 30 specimens of this species firmly embedded in the argillaceus limestone that has fallen from the top of the cliff along the west side of the Escanaba River. All were preserved with their flat sides up.

Found chiefly at Cornell and Chandler Falls, in the argillaceous limestone at the top of the section.

### GENUS MACLURITES LESUEUR

**MACLURITES CRASSUS** (Ulrich and Scofield)

Plate I, Figs. 1-3

*Maclurites crassus* has a heavier shell than *Maclurites bigsbyi* and the inner whorls are convex and slightly elevated on the under side. The umbilical depression is also wider. Casts of the interior show these differences especially well. The whorls of *M. crassus* are more rounded in cross section, especially on the lower side.

The umbilical opening is so large that almost the entire width of the inner whorls is visible. The shell is very thick.

Found above the bridge at Cornell in the argillaceous limestone at the top of the section.

### Genus HYOLITHES Eichwald

**HYOLITHES** sp.

Plate VII, Fig. 13

No complete specimens of *Hyolithes* have been found in the Trenton rocks of the Escanaba area but fragmentary specimens are fairly common in exposures of hard dolomite along the Ford River, two miles southeast of Hyde, in Delta County, Michigan. Other fossils are not as abundant at this locality as they are in the shaly parts of the Trenton at Cornell and Chandler Falls.

At least two species of *Hyolithes* are found in the rocks of the Ford River. In one the cross section is "pear-shaped" or triangularly elliptical. The longest diameter of this cross section measures 12mm. and the short diameter 9 mm. Another specimen, which is somewhat crushed, has one flattened side and one that is slightly convex. Transverse striae run completely around the shell. These striae are of unequal size, unequally spaced, and are slightly arched towards the aperture.

Trenton, in the hard dolomite of the Ford River locality.

## Phylum ARTHORPODA

### *Class* CRUSTACEA

### *Subclass* TRILOBITA

### Genus ILLAENUS Dalman

**ILLAENUS AMERICANUS** (Billings)

Plate V, Fig. 23

*Illaenus crassicauda* Hall. Pal. New York, 1, p. 24, pl. 4 (bis), fig. 13.

Thorax with 10 segments. Axial lobe moderately convex, narrowing from a width of 19 mm. at the enterior end to 15 mm. at the posterior end. The cephalon is short, the eyes small and widely separated.

Cephalons and pygidia are fairly common in the Chandler Falls member of the Trenton in Escanaba River area, in the conglomerate horizon and for a few feet above this horizon. At Cornell and Chandler Falls.



### Genus BUMASTUS

**BUMASTUS TRANSVERSALIS** Weller

Plate VIII, Fig. 3

*Illaenus trentonensis* Emmons. 1842, Geology of New York; Rept. 2nd Dist., p. 390, fig. 3.

The specimen from St. Joseph Island has nine thoracic segments instead of eight as in the original described by Emmons. Specimens from other localities have nine and some ten segments. Enrolled individuals appear to be commoner than extended ones. No longitudinal lobation can be observed on the cephalon or pygidium. Axial furrows are present along the sides of the thorax.

Trenton. St. Joseph Island and Chandler Falls, Escanaba River, Michigan.

### Genus AMPHILICHAS Raymond

**TETRALICHAS STAEBERLI**, sp. nov.

Plate VII, Figs. 1-3

Glabella very convex, with the middle lobe strongly elevated above the lateral ones. Posterior slope of the middle lobe straight, except for a slight concavity about one-third of the distance down the slope. Curvature of the anterior slope of the middle lobe abruptly downward from about the mid-point. Slopes of the lateral lobes from front to back moderately convex, steepest in front. Palpebral lobes low, separated from the lateral lobes by a furrow that is nearly parallel to the furrow separating the central from the lateral lobes. Neck furrow well-developed. Surface covered with pustules of various sizes, with the largest ones quite numerous and prominent.

The middle lobe of the glabella is lower with relation to the lateral lobes than in *Amphitichas cucullus;* the anterior slope of the middle lobe is more abruptly rounded, and the curvature of the lateral lobes is less convex.

Trenton. Conglomerate zone. Trenary, Michigan.

### Genus HEMIARGES

**HEMIARGES PAULIANUS** (Clarke)

Plate 9, Fig. 14

The median lobe of the cephalon broadens towards the anterior end. The lateral lobes are separated from the median one by prominent furrows. The cephalon is covered with numerous rounded tubercles of variable size.

Abundant in the Chandler Falls member of the Trenton in the Escanaba River area at Chandler Falls and Cornell.

Trenton. Hull.

### GENUS ISOTELUS DEKAY

**ISOTELUS GIGAS** Dekay

Plate VIII, Figs. 1, 12

*Isotelus gigas* Dekay. 1924, Ann Lyc. Nat. Hist. New York, Vol. 1, p. 176, pl. 13, figs. 1, 2.

This species is common in the Trenton rocks of Michigan and on St. Joseph Island. Some of the specimens are preserved with the hypostome still in place. Fragments are exceedingly abundant on some of the layers in the upper part of the Bill's Creek beds. A single pygidium from the Groos Quarry member of the Trenton of the Escanaba River area, found near the town of Rapid River, Michigan, measures 10 inches across at the widest part.



## Bibliography


Case, E. C. and Robinson, W.I. Geology of Limestone Mountain. Michigan Geological and Biological Survey. Publication 18, Geological Series 15. pp. 167-181. 1915.

Ehlers, G. M. An Ordovician Reef on Sulphur Island, Lake Huron. Michigan Academy of Science, Arts, and Letters. Vol. IV, 1924.

and R. Ruedeman. Occurrence of the Collingwood Formation in Michigan. Contributions from the Museum of Geology. University of Michigan. Vol. II, No. 2, pp. 13-18. 1924.

Foerste, A. F. Upper Ordovician Formations in Ontario and Quebec, Canada. Department of Mines. Geological Survey. Memoir 83. No. 70, Geological Series.

Hall, James. Lower Silurian System. Report of the Geology of the Lake Superior Land District, J. W. Foster and J. D. Whitney. Part II. The Iron Region together with the General Geology. pp. 140-151. 1851.

Hussey, R. C. The Richmond Formation of Michigan. Contributions from the Museum of Geology, University of Michigan. Vol. II, No. 8. pp. 113-187. Plates. 1926.

———Cystoids from the Trenton Rocks of Michigan. Contributions from the Museum of Paleontology. University of Michigan. Vol. III, No. 4, pp. 77-79. 1926.

———The Trenton and Black River Rocks of Michigan. State of Michigan Geological Survey Division. Publication 40. Geological Series 34. Part III. 1936.

———New Species of Fossils from the Middle Ordovician of Michigan. Papers of the Michigan Academy of Science, Arts, and Letters. Vol. XXVI. 1940.

Kay, G. Marshall. Stratigraphy of the Decorah Formation. Contributions of the Department of Geology, Columbia University. Vol. 42, No. 4. Reprint from Journal of Geology, Vol. XXXVII, No. 7, October-November 1929.

———Ordovician Stewartville-Dubuque Problems. Journal of Geology. Vol. XLIII, No. 6, August-September 1935.

———Stratigraphy of the Trenton Group. Bulletin of the Geological Society of America. Vol. 48, pp. 233-302. 1937.

Rominger, Carl. 1873. Paleozoic Rocks. Michigan Geological Survey.

Wilson, Alice E. Rafinesquina and its Homomorphs Opikina and Opikinella. From the Ottawa Limestone of the Ottawa-St.Lawrence Lowlands. Transactions of the Royal Society of Canada. Third Series, Vol. XXXVIII, Section IV. 1944.

———Strophomena and its Homorphs Trigrammaria and Microtrypa. From the Ottawa Limestone of the Ottawa-St. Lawrence Lowlands. Transactions of the Royal Society of Canada. Third Series, Section IV, Vol. XXXIX, 1945.

———Brachiopoda of the Ottawa Formation of the Ottawa-St. Lawrence Lowlands. Canada. Department of Mines and Resources. Geological Survey Bulletin. No. 8, 1946.

———Miscellaneous Classes of Fossils, Ottawa Formation, Ottawa-St. Lawrence Valley. Canada. Department of Mines and Resources. Geological Survey Bulletin. No. 11, 1948.

———Gastropoda and Conularida of the Ottawa Formtion of the Ottawa-St. Lawrence Lowlands. Geological Survey of Canada. Bulletin 17, 1951.

Ver Wiebe, Walter A. Stratigraphy in Chippewa County, Michigan. Papers of the Michigan Academy of Science, Arts, and Letters. Vol. 8. pp. 309-331. 1927.

Winchell, Alexander. First Biennial Report of Progress of the Geological Survey of Michigan. Chapters 3 and 4. 1861.

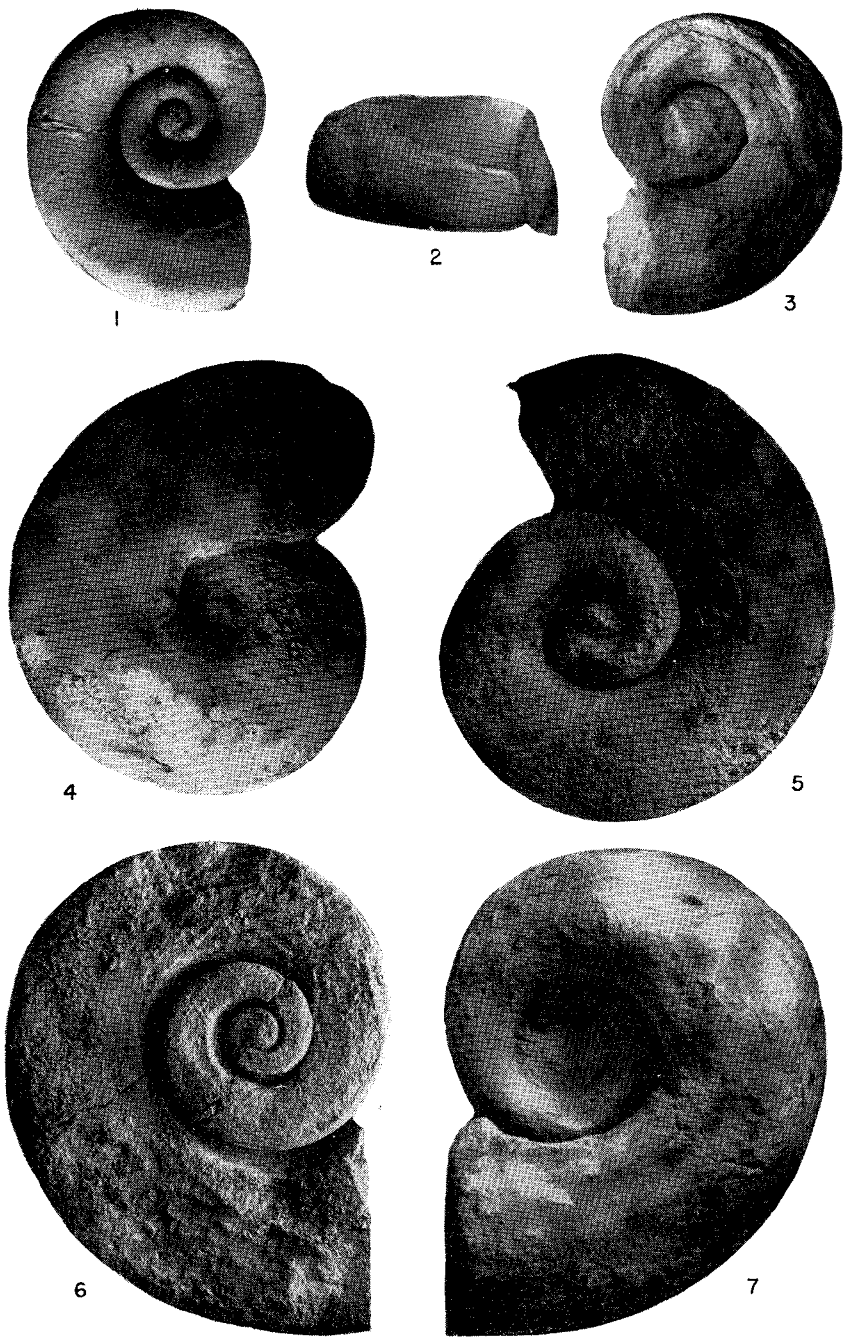



PLATE I



Explanation of Plate I

Figures 1-3. *Maclurites crassus* (Ulrich and Scofield). Trenton. Chandler Falls member.

Figures 4, 5. *Maclurites cuneata* Whitfield. Trenton. Upper part of Chandler Falls member.

Figures 6, 7. *Maclurites bigsbyi* Hall. Trenton. Upper part of Chandler Falls member.

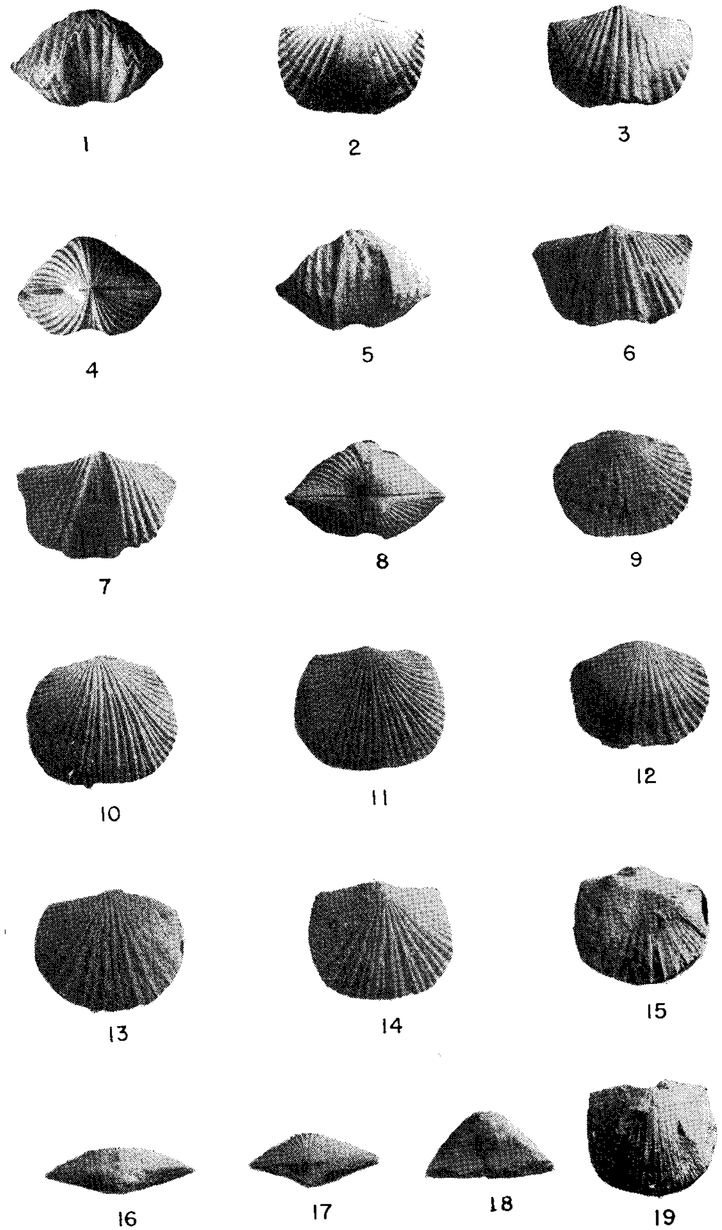


PLATE II



Explanation of Plate II

Figures 1-8. *Platystrophia trentonensis* (McEwan)

Figures 9, 12, 17. *Plesiomys meedsi* (Winchell and Schuchert)
9. Ventral valve
12. Dorsal valve

Figures 10, 11. *Plesiomys meedsi* (Winchell and Schuchert)
10. Dorsal valve
11. Ventral valve

Figures 13, 14, 16. *Plesiomys meedsi* (Winchell and Schuchert)
13. Dorsal valve
14. Ventral valve

Figures 15, 18, 19. *Hesperorthis tricenaria* Conrad.
15. Dorsal valve
19. Ventral valve

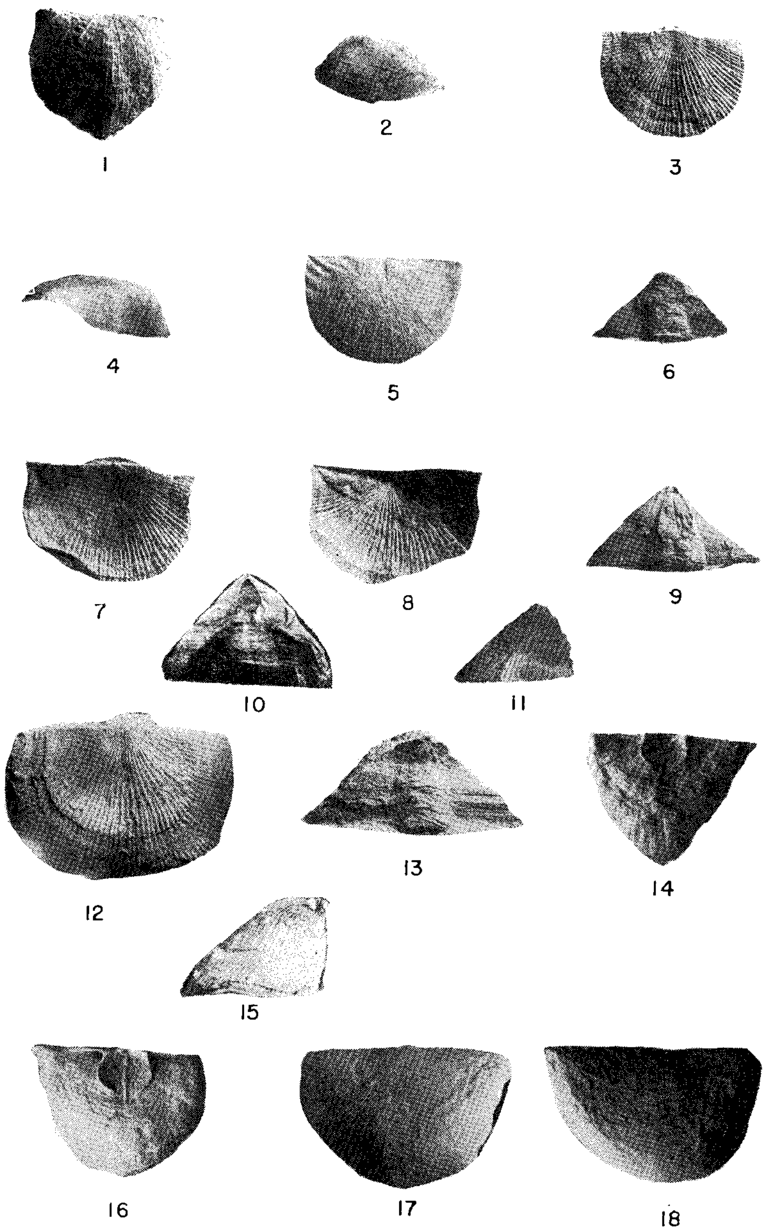



PLATE III



Explanation of Plate III

Figures 1, 2, 14. *Trigrammaria duchainei* n. sp. Trenton. Chandler Falls member.
1. Brachial valve
2. Side view of brachial valve
14. Interior of ventral valve assigned to this species.

Figures 3, 6, *Vellamo trentonensis* (Raymond). Trenton. Chandler Falls member.
3. Brachial valve
6. Palintrope

Figures 4, 17, 18. *Leptaena unicostata* (Meek and Worthen). Trenton Groos Quarry member.
4. Side view
17. Ventral valve
18. Mold of dorsal valve

Figure 5. *Rafinesquina* sp. Ventral valve. Trenton. Groos Quarry member.

Figures 7, 8, 9. *Vellamo trentonensis* (Raymond). Trenton. Chandler Falls member.
7. Dorsal valve.
8. Ventral valve.
9. Palintrope.

Figure 10. *Vellamo trentonensis* (Raymond). Trenton. Chandler Falls member.

Figure 11. *Vellamo trentonensis* (Raymond). Side view. Trenton. Chandler Falls member.

Figures 12, 13, 15. *Vallamo trentonensis* (Raymond). Trenton. Chandler Falls member.
12. Dorsal valve.
13. Palintrope.
15. Side view .

Figure 16. *Strophomena* sp. Ventral valve. Trenton. Chandler Falls member.

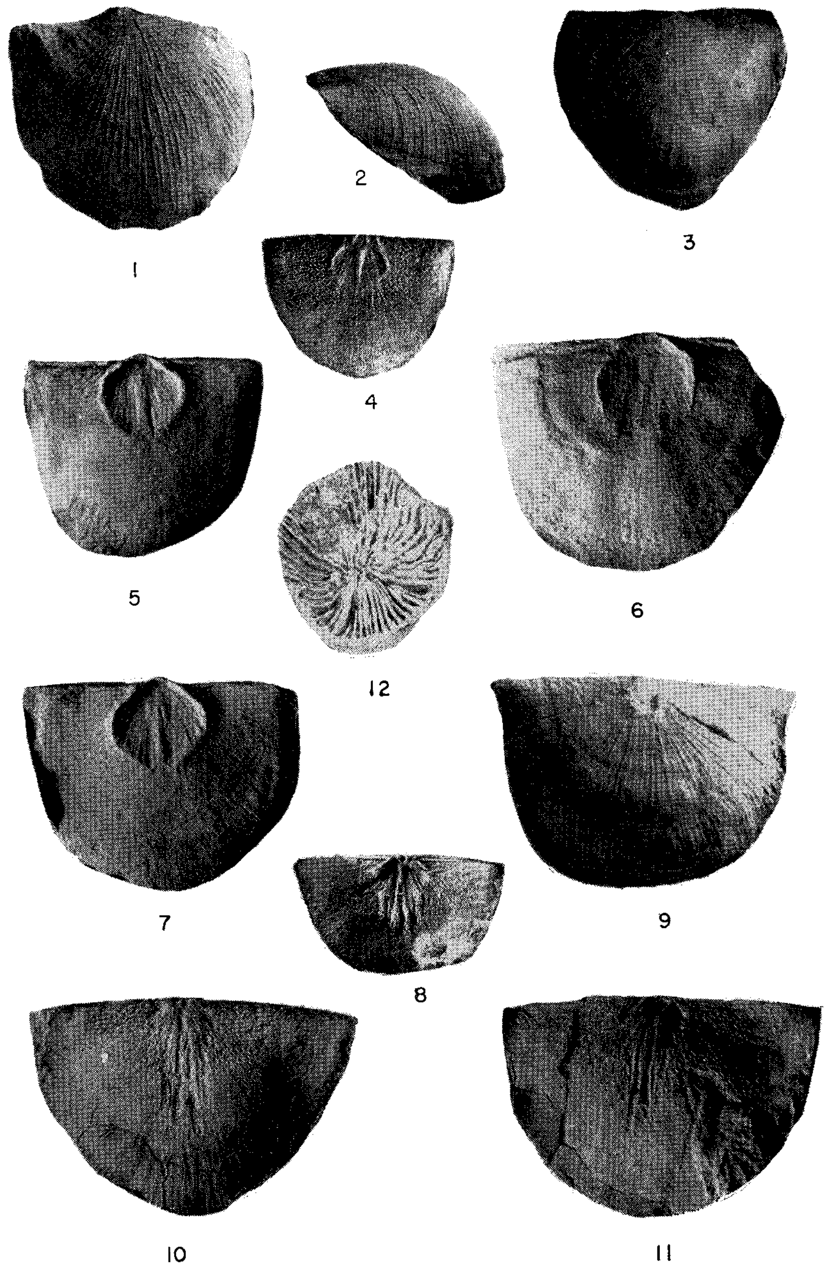



PLATE IV



Explanation of Plate IV

Figures 1, 2. *Rafinesquina deltoidea* (Conrad). Trenton. Chandler Falls member.
1. Ventral valve.

Figure 3. *Rafinesquina deltoidea* (Conrad). Trenton. Chandler Falls member. Ventral valve.

Figure 4. *Rafinesquina* sp. Dorsal valve. Trenton. Chandler Falls member.

Figures 5, 6, 7, 9. *Strophomena filitexta* Hall. Trenton. Chandler Falls member.
5, 6, 7. Ventral valves.
9. Dorsal valve.

Figures 8, 10, 11. *Microtrypa warmingtoni* n. sp. Trenton. Chandler Falls member. Brachial valves.

Figure 12. *Streptelasma* sp. Trenton. Chandler Falls member.

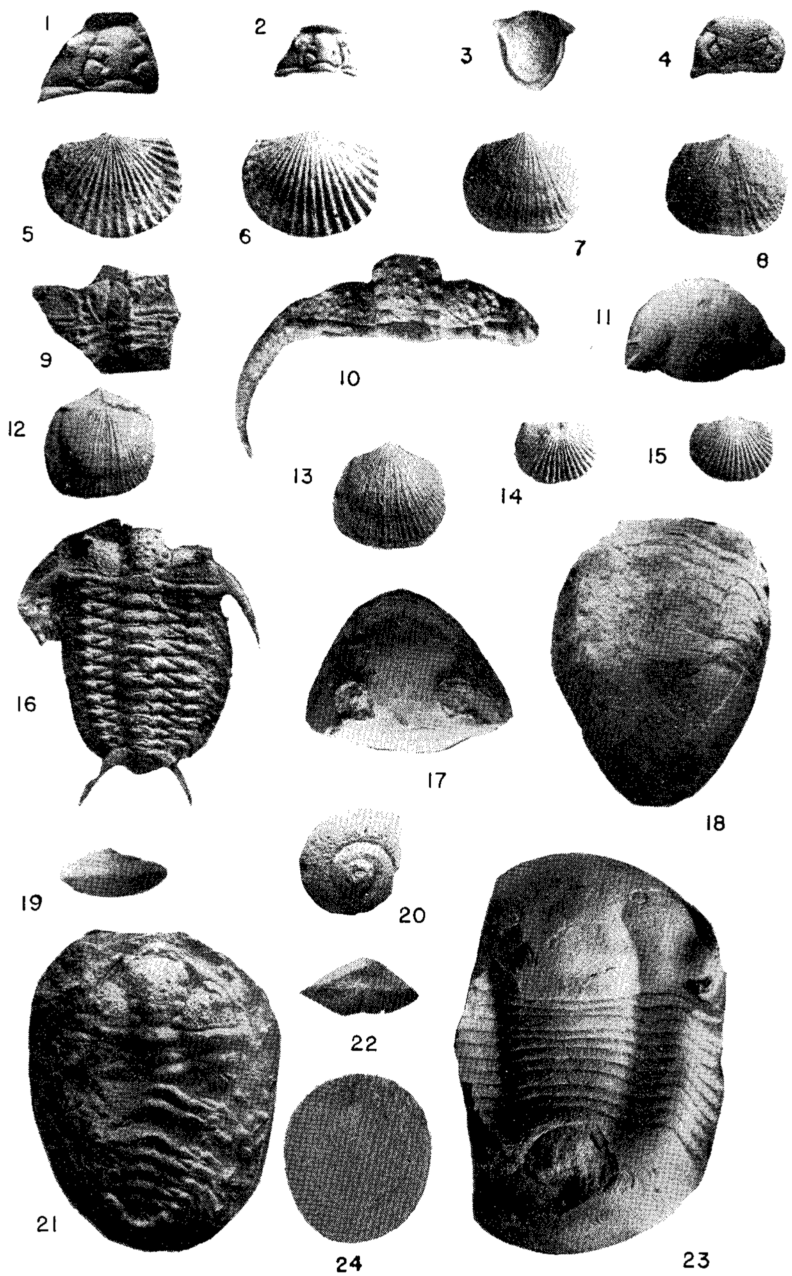


PLATE V



Explanation of Plate V

Figures 1, 2. *Flexicalymene senaria* (Conrad). Trenton. Chandler Falls member.

Figure 3. *Ceraurus* sp. Hypostome. Trenton. Chandler Falls member.

Figure 4. *Calliops callicephala* (Hall). Trenton. Chandler Falls member.

Figures 5, 6. *Plectorthis plicatella trentonensis* (Foerste). Trenton Chandler Falls member.
5. Dorsal valve.
6. Ventral valve.

Figures 7, 8, 22. *Glyptorthis bellarugosa* (Conrad). Trenton. Chandler Falls member.
7. Dorsal valve.
8. Ventral valve.
22. Hinge line view.

Figure 9. *Ceraurus* sp. Showing hypostoma in place. Trenton. Chandler Falls member.

Figure 10. *Ceraurus pleuexanthemus* Green. Trenton. Chandler Falls member.

Figure 11. *Thaleops ovatus* Conrad. Trenton. Chandler Falls member.

Figures 12, 13. *Glyptorthis bellarugosa* (Conrad). Trenton. Chandler Falls member.
12. Dorsal valve.
13. Ventral valve.

Figures 14, 15. *Plectorthis plicatella trentonensis* (Foerste). Trenton. Chandler Falls member.
14. Dorsal valve.
15. Ventral valve.

Figure 16. *Ceraurus pleurexanthemus* Green. Trenton. Chandler Falls member.

Figures 17, 18. *Isotelus gigas* Dekay. Trenton. Chandler Falls member.

Figures 19, 20. *Liospira* sp. Trenton. Chandler Falls member.

Figure 21. *Ceraurus pleurexanthemus* Green. Trenton. Chandler Falls member.

Figure 23. *Illaenus americanus* Billings. Trenton. Chandler Falls member.

Figure 24. *Crainops* (*Pholidops*) sp. Trenton. Chandler Falls member.

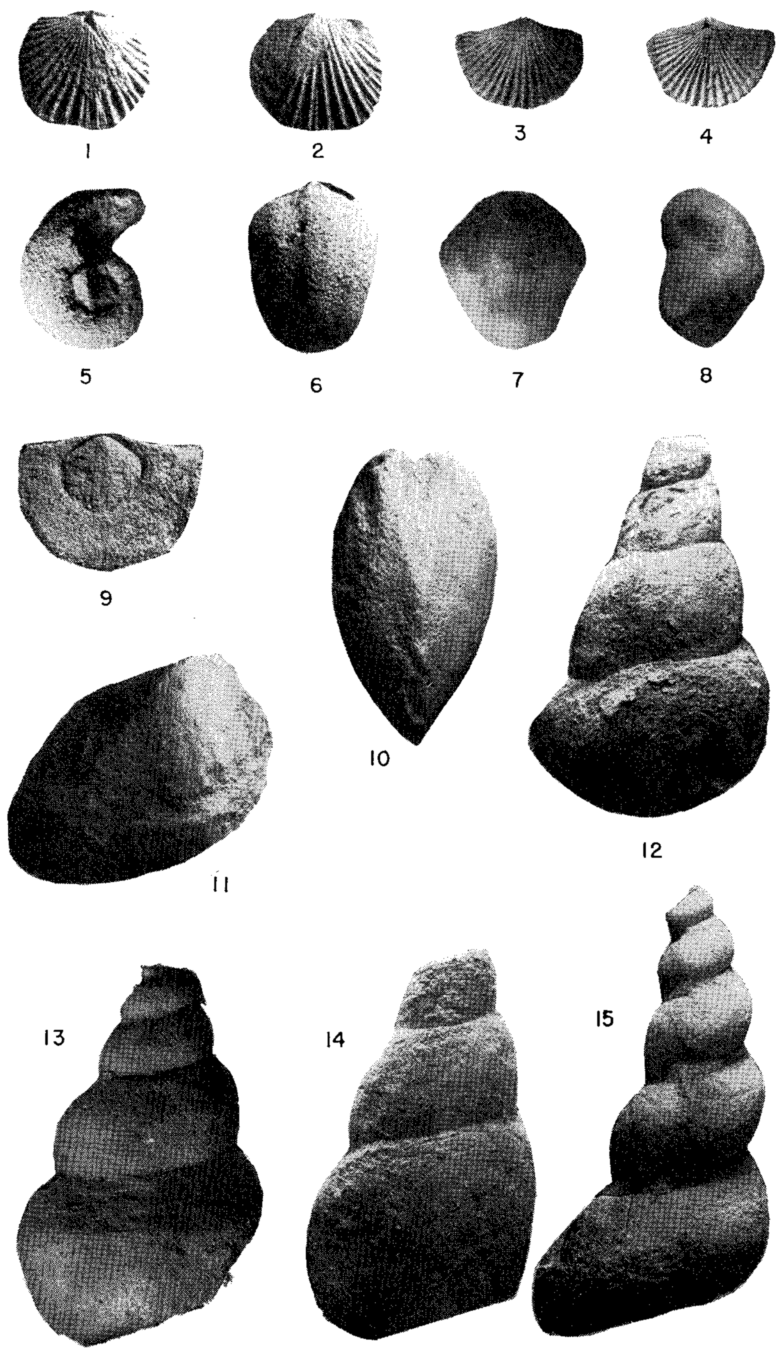



PLATE VI



## Explanation of Plate VI

Figures 1, 2. *Plectorthis plicatella trentonensis* Foerste. Trenton. Chandler Falls member.
1. Ventral valve.
2. Dorsal valve.

Figures 3, 4. *Hesperorthis tricenaria* Conrad. Trenton. Chandler Falls member.
3. Ventral valve.
4. Dorsal valve.

Figures 5, 6. *Tetranota bidorsata* (Hall). Black River. Bony Falls. Upper beds.

Figures 7, 8. *Tetranota bidorsata* (Hall). Trenton. Chandler Falls member.

Figure 9. *Strophomena incurvata* (Shepard). Mold of ventral valve. Black River. Bony Falls member.

Figures 10, 11. *Whitella* aff. praecipta Ulrich. Trenton. Chandler Falls member.

Figures 12, 14. *Fusispira nobilis* (Ulrich and Scofield). Trenton Chandler Falls member.

Figure 13. *Hormotoma* sp. Trenton. Chandler Falls member.

Figure 15. *Hormotoma trentonensis* Ulrich and Scofiield. Trenton. Chandler Falls member.

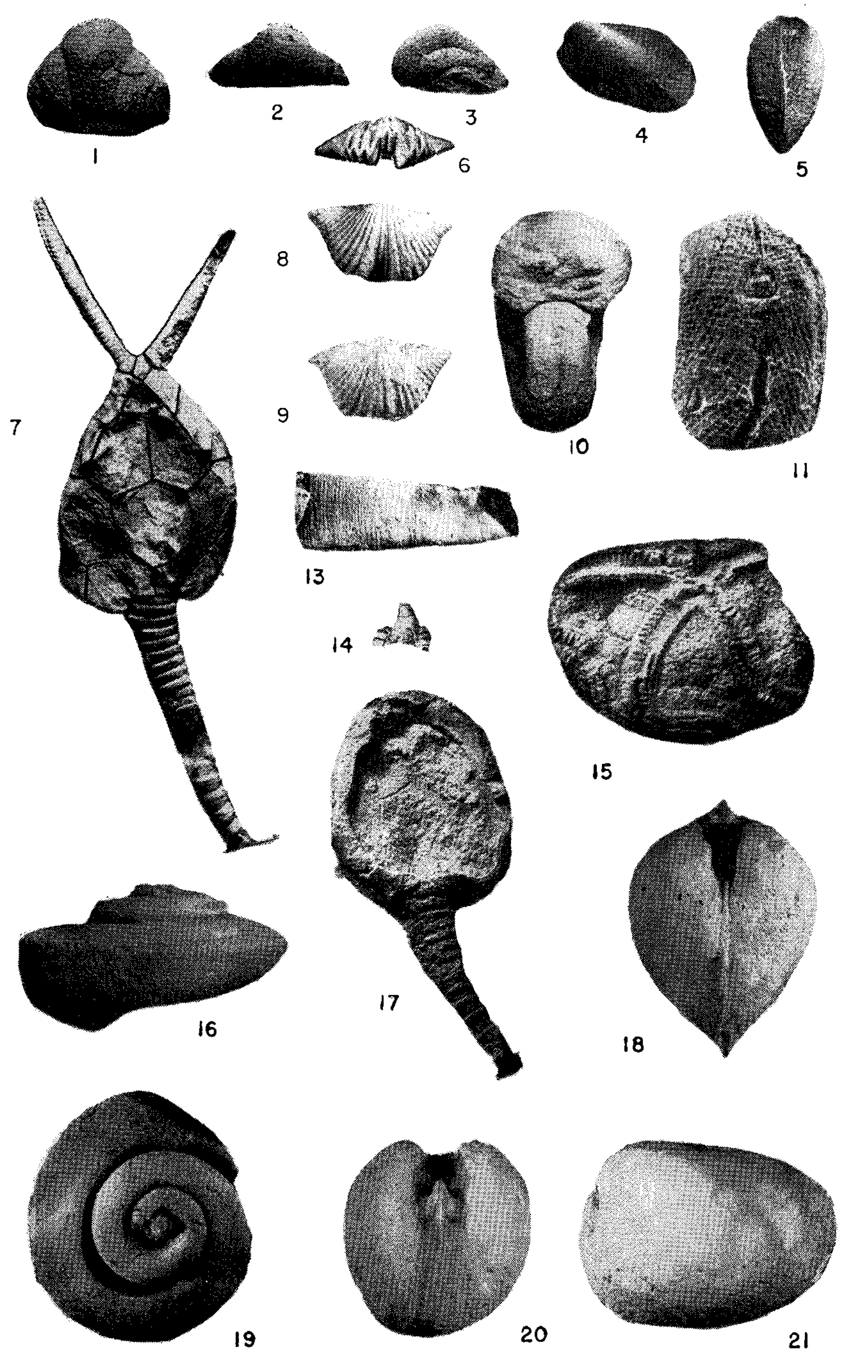



PLATE VII



Explanation of Plate VII

Figures 1-3. *Tetralichas staebleri* Hussey. Trenton. Chandler Falls member. Trenary, Michigan.

Figures 4, 5. *Whitella eardleyi* Hussey. Trenton. Groos Quarry member. Several localities.

Figures 6, 8, 9. *Platystrophia bowlesi* n. sp. Trenton. Chandler Falls member. Several localities including Neebish Channel cut.

Figure 7. *Pleurocystites squamosus* Billings. Antanal side. Sutures inked. Trenton. Chandler Falls member at Chandler Falls.

Figures 10, 11. *Bucania buckwalteri* Hussey. Trenton. Chandler Falls member.
11. Markings X2.

Figure 13. *Hyolithes* sp. Trenton. Groos Quarry member. Ford River locality.

Figure 14. *Bathyurus* (*Raymondites*) sp. Portion of glabella. Black River Bony Falls member. Bony Falls locality.

Figure 15. *Edrioaster bigsbyi* (Billings). Trenton. Chandler Falls member. at Chandler Falls.

Figures 16, 19. *Liospira bachmani* Hussey. Trenton. Groos Quarry member in the quarry at Groos, Michigan.

Figure 17. *Pleurocystites squamosus* Billings. Anal side. Trenton. Chandler Falls member at Chandler Falls.

Figures 18, 20, 21. *Vanuxemia calveri* Hussey. Trenton. Chandler Falls member at Cornell, Michigan.

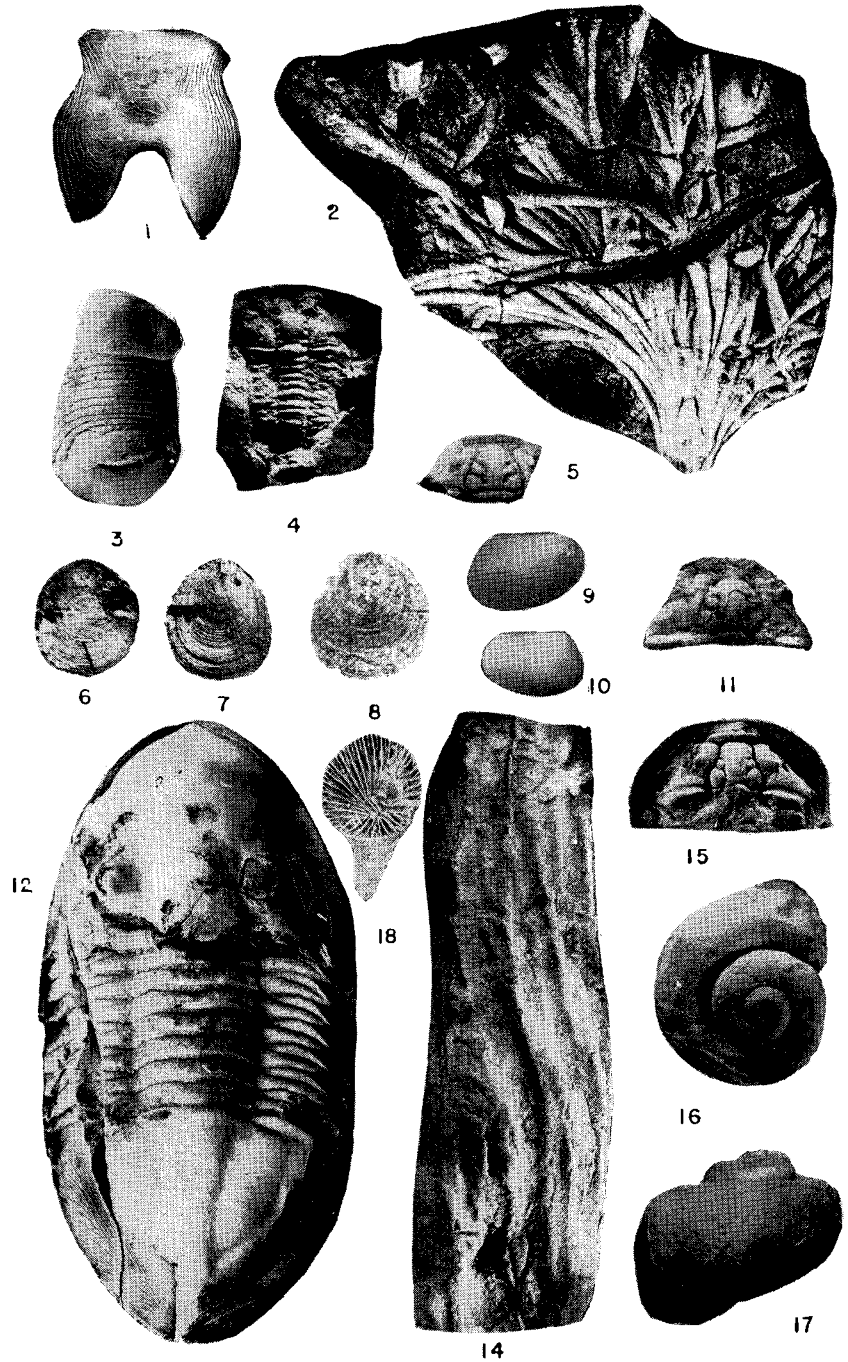



PLATE VIII



Explanation of Plate VIII

Figure 1. *Isotelus gigas* Dekay. Hypostoma. Trenton of St. Joseph Island.

Figure 2. *Phycodes circinatum* Rhein. Richter. (Licrophycus minor Billings.) Trenton. Chandler Falls member.

Figure 3. *Bumastus transversalis* Weller. Trenton. Lower part Chandler Falls member and Trenton of St. Joseph Island.

Figure 4. *Ceraurus pleurexanthemus* Green. Trenton. Lower part of Chandler Falls member at Chandler Falls and Cornell.

Figure 5. *Flexicalymene senaria* (Conrad). Trenton. Chandler Falls member.

Figures 6, 7. *Lingula changi* Hussey. From slabs of Collingwood shale in the drift near Newberry, Michigan.

Figure 8. *Lingula changi* Hussey. From the Bill's Creek beds exposed at the type locality on Bill's Creek.

Figures 9, 10. *Eoleperditia fabulites* Conrad. Common in the Trenton of St. Joseph Island. Found also in the upper beds at Bony Falls.

Figure 11. *Flexicalymene senaria* (Conrad). Trenton. Chandler Falls member.

Figure 12. *Isotelus gigas* Dekay. This specimen from Trenton of St. Joseph Island. Fragments common in upper part of Bill's Creek beds. Chandler Falls member of Cornell and Chandler Falls sections.

Figure 13. *Streptelasma corniculum* Hall. Trenton. Chandler Falls member.

Figure 14. *Aulacera undulata* (Billings). Richmond of Drummond Island, Michigan. Poe Point.

Figure 15. *Flexicalymene* sp. Trenton. Chandler Falls member.

Figures 16, 17. *Holopea weaveri* Hussey. Trenton. Chandler Falls member.

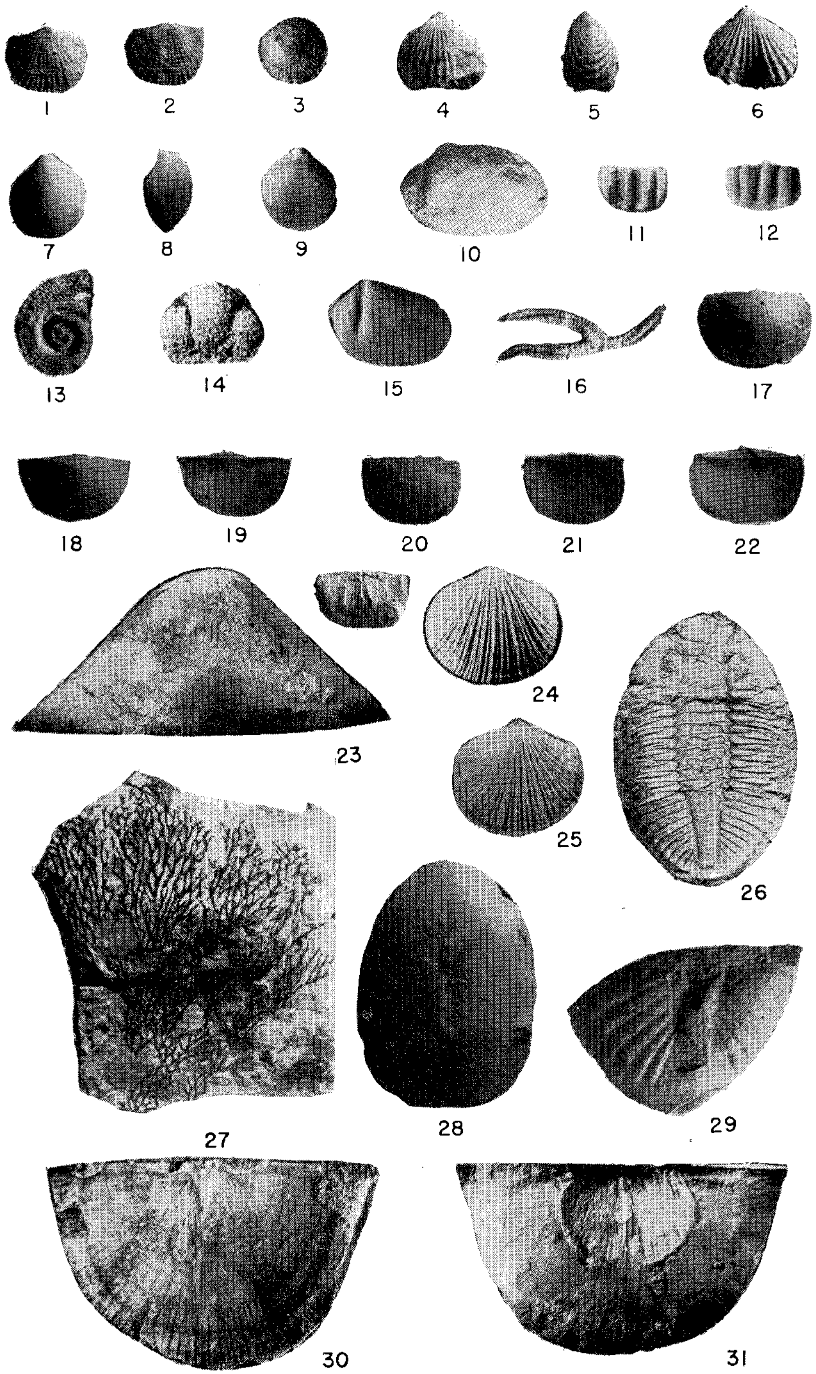



PLATE IX



## Explanation of Plate IX

Figures 1, 2. *Glyptorthis bellarugosa* (Conrad). Trenton. Chandler Falls member.

Figure 3. *Crania setigera* Hall. Trenton. Chandler Falls member.

Figures 4-6. *Rhynchotrema minnesotense* Sardeson. Trenton. Chandler Falls member at several localities.

Figures 7-9. *Catazyga uphami* (Winchell and Schuchert).

Figure 10. *Cleidophorus hayesi* n. sp. Bill's Creek beds.

Figures 11, 12. *Tetradella regularis* (Emmons). X 13. Bill's Creek beds. Upper part.

Figure 13. *Phragmolites* sp.

Figure 14. *Hemiarges paulianus* (Clark). X 2. Trenton. Chandler Falls member. Lower beds.

Figure 15. *Cleidophorus noquettensis* n. sp. Bill's Creek beds. Upper part of section.

Figure 16. Unidentified starfish. Trenton. Chandler Falls member. Lower beds.

Figures 17-22. *Sowerbyella sericea* (Sowerby).

Figure 23. *Prasopora orientalis* Ulrich. Trenton. Chandler Falls member. Common just below the conglomerate zone.

Figures 24, 25. *Resserella rogata* (Sardeson). X 2. Trenton. Chandler Falls member. Very abundant in lower part of section.

Figure 26. *Ogygites latimarginatus* (Hall). Collingwood. Manitoulin Island.

Figure 27. *Dictyonema* sp. Trenton. Groos Quarry member. Ford River locality.

Figure 28. *Pseudolingula* (*Lingula*) *iowensis* Owen. Trenton. Groos Quarry member. Groos Quarry locality.

Figure 29. *Ogygites* sp. Trenton. Groos Quarry member.

Figure 30. *Strophomena filitexta* Hall. Brachial valve. Trenton.

Figure 31. *Strophomena* sp. Pedicle valve. Trenton. Chandler Falls member.

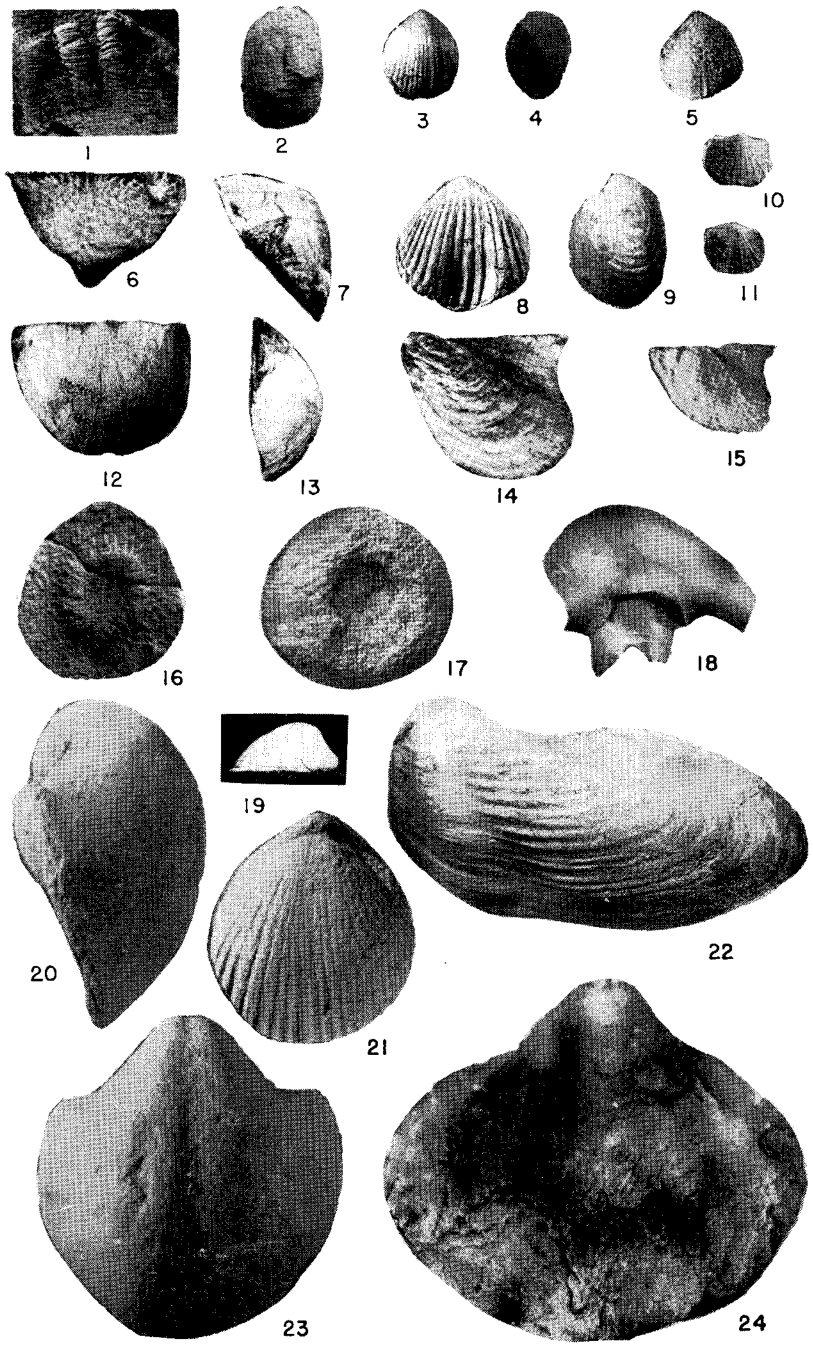



PLATE X



### Explanation of Plate X

Figure 1. *Cornulites flexuosis* (Hall). Trenton. Chandler Falls member. Lower beds.

Figure 2. *Pseudolingula* (*Lingula*) *iowensis.* Trenton Groos Quarry member.

Figures 3, 4, 5, 21. *Zygospira recurvirostris* (Hall) Trenton. Chandler Falls member. 3, 4 X 2. 21 X 4.

Figures 6, 7. *Trigrammaria stummi* n. sp. Trenton. Groos Quarry member. 6, dorsal valve. 7, side view. X 2.

Figures 8, 9. *Rhynchotrema* sp.

Figures 10, 11. *Glyptorthis bellarugosa* (Conrad). Trenton. Chandler Falls member. Lower beds.

Figures 12, 13. *Rafinesquina deltoidea* (Conrad) Trenton. Chandler Falls member.
12. Ventral valve.

Figure 14. *Pterinea aff. insueta* (Emmons). Bill's Creek beds.

Figure 15. *Pterinea* sp. Bill's Creek beds.

Figure 16. *Receptaculites* sp.

Figure 17. *Lichenocrinus* sp.

Figure 18. *Isotelus gigas* Dekay. Hypostoma.

Figure 19. *Archinacella* sp.

Figures 20, 23. *Cyclospira bisulcata* Emmons. X 5. Chandler Falls member.

Figure 22. *Cuneamya childsi* Hussey. Trenton. Groos Quarry member.

Figure 24. *Prasopora simulatrix* Ulrich. Trenton. Chandler Falls member. Lower beds.

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