STATE OF MICHIGAN
DEPARTMENT OF CONSERVATION
GEOLOGICAL SURVEY DIVISION

Publication 40. Geological Series 34.
OCCASIONAL PAPERS
ON THE
GEOLOGY OF MICHIGAN

PREPARED UNDER THE DIRECTION OF
R. A. SMITH, State Geologist

PUBLISHED AS A PART OF THE ANNUAL REPORT OF THE GEOLOGICAL SURVEY DIVISION FOR 1936.

Franklin DeKleine Company, Printers, Lithographers, Bookbinders, Lansing

Contents

PART III. THE TRENTON AND BLACK RIVER ROCKS OF MICHIGAN 1

Acknowledgements 1

Historical Review 2

General Distribution and Attitude of the Rocks..... 2

Relation of the Trenton to the Richmond..... 3

Detailed Descriptions of Sections 3

Black River 3
At Bony Falls, Delta County (Location 9).....3
At Trenary, Alger County (Location 26). 4
Near Spaulding, Menominee County (Locations 42, 85, 86).....5
At McFarland, Marquette County (Location 40).....5
At Lathrop, Delta County (Location 28). 5

Black River and Trenton..... 6
At Cornell, Delta County (Location 5). 6

Trenton 7
At Dam No. 2, Escanaba, Delta County (Location 8).....7
On Escanaba River, near Cornell, Delta County (Location 7).....8
At an abandoned Quarry southeast of Cornell, Delta County (Location 11).....9
Bed of Rapid River at Rapid River (Location 13).....9
Island in Escanaba River northeast of Groos Quarry (Location 12).....10
Ford River, Delta County (Location 19). 10
East of Bark River, Delta County (Location 22).....10
West of Perkins, Delta County (Location 25).....10
At Trunkline Bridge No. 64 across Whitefish River (Location 27).....10
Banks of Whitefish River (Location 29).....10
Near Masonville, Delta County (Location 31). 10
North of Bark River, Delta County (Location 1). 11
Near Wilson, Menominee County (Location 3).....11
Southeast of Schaffer, Delta County (Location 62).....11
West of Schaffer, Delta County (Location 63). 11
At Brampton, Delta County (Location 23).....11
Twelve and one-fifth miles northwest of Cornell in Marquette County (Location 14).....11
Northwest of Faunus, Menominee County (Location 51).....11
Bed of Days River, Delta County (Location 30).....11
Northwest of Cornell (Location 16).....11

Bibliography 11

List of Numbered Field Stations described in report, University of Michigan Expeditions of 1927-28. 12

List of Plates

Figure 1. *Black River rocks exposed at Bony Falls, Delta County (Location 9).*.....3

Figure 2. *Black River rock exposed along the railroad at Trenary, Alger County (Location 26).* 4

Figure 3. *Black River and Trenton exposed along the Escanaba River at Cornell, Delta County, Michigan. (Location 5)* 6

Figure 4. *Trenton Rocks exposed along the Escanaba River at Cornell, Delta County, Michigan. (Location 5, Zone 6).*...7

Figure 5. *Trenton Rocks exposed along the Escanaba River at Cornell, Delta County, Michigan.*.....7

Figure 6. *Trenton Rocks exposed along the Escanaba River at Location 7.*.....8

Figure 7. *Trenton Rocks exposed in the Groos Quarry (Location 10).* 9

Figure 8. *Trenton Rocks exposed in the bed and along the bank of the Rapid River at Rapid River, Michigan (Location 13).* 10

PART III. THE TRENTON AND BLACK RIVER ROCKS OF MICHIGAN

By
R. C. HUSSEY, PhD.
University of Michigan.

Published as a part of the annual report of the Michigan Geological Survey Division, Department of Conservation, for 1936

ACKNOWLEDGEMENTS

The writer is indebted to several persons for assistance in the preparation of this report. To Professor E. C. Case, who directed the investigation, for help in the field work and in the preparation of the manuscript. Many of the correlations proposed in this paper were suggested in field conferences by Dr. E. O. Ulrich whose wide knowledge of stratigraphic relations in different areas was of the utmost value in the work. To Dr. R. A. Smith, the State Geologist of Michigan, through whom the funds were made available for carrying on the field work.

HISTORICAL REVIEW

James Hall. "Report on the Geology of the Lake Superior Land District," Foster and Whitney, Part Two, 1851. Pages 140-151. The most valuable part of this report is that dealing with the Ordovician section exposed along the Escanaba River. A general description of the rocks is given beginning at the mouth of the river and extending for several miles along the meanders of the stream. The changing attitude of the beds and lithologic and faunal differences were noted. Fossils were collected at numerous points along the river and these enabled Hall to correlate the beds with the typical New York section; the Chazy, Birdseye, Black River and Trenton horizons were recognized. It is easy to recognize today, from Hall's descriptions, several of the important points that were studied. The Trenton limestone exposed near the mouths of Rapid River and Ford River are briefly described and correlated with equivalent exposures along the Escanaba. The Ordovician rocks exposed along the lower course of the Menominee River and the eastern shore of Green Bay are briefly discussed. The report is very valuable because it outlines for the first time the general succession of Black River and Trenton rocks in Northern Michigan.

Alexander Winchell. "First Biennial Report of Progress of the Geological Survey of Michigan". 1861. Chapters 3 and 4 are devoted to a "General Sketch of the Geology of Michigan and its Connection with Surrounding Districts". A short discussion of the Trenton is given on pages 52-53, in which the following paragraph appears: "The Trenton Group forms a belt about 4 miles wide extending west-northwest across St. Joseph's Island, reappearing in the high bluffs opposite Little Sailor Encampment Island, and extending thence across the middle of Great Sailor Encampment Island. From here it stretches west in a gradually widening belt, which, bending around to the southwest, lies with its southern border on the west shore of Little Bay de Noquet and Green Bay, whence it continues across Wisconsin into northern Illinois".

Dr. Carl Rominger. "Paleozoic Rocks", published by the Michigan Geological Survey in 1873. Pages 58-71. Dr. Rominger examined in particular the rocks exposed on St. Joseph's Island, along the Escanaba River, and on the west branch of the Whitefish River. The paper deals with the Trenton in a very general way and no detailed sections are described. The rocks along the Escanaba River were studied for several miles above the mouth of the stream and the general succession of beds was determined together with the important lithologic changes. Fossils were collected at several localities and several faunal lists are given. The numerous broad undulations in the rocks along the river were noticed as well as the general southeasterly dip of the beds. The total thickness of the Escanaba River section was estimated at about 100 feet.

E. C. Case and W. I. Robinson. Michigan Geological and Biological Survey. Publication 18, Geological Series 15. Pages 167-181. "The Geology of Limestone Mountain and Sherman Hill in Houghton County, Michigan".

In this paper the authors describe the geology and paleontology of three outliers of Paleozoic rocks lying half a mile east of the village of Hazel, Michigan. The generalized section includes rocks of Black River, Trenton, and Richmond age. The Upper Buff, Upper Black River, Upper Blue and Decorah of the Limestone Mountain section are represented by the same formations along the Escanaba River. Faunal lists are given for the various horizons.

GENERAL DISTRIBUTION AND ATTITUDE OF THE ROCKS

The principal outcrops of Black River and Trenton rocks in the Northern Peninsula of Michigan are found within a belt about 20 miles wide extending in a general northeasterly direction past the towns of Escanaba and Rapid River, with the eastern edge of the belt bordering the western side of Little Bay de Noc. The rock is close to the surface over the whole region but glacial drift and wooded areas cover it in most places. North and east of the town of Trenary the country becomes swampy and outcrops are exceedingly rare although the beds are apparently continuous beneath the surface and reappear at the eastern end of the peninsula on Drummond Island. A number of exposures are in shallow ditches along the roads but show only the upper surface of the rock. Typical fossils fortunately are found at most of the places and the beds may be placed in their proper stratigraphic positions. Very excellent outcrops are afforded by a few quarries where the rock may be studied in great detail. The best section is found in Delta County along the Escanaba River. Up stream from about 2 miles above the mouth of the river the rocks are almost continuously exposed for 20 miles along the meanders of the stream. The river flows over rock for the entire distance. The general dip of the beds is down stream or southeastward although in many places local dips are northwestward. In general stratigraphically lower beds appear upstream, but the same beds may reappear at several places along the river due to the numerous undulations in the rock. These flexures are probably the result of deposition upon an uneven sea bottom and to settling of the sediment after deposition. The nature of the bottom upon which the early Paleozoic sediments were deposited may be inferred from a study of the pre-Cambrian surface wherever it is exposed in Northern Michigan. This surface is always irregular and could easily account for many of the undulations in the Ordovician rocks along the Escanaba River and for the flexures in the beds of the Richmond formation above the Trenton.

RELATION OF THE TRENTON TO THE RICHMOND

The contact between the Trenton and the Richmond is not exposed at any of the known localities. The lowest member of the Richmond formation in Michigan is the thin-bedded, dark brown, Bill's Creek shale, described by the author in a paper on "The Richmond Formation of Michigan".[1] This shale has been correlated with the Maquoketa. The highest observed member of the Trenton is an uneven-bedded, argillaceous and dolomitic limestone. The Bill's Creek shale is exposed along Haymeadow Creek, about 10 miles northeast of Rapid River, Delta County, Michigan, and the Trenton limestone is found along the Whitefish River about a mile and a half west of the shale outcrop on the edge of the Hiawatha National Forest. The dip of the rocks in both places is very flat and the covered interval between the base of the Richmond and the top of the Trenton cannot be very great, probably not more than 5 feet. It is altogether probable that the Bill's Creek beds rest directly upon the Trenton although the exact nature of the contact is in doubt. However, it is reasonably certain that the contact is a disconformable one.

[1]Contributions from the Museum of Geology of the University of Michigan. Vol. 2, No. 8. July 15, 1926.

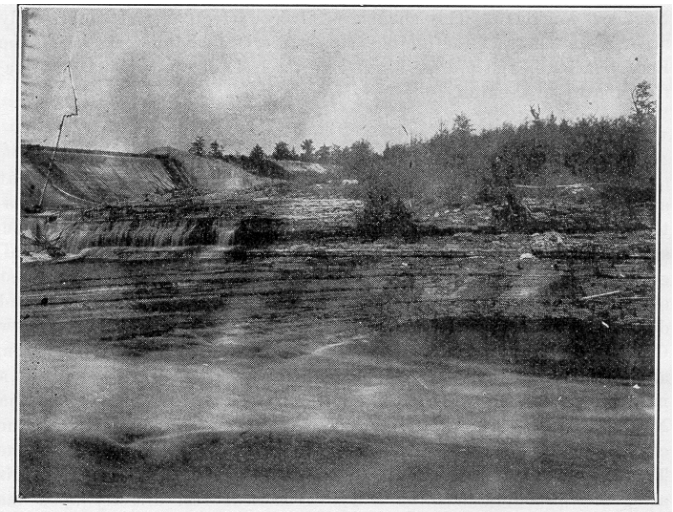

Figure 1. Black River rocks exposed at Bony Falls, Michigan. Location 9.

DETAILED DESCRIPTIONS OF SECTIONS

Black River

Exposure at Bony Falls (Loc. 9), Section 1, T. 41 N., E. 24 W., Delta County.

The Escanaba River at Bony Falls (Fig. 1) formerly tumbled over a ledge of rock and formed a waterfall about 30 feet high. The construction of a hydro-electric power plant diverted the water from the eastern part of this escarpment and produced an excellent exposure of the Black River. The rock at this location is stratigraphically the lowest part of the Black River section exposed along the river. The beds are nearly horizontal with a slight dip to the southeast. Above the dam the banks of the stream are low and muddy with no outcrops; below the dam the rocks are exposed in the vertical banks of the river for 200 yards. Outcrops are seldom found any distance back from the river because of the soil covering and the wooded nature of the country.

Top of section	Feet	Inches
10. Limestone, argillaceous, buff colored. Equivalent to the Upper Buff of Wisconsin.	2	0
9. Limestone, relatively pure, fine grained, laminated beds, with irregular partings of sandy interlaminations. Top layer thickest, with irregular contact with zone 10. *Columnaria halli*.	4	0
8. Resembles zone 9, but lower in magnesium; moderately fine grained, weathers with rough upper surface. Very fossiliferous. Fucoid in lower part. Mississippi Valley type of Platteville this far down in the section.	0	21
7. Pure limestone, similar to zone 8. Many crinoid columns. First appearance of normal form of *Orthis tricenaria*.	3	0
6. Limestone similar to that in zone 7 but with abundant Fucoid. *Stromatocerium ruyosum* (Black River of New York form). Lower one foot contains long forms of *Strophomena incurvata* (Lowville of New York forms).	2	0
Unconformity due to subaerial erosion. Much missing.		
5. Irregularly bedded limestone, upper surface pitted, planed off across the pits or borings. Fauna as in zone 6. Many crinoid columns. *Solenopora* sp. in top 2 feet. Typical Lowville ends here. Bentonite layer at top.	5	0
4. Argillaceous limestone in layers 2 to 8 inches thick, with very irregular lower surface. Intraformational conglomerate. Ripple marks of oscillating type just below conglomerate.	8	0
3. Fine grained, gray, argillaceous limestone, irregularly bedded. Nodular surface as above.	6	0
2. Highly magnesian, blue, mostly fine grained, finely crystalline limestone. Lower 6 feet mottled with pink and green. *Actinoceras* and *Cycloceras*. The beds beveled by erosion.	7	6

1. Blue limestone (Platteville). Not seen in position but blasted out of river below dam.

The rock in zone 10 is correlated with the Upper Buff of Wisconsin; the beds in Wisconsin have a thickness of 55 feet and consist of fine grained, rather heavy-bedded limestone, mottled and banded with light gray and buff, giving the whole a buff-colored appearance; chert nodules are characteristic of the upper part of the beds. The Upper Buff at Bony Falls is more argillaceous than the corresponding beds in Wisconsin and the known thickness is much less. There is no other known exposure of the Upper Buff in Michigan.

The rock of zone 10 contains few fossils other than an occasional specimen of *Leperditia fabulites*.

The contact between the rock of zone 9 and the Upper Buff above is irregular. This zone is characterized by the presence of *Columnaria halli*; one colony measuring 5 feet in diameter was found in place, with the corallites unusually well preserved. This evidence points to the existence of a temperate climate in Michigan at that time.

Zone 8 is the typical horizon for *Leperditia fabulites* and they are here in considerable numbers although none of the specimens found are of more than medium size. Fossils are common throughout the whole zone but good specimens are not easily obtained. The rock this far down in the section represents the Mississippi Valley rather than the southeastern Wisconsin type of Platteville.

Zone 7 is very fossiliferous and is characterized by the appearance of *Pianodema sp*. and numerous specimens of *Petraea profundum*. The rock is a very pure limestone similar to that in zone 8.

Zone 6 contains an abundance of Fucoid remains and many interiors of the Lowville form of *Strophomena incurvata*.

The top of zone 5 is characterized by a very rough, pitted surface which was apparently produced by subaerial erosion, possibly by river action; this is just one of the many breaks characteristic of Black River rocks.

The fauna is very similar to that in zone 6 with the important addition of *Maclurites bigsbyi*, *Orthoceras sp*., and a form of Endoceras with narrow septa and a shell that expands rapidly from 0 to 8 inches within 3 feet. This zone represents the base of the typical Lowville.

A layer of intraformational conglomerate is found 6 feet below the top of zone 4. Immediately below the conglomerate there is a layer showing ripple marks of the oscillating type.

The rock of zone 3 is very irregularly bedded and argillaceous, but that of zone 2 is dolomitic and mottled with pink, light gray, dark gray, and light brown. Occasional specimens of *Actinoceras sp*. and *Cycloceras sp*. are found.

The rock of zone 1 is below the level of the river. Great quantities of the rock have been blasted from the river bed and may be seen piled along the east bank of the stream. This zone is correlated with the Lower Blue of Wisconsin.

The whole section at Bony Falls indicates deposition in shallow water with oscillations of the sea bottom sufficient at times to bring the beds above water and produce an erosion surface such as that at the top of zone 5. The small ripple marks and the intraformational conglomerate are indications of shallow water. An occasional uplift of the neighboring land with a little rejuvenation of the streams would have been enough to furnish the argillaceous material found throughout the section. Water sufficiently clear to permit the growth of reef-forming corals prevailed during the deposition of zone 9.

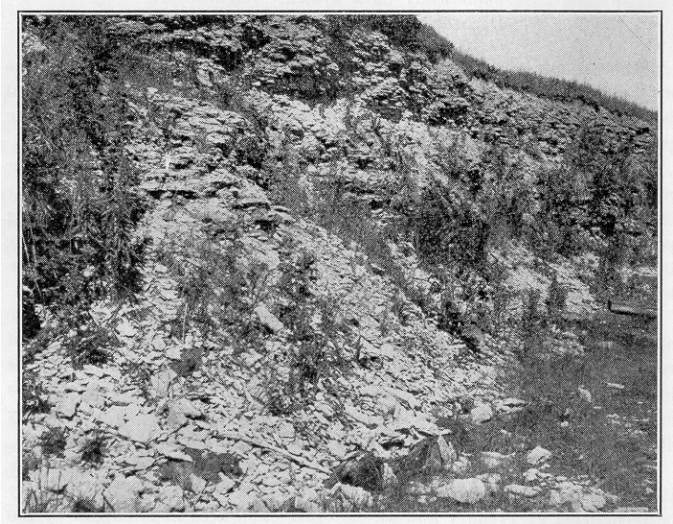

Figure 2. Black River rock exposed along the railroad at Trenary.

Exposure at Trenary Alger County (Loc. 26).

The Black River rocks (Fig. 2) are exposed just south of town in a railroad cut, in a quarry west of the road and along the road south of the quarry, (U. S. Highway 41). The following is the quarry road section:

Top of section		Feet	Inches
3.	Argillaceous limestone, thin, irregular-bedding. Fresh surfaces light to dark gray, weathering yellowish. Dolomitic layer near bottom contains Ostracods. This zone belongs to the basal Trenton.	3	

2.	Argillaceous limestone, thin, irregular bedding. Fresh surfaces bluish green, weathering light gray to yellowish gray. Covered interval of one foot at base of zone included in total thickness. Upper Decorah.	18	8
1.	Exposure in quarry. Argillaceous limestone, somewhat siliceous, irregular bedding, with beds from 1 inch to 1 foot thick. Fresh surfaces from light gray to bluish gray and brown. Weathers moderately dark brown. Highest pre-Decorah	10	8

There is an interval of unknown thickness between the base of the section at Trenary and the top of the section at Bony Falls. This interval is probably not very great and may not be more than 5 feet. The missing portion of the section quite likely belongs to the Upper Buff.

The quarry rock of zone 1 is much more siliceous than that in any other part of the section and the bedding in general is thicker and more regular in the upper part. The beds contain very few fossils, most of them being poorly preserved casts of *Strophomena incurvata*. The rock in this zone is correlated with the highest pre-Decorah and is considered the equivalent of the Vanuxemia beds in Minnesota.

A covered interval of 1 foot separates the top of zone 1 from the base of zone 2; this interval probably belongs to the lower zone. The rock of zone 2 is highly argillaceous with very irregular bedding; most of the layers are thin with an occasional thicker one. This same horizon is exposed along the railroad, 100 feet southeast. Fossils are moderately abundant and are irregularly distributed in layers and lenses.

This zone is correlated with the Upper Decorah and marks the transition between the Black River and the Trenton. The basal Trenton may be recognized at Trenary and at the other exposures in Michigan by the presence of many specimens of the small brachiopod, *zygospira recurvirostris* and by a dolomitic layer containing Ostracods. The *Zygospira* appears suddenly in great abundance and is a most useful guide fossil since the Black River cannot be separated from the Trenton upon lithologic grounds.

Exposure 3/10 miles northwest of Spalding, Menominee County on U. S. Highway 2 (Loc. 42).

The rock at this locality consists of argillaceous and dolomitic limestone, non-crystalline to moderately coarsely crystalline, and varying from soft to hard. The exposure is in the shallow ditch along the road and is not extensive. A few poorly preserved fossils were found among them being *Rafinesquina minnesotense* and *Strophomena incurvata*. This rock is stratigraphically above that at Bony Falls (Loc. 9), and may be placed at the base or just below the base of the quarry rock at Trenary (Loc. 26).

Exposure 3/4 miles east of Spalding on U. S. Highway 2 (Loc. 85).

Dolomitic limestone with argillaceous lenses, finely crystalline. Fresh surfaces yellowish brown becoming dark gray after weathering. The outcrop is found in the roadside ditch and extends for 1/4 mile. Fucoid markings are numerous. Glacial striae run N. 45° E. This exposure is correlated with the rock in the quarry at Trenary (Loc. 26).

Exposure 7/10 mile northwest of Spalding, near Spalding Fire Tower (Loc. 86).

Argillaceous limestone with irregular layers varying in thickness from 1 to 8 inches. Fresh surfaces light gray, brown, mottled. Weathers light gray, brown, greenish. Occasional dolomitic lenses. This location is stratigraphically higher than that at Loc. 85 and represents the same horizon as the top of the quarry at Trenary, or high middle Black River. Some fragments of greenish argillaceous limestone found near the exposure are Decorah which is probably present just beneath the soil of the adjoining field. The following fossils have been identified from Loc. 86:

Pianodema sp.
Clionychia sp.
Sinuites sp.
Eotomaria sp.
Actinoceras sp.

The Cyrtodontae found at this location are similar to those in the equivalent horizon at Minneapolis and indicate a possible overlap in that direction.

Exposure at McFarland, Southeastern Marquette County on Michigan Highway 35 (Loc. 40).

The rock is exposed in a quarry operated several years ago for road material, and consists of argillaceous and somewhat dolomitic limestone. The color of fresh surfaces is greenish blue becoming light gray and yellowish after weathering. This exposure represents the same horizon as zone 2 at Loc. 26.

Exposure at Lathrop Northwestern Delta County on Michigan Highway (Loc. 28).

The rock is exposed in a shallow quarry along the east side of the road and is similar lithologically to the rock at Loc. 40 with which it is correlated.

Black River and Trenton

Exposure at Cornell, Southwestern Delta County, Black River and Trenton (Loc. 5).

This is the chief exposure of Black River and Trenton rocks in the Northern Peninsula of Michigan and extends for a mile along the eastern side of the Escanaba River north of the concrete bridge. The detailed section follows:

Top of section		Feet	Inches
Trenton			
6.	Argillaceous limestone, thin, irregular bedding. Color of fresh surfaces varies from light gray to dark gray and greenish, weathering gray and yellowish. Chief horizon for *Maclurites.*	10	
5.	Interbedded argillaceous limestone and shale, non-crystalline to coarsely crystalline. Color of fresh surfaces light to dark gray, weathering gray and brown, mottled. Conglomerate at top. *Plesiarges* common.	4	
4.	Limestone, becoming thicker and more regularly bedded. Hard, dolomitic at base. Contains a layer with uneven upper surface as though eroded.	5	9
3.	Argillaceous and dolomitic limestone, irregular bedding. Lens-like interbedded gray and green shale, decreasing in amount toward top. Small *Zygospira recurvirostris* common. Base of Trenton.	17	2
Black River			
2.	Argillaceous limestone and interbedded shale, hard to soft. Texture and color not uniform, varying from dark to light gray. Fucoid markings. Top of Decorah (Black River).	5	9
1.	Argillaceous limestone, mostly in thin, irregular beds. Fresh surfaces light gray to dark gray, weathers yellowish brown. Weathers with irregular upper surface.	5	4

This is the only exposure along the Escanaba River where the contact between the Black River and Trenton rocks may be seen. The general dip of the rock is down stream or southeast but there are numerous undulations in the beds which produce local dips to the northwest. These undulations appear as low anticlines and synclines and often cause the same beds to appear at several places along the river. The amount of dip varies from about 1° to 9°.

The rock forms vertical bluffs 30 feet high in some places along the stream, usually on the outside of the bend; in other places the river banks are low and swampy with very poor outcrops. At some localities the rock weathers rapidly and forms a heavy talus slope where fossils may be collected in abundance; where the material is harder fossils are very difficult to obtain. The fossils are unevenly distributed in the layers and are usually found in lenses.

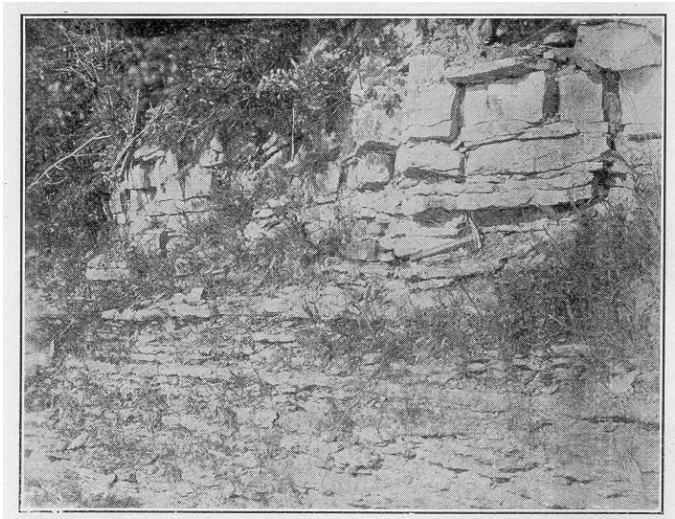

Figure 3. Black River and Trenton exposed along the Escanaba River at Cornell, Michigan, Location 5. The hammer rests on the top of the Black River.

The Black River beds at Loc. 5 contain more limestone and dolomite and somewhat less argillaceous material than the Trenton and consequently do not weather so rapidly. Fossils are not as abundant in the Black River as in the Trenton and are usually more difficult to obtain. The break between the two formations cannot be detected upon lithologic grounds but is entirely a faunal one. The relatively unfossiliferous Black River is succeeded by the more highly fossiliferous Trenton with the typical brachiopod, *Zygospira recurvirostris* at the very base.

A well marked layer of intraformational conglomerate occurs at Loc. 5 in zone 5 and at Loc. 8 in zone 2. This conglomerate is composed of water-worn pebbles and slabs of various sizes some of which are a foot wide. The fragments composing the conglomerate are all rounded and many of the flat slabs resemble typical shingle. In a fresh cross section through the conglomerate the pebbles are not as sharply defined as after weathering when they become conspicuous and are somewhat darker than the surrounding matrix. The

pebbles often weather loose from the surrounding material. Many of the rocks have been bored by some unidentified forms, probably worms.

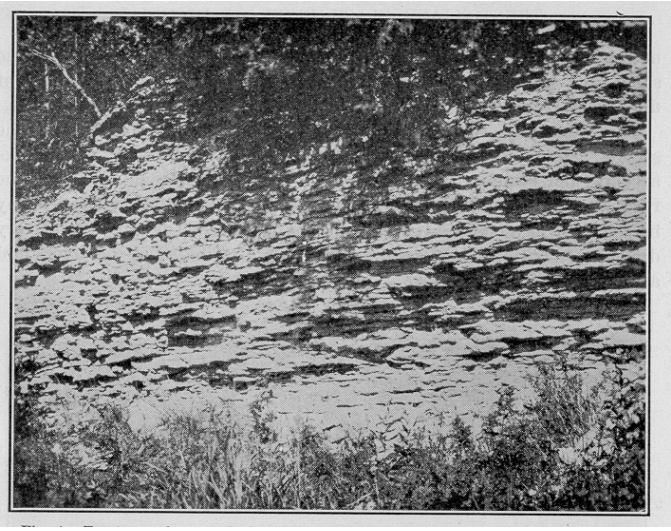

Figure 4. Trenton rock exposed along the Escanaba River at Cornell, Michigan. Loc. 5, Zone 6. This view shows the uneven character of the bedding in much of the Trenton.

Figure 5. Trenton rock exposed along the Escanaba River at Cornell, Michigan. Loc. 5.

TRENTON

The most fossiliferous part of the Trenton is the first three or four feet immediately below the conglomerate. A change in strength of current caused deposition of the conglomerate; possibly a shallowing of the water, caused a decided change in food supply and thus a reduction in the number of individuals and species of animal life. This increase in the amount of shaly material above the conglomerate may have made conditions rather unfavorable for the existence of life.

Among the most characteristic fossils of zone 5 are the following: *Plectambonites sericeous* (very abundant), *Fusispira nobilis*, *Clitambonites sp*., *Dinorthis meedsi*, *Orthis triceneria*, and *Catazyga uphami*. *Catazyge uphami* is considerably more abundant in Michigan than in Minnesota.

Zone 6 (Fig. 4) contains occasional specimens of *Maclurites*; it is possible that this form goes down to the conglomerate layer but it has not been found below zone 6 at any of the localities. Fossils are not abundant in this zone.

Deposition seems to have continued somewhat longer in the zone below the conglomerate at Loc. 5 (Figs. 4, 5) than at Loc. 8, (Dam No. 2 on Escanaba River) giving about three feet more material at Loc. 5 and also a more typical development of the conglomerate zone fauna.

Exposure at Loc. 8, Dam No. 2, on Escanaba River, 3 miles north of Escanaba, Delta County.

The detailed section is as follows:

Top of section		Feet	Inches
Trenton			
6.	Argillaceous limestone in thin, irregular beds. Weathers yellowish. A little harder than zone 5 which it overhangs. *Maclurites* horizon.	5	
5.	Argillaceous limestone in thin, irregular beds. Thin layers or lenses crowded with *Plectambonites sericeus*. This zone grades in color into the yellowish zone above and the greenish blue zone below.	17	
4.	Argillaceous limestone in thin, irregular beds, similar to zone 5 but more shaly and dominantly bluish green in color. Layers and lenses of limestone filled with *Plectambonites sericeus*. Remainder of limestone less fossiliferous.	5	2
3.	Dense limestone in layers 2 to 3 inches thick, with sharply impressed fucoid markings. Between the limestone layers is bluish green fissile shale with less sharp fucoid markings.	1	
2.	Conglomerate of worn shore debris and fragments of fossils. Some of the conglomerate pebbles have been bored by some unidentified forms, probably worms. Argillaceous limestone and shale.	5	6

	Zone continued downwards in bluish green, irregularly bedded shale with abundant Bryozoa and other fossils.	3	9
1.	Bluish green, argillaceous limestone in irregular beds with many crinoid stems in some layers. Much less fossiliferous than the lower part of zone 2.	7	11

Location 8 at Dam No. 2 offers one of the best sections of the Trenton exposed along the Escanaba River. A large amount of material chiefly from zones 1, 2 and 3 has been blasted from the bed of the river and piled along the eastern bank where it is weathering rapidly; fossils in great abundance are found in this material.

The rocks along the west side of the river stand in a nearly vertical cliff about 30 feet high and form a shallow syncline a hundred yards long. 200 yards down stream from the upper end of the exposure the rocks dip up rather steeply southeastward, down stream. 100 yards farther on the dip has flattened to about 1°. Such undulations are characteristic of the Escanaba River section.

The same conglomerate layer that occurs at Cornell (Loc. 5, zone 5) is exposed here at the top of Zone 2. The pebbles are all water worn and suggest the debris of an old shore. The most fossiliferous beds in the whole section are just below the conglomerate. This zone contains numerous specimens of *Plectambonites sericeus*. Other fossils are: *Clitambonites sp*. (not common), *Catazyga uphami* (common), *Fusispira nobilis*, *Dinorthis meedsi*, *Orthis tricenaria* and *Prasopora sp*. The reduction in individuals and number of species of fossils in the beds above the conglomerate is as marked here as at Cornell.

Conditions of deposition of the Trenton in general, and particularly the material at Cornell and at Loc. 8, indicate that the water was shallow and the shore at no great distance. At Loc. 8 ripple marks of the oscillation variety are common; in zone 1, ripple marks measuring 4 inches from crest to crest have been found. The rounded character of the material composing the conglomerate shows that it was probably rolled around in the shallow water near shore or formed part of the material along the beach.

Figure 6. Trenton rock exposed along the Escanaba River at Location 7. The dip of the rock here is down stream or to the east.

Conditions were unusually favorable for the development of certain types of Bryozoa in the zone immediately below the conglomerate; an unusual number of specimens of large, conical *Prasopora* have been found at Locs. 5 and 8, where they form a very striking element in the fauna. Some specimens were found imbedded in the shale without any very firm place of attachment; in other places they were found attached to the upper surface of the hard limestone layers. This bryozoan is more numerous in Michigan than in Minnesota.

The whole section exposed at Loc. 8 is placed within the Prosser, and according to Dr. E. O. Ulrich it is the equivalent of the Glens Falls of New York.

Location 7. (Fig. VI.) Section. Escanaba River, 11/2 miles east of Cornell, Delta County.

Top		Feet	Inches
3.	Limestone, dense, massive bedded, gray, like zone 3, Loc. 10 (Groos Quarry). At the base is a thin layer of dark brown shale, weathering bluish; possibly the equivalent of the shale layer that covers the floor of the Groos Quarry.	6	8
2.	Heavier, more regularly bedded limestone.	8	9
1.	Argillaceous limestone in thin, irregular beds. Weathering yellowish. The *Maclurites* horizon of Locs. 5 and 8.	14	9

This section overlaps the upper part of the section at Loc. 8 and the lower part of the section at Loc. 10 (Groos Quarry).

Section at Loc. 10, the Groos Quarry. (Fig. VII.) Wells Twp. five miles north of Escanaba, Delta County.

Top		Feet	Inches
4.	Argillaceous limestone in thin, irregular layers, with dolomitic layers and lenses. A thin shaly parting layer, 1/4 to 1 inch thick at the bottom, disintegrating to mud. *Mesotrypa Sp*. in the base.	4	
3.	Fairly dense, gray, massive limestone. Some irregular layers especially at the top. Fossils in lenses and in the parting layers. Some layers and lenses of lithographic limestone. Zone with *Whitella sp*. 16-18 feet below top of zone. Occasional thin lenses of dark brown shale found within the first four feet above the bottom of zone.	24	8
2.	Dark brown to black shale, weathering blue. Very fossiliferous. Forms the floor of the quarry.	2	3
1.	Fine grained limestone, irregular bedding. Resembles zone 3. Bottom not seen.	6	6

The rock of zone 4 is much more argillaceous than the rocks of zone 3 and the bedding is thinner and more irregular. This is the most fossiliferous part of the quarry although the fossils do not easily separate from the rocks. The upper surface of the rock in this zone has been heavily glaciated, the striae running N. 4° E. At the base of the zone there is a shaly layer about one inch thick which may be an old buried soil and consequently marks the position of an unconformity. The break is local and no faunal change took place during the interval of erosion.

The rock in zone 3 makes up most of the quarry face, and consists of hard, rather massive bedded limestone which breaks with a sub-conchoidal fracture. The rock from this zone is used a great deal, locally, for road material. Fossils in zone 3 are irregularly distributed in lenses and are very difficult to obtain because of the hardness of the surrounding matrix. The same *Whitella* horizon that is 20-22 feet below the top of the quarry is found at locations 12, Island in the Escanaba River northeast of Groos and 13, at the bridge across the Rapid River, at Rapid River (Fig. 8).

In the bottom 4 feet of zone 3 there are occasional thin layers and lenses of dark brown shale, weathering bluish, and varying in thickness from 1-4 to 1 inch. The contact between the shale and the limestone is always sharp, with no gradation from one to the other; some of the layers of shale are very fossiliferous.

Zone 2 is one of the shale layers which covers the entire floor of the quarry and contains an abundance of fossils of the same sort as those found in zone 4. The equivalent of this shale layer has been found at locations 7 east of Cornell and 19 on the Ford River, southeast of Hyde.

The rock of zone 1 is below the floor of the quarry and is not very accessible for study but it is the same as the rock in zone 2 at location 7 where it may easily be seen.

The rock exposed at the Groos Quarry is the highest Trenton horizon that has yet been found in the area studied and probably does not lie far below the base of the Richmond. It is correlated with the Prosser.

Location 11.

An abandoned quarry, 7 6-10 miles southeast of Cornell, Delta county, Michigan. The rock at this location is of the same horizon as that in the upper middle part of the Groos quarry, Loc. 10. The rock is lithologically the same and contains the same fauna as that at Loc. 10. The total thickness exposed is 12 feet.

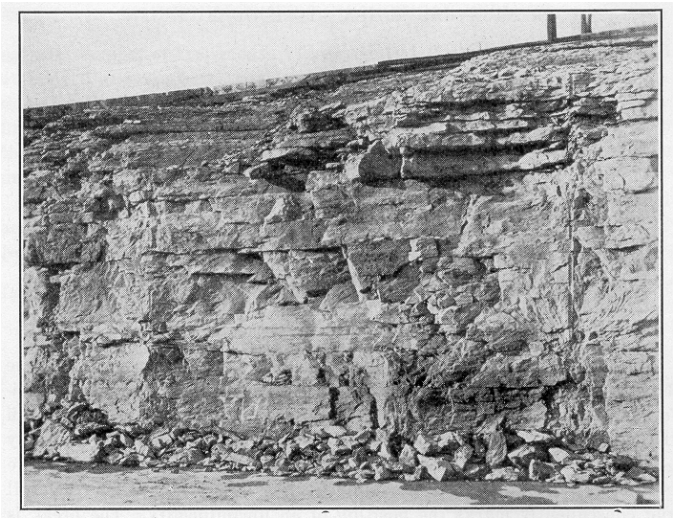

Figure 7. Trenton rock exposed in the Groos Quarry at Location 10.

Location 13.

Rapid River, Delta County, Michigan, in the bed of the Rapid River.—The rock is exposed in the bed and along the banks of the river just north of town and may be seen for 250 yards below the river bridge. The dip is slightly to the southeast, a little less than the gradient of the stream.

The rock consists of thin, irregularly bedded, argillaceous limestone with dolomitic and lithographic layers and lenses. The color varies from light to dark gray on fresh surfaces and light gray to brownish gray after weathering. The upper surface of many of the

layers has a very decided nodular appearance due to the extreme irregularity of the bedding. Fossils are abundant and occur in layers and lenses; good specimens are not easily obtained.

On the east bank of the river, 200 yards below the bridge and 8 inches above the level of the river, there is a well defined layer containing numerous specimens of *Whitella sp*. The pelecypods range through a vertical thickness of about 2 inches. This is the same horizon as that found in the Groos quarry, Loc. 10. The total thickness of the rock exposed at Loc. 13 is 8 feet.

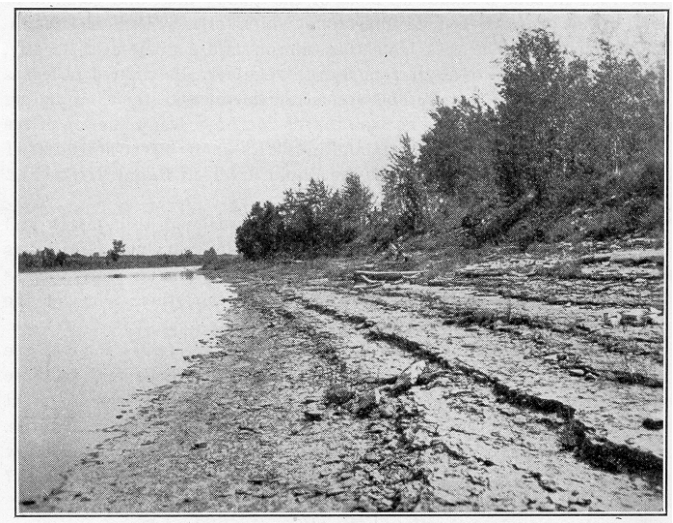

Figure 8. Trenton rock exposed in the bed and along the bank of the Rapid River at Rapid River, Michigan, Location 13.

Location 12.

About 1/4 mile northeast of the Groos quarry, in Delta County, a little island stands in the middle of the Escanaba River. The rock is exposed all around the sides of the island, offering especially good opportunities for study as the water in the river is often very low.

Section. Top.		Feet	Inches
2.	Argillaceous limestone in thin, irregular beds; dolomitic lenses. Weathers yellowish.	4	
1.	Argillaceous limestone with lithographic lenses; bedding thin. Weathers with rough, sharply irregular surface. Zone containing numerous specimens of *Whitella sp.* 61/2 feet from top of zone.	12	

The nearness of this exposure to that in the Groos Quarry, Loc. 10, makes it possible to correlate the two without difficulty. Zone 2, Loc. 12, is equivalent to zone 4, Loc. 10. Zone 1, Loc. 12, is equivalent to the upper part of zone 3, Loc. 10. The whole section is Prosser.

Location 19.

Ford River, 2 miles southeast of Hyde, Delta County, Mich. The rock at this locality consists of thin bedded, argillaceous limestone with dolomitic and lithographic layers and lenses. The color of fresh surfaces varies from light to dark gray and after weathering is mottled brown, greenish, yellowish brown. The bedding is very irregular and weathering produces rough, nodular surfaces. A thin layer of dark brown shale, 1/4 to 1 inch thick, occurs 2 feet 10 inches from the top of the section. The total thickness exposed is 5 feet 4 inches. The horizon is equivalent to zone 3, Loc. 10.

Location 22.

Exposure just east of Bark River, Delta County, Mich., on the south side of the road U. S. Highway 2-41. Three feet of argillaceous limestone in thin, irregular beds. This exposure is correlated with the *Maclurites* horizon of the sections at Cornell, Loc. 5, and Loc. 8.

Location 25.

A small quarry just north of the road, 1/4 mile west of Perking, Delta County, Michigan, Highway 35. The rock consists of thin bedded, argillaceous limestone, with dolomitic and lithographic layers and lenses. Four feet of rock exposed above the water level. The horizon is the same as that of Loc. 13, Rapid River, Mich.

Location 27.

Near bridge (Trunk line bridge No. 64) across the Whitefish River, on the road between Rapid River and Trenary, Mich. The rock is exposed in the bed of the river and along the banks for 100 yards above the bridge. The horizon is the same as the middle part of the Groos Quarry, Loc. 10. Thickness exposed, 6 feet.

Location 29.

The rock is poorly exposed along the banks of the Whitefish River, 7 miles northeast of Rapid River. About 1/2 mile to the east the Bill's Creek shale, basal Richmond, is found along the banks of Haymeadow Creek. The country between the two exposures is flat and heavily wooded concealing the contact; but the flat dip of both the Trenton and the Richmond in this locality makes it unlikely that a large covered interval exists between the observed top of the Trenton and the base of the Bill's Creek shale. The horizon of the rock at Loc. 29 is the same as that found in zone 4, Loc. 10.

Location 31.

The same horizon as that found at Loc. 13 occurs along both sides of the road, U. S. Highway 41, just north of the village of Masonville, Delta County, Mich. Only the upper surface of the rock is exposed but the fossils are identical with those found at Loc. 13.

Location 1.

Two miles north of Bark River, Delta County, Mich. The rock is fairly well exposed along both sides of the road and consists of argillaceous limestone in thin, irregular beds, moderately hard, dark gray on fresh surfaces, light gray to yellowish brown after weathering. This exposure is correlated with the *Maclurites* horizon as found at Locs. 5 and 8. Thickness 5 feet 4 inches.

Location 3.

Two miles east and 1 mile south of Wilson, Menominee County, Mich. Rock is exposed along both sides of the road and consists of argillaceous limestone in thin, irregular beds, with dolomitic lenses. Dark gray on fresh surfaces, weathering light gray and yellowish brown. Dip south 4°. This exposure is correlated with the Maclurites horizon as found at Locs. 5 and 8. Thickness 13 feet 5 inches.

Location 62.

Along the road, 2 miles southeast of Schaffer, western Delta County, on Highway M-69. This rock represents the same horizon as that found at Rapid River, Mich., Loc. 13.

Location 63.

One-half mile west of Schaffer, Mich. The three feet of rock exposed along the road at this location represents the same horizon as that found at Rapid River, Mich., Loc. 13.

Location 23.

At Brampton, Delta County, Mich., on M-35. This is a poor exposure of the same rock as that found at Rapid River, Mich., Loc. 13.

Location 14.

Along the road, 12 1-5 miles northwest of Cornell, in Marquette County, Mich. The typical Maclurites horizon as found at Cornell, Loc. 5, outcrops in the shallow ditches along both sides of the road. Glacial striae N. 36°-40° W. Dip 5° E.

Location 51.

Eight-tenths of a mile northwest of Faunus, Menominee, Mich., on Highway 69. Dolomitic limestone. Fresh surfaces moderately light gray to brown, weathering dark gray to dark brown. Glacial striae 49° E. Thickness 6 feet. This outcrop may represent the basal Black River and if such, it is not far above the top of the Ozarkian.

Location 30.

Exposure in the beds of the Days River, Delta County, just west of the bridge, on U. S. Highway 2-41 between Escanaba and Rapid River, Mich., about one mile southwest of Masonville. The horizon is the same as that found at Rapid River, Loc. 13.

Location 16.

Exposure along the east side of the road, 2 1-5 miles northwest of Cornell. This rock represents the Maclurites horizon as found at Locs. 5 and 8. Thickness 3 feet.

BIBLIOGRAPHY

Bassler, R. S., 1915. Bibliographic Index of American Ordovician and Silurian Fossils. Smithsonian Institution. U. S. National Museum. Bulletin 92. Vols. 1 and 2.

1919. The Cambrian and Ordovician Deposits of Maryland. Maryland Geological Survey. Cambrian and Ordovician.

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

Cumings, E. R. 1907. The Stratigraphy and Paleontology of the Cincinnatian Series of Indiana. Indiana. Department of Geology and Natural Resources. 32nd Annual Report.

1900. Lower Silurian System of Eastern Montgomery County, New York. Bulletin of the New York State Museum. No. 34. Vol. 7.

Clarke, J. M. 1897. The Lower Silurian Trilobites of Minnesota. The Geological and Natural History Survey of Minnesota. Vol. Ill, Part II. pp. 695-759.

1897. The Lower Silurian Cephalopoda of Minnesota. The Geological and Natural History Survey of Minnesota. Vol. III. Part II. 761-812.

Foerste, A. F. 1908-09. Preliminary Notes on Cincinnatian Fossils. Bulletin of the Scientific Laboratories of Denison University. Vol. 14.

1908-09. Preliminary Notes on Cincinnatian and Lexington Fossils. Bulletin of the Scientific Laboratories of Denison University. Vol. 14.

1912. Strophomena and Other Fossils from Cincinnatian and Mohawkian Horizons, Chiefly in Ohio, Indiana, and Kentucky.

Bulletin of the Scientific Laboratories of Denison University. Vol. XVII, pp. 247-340.

Fritz, Madeline A. 1925. The Stratigraphy and Paleontology of Toronto and Vicinity. Part IV. Hydrozoa, Echinodermata, Trilobita, and Markings. Thirty-second Annual Report of the Ontario Department of Mines. Vol. XXXII, Part VII.

Hall, James. 1847. Paleontology of New York. Descriptions of the Organic Remains of the Lower Division of the New York System. Natural History of New York. Part VI. Paleontology. Vol. 1. 1851. Report on the Geology of the Lake Superior Land District, Foster and Whitney. Part 2. pp. 140-151.

Hall, James and Whitfield, R. P. 1875. Descriptions of Invertebrate Fossils mainly from the Silurian System. Geological Survey of Ohio. Vol. II. Part II. pp. 67-110.

Hussey, R. C. 1926. The Richmond Formation of Michigan. Contributions from the Museum of Geology, University of Michigan. Vol. II. 1928. Cystoids from the Trenton Rocks of Michigan. Contributions from the Museum of Paleontology, University of Michigan. Vol. III. No. 4.

McEwan, Eula D. 1919. A study of the Brachiopod Genus Platystrophia. Proceedings of the U. S. National Museum. Vol. 56, No. 2297.

Meek, F. B. 1873. Descriptions of Invertebrate Fossils of the Silurian and Devonian Systems. Fossils of the Cincinnati Group. Geological Survey of Ohio. Vol. 1. Part II. Paleontology.

Miller, W. J. 1914. The Geological History of New York State. New York Museum Bulletin 168.

Prosser, C. S. and Cumings, E. R. Sections and Thickness of the Lower Silurian Formations on West Canada Creek and in the Mohawk Valley. Geological Survey of the State of New York. 15th Annual Report of the State Geologist.

Prosser, C. S. 1900. Notes on the Stratigraphy of Mohawk Valley and Saratoga County, New York. Bulletin of the New York State Museum. No. 34. Vol. 7.

Raymond, P. E. 1921. A Contribution to the Description of the Fauna of the Trenton Group. Canada. Department of Mines. Geological Survey. Museum Bulletin No. 31. Geological Series 38.

Ruedemann, Rudolf. 1912. The Lower Siluric Shales of the Mohawk Valley. New York State Museum. Museum Bulletin 162.

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

Schuchert, Chas. 1908. Paleogeography of North America. B.G.S.A. Vol. 20.

Stewart, Beatrice Helen. 1912. The Stratigraphy and Paleontology of Toronto and Vicinity. Twenty-ninth Annual Report of the Ontario Department of Mines. Vol. XXIX. Part VI. Part 1.

Ulrich, E. O. and Scofield, W. H. The Lower Silurian Gastropoda of Minnesota. The Geological and Natural History Survey of Minnesota. Vol. III. Part II 813-1081.

Ulrich, E. O. 1893. New and Little Known Lamellibranchiata from the Lower Silurian Rocks of Ohio and Adjacent States. Report of the Geological Survey of Ohio. Vol. VII. Chapter VII.

1895. On Lower Silurian Bryozoa of Minnesota. The Geological and Natural History Survey of Minnesota. Vol. III. Part I. Paleontology, pp. 96-332.

1897. The Lower Silurian Lamellibranchiata of Minnesota. The Geological and Natural History Survey of Minnesota. Vol. III. Part II. 475-627.

1897. The Lower Silurian Ostracoda of Minnesota. The Geological and Natural History Survey of Minnesota. Vol. Ill, Part II. 629-693.

1911. Revision of the Paleozoic Systems. B.G.S.A. Vol. 22.

Ulrich, E. O. and Bassler, R. S. 1923. Paleozoic Ostracoda: Their Morphology, Classification and Occurrence. Maryland Geological Survey. Silurian. 271-391.

Whitfield, R. P. 1882. Part III. Geology of Wisconsin. Survey of 1873-79. Vol IV.

Weller, Stewart. 1913. The Paleozoic Faunas. Geological Survey of New Jersey. Report on Paleontology. Vol. III. Chapter VII, Faunas of the Ordovician Age.

Winchell, N. H. and Schuchert, Charles. 1895. The Lower Silurian Brachiopoda of Minnesota. The Geological and Natural History Survey of Minnesota. Vol. Ill, Part I. Paleontology. 333-474.

1895. Sponges Graptolites and Corals from the Lower Silurian in Minnesota. The Geological and Natural History Survey of Minnesota. Vol. Ill, Part I. Paleontology. 55-59.

Winchell, N. H. and Ulrich, E. O. The Lower Silurian Deposits of the Upper Mississippi Province. The Geological and Natural History Survey of Minnesota. Vol. Ill, Part II. Paleontology.

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

Wooster, L. C. 1882. Part 2. Geology of Wisconsin. Survey of 1873-79.

Zittel, K. A. Von. 1913. Text-Book of Paleontology.

TRENTON AND BLACK RIVER ROCKS OF MICHIGAN

List of numbered field stations described in the report, expeditions of 1927-28, University of Michigan.

1. Two miles north of Bark River, Michigan. Roadside exposure.
3. Two miles east and 1 mile south of Wilson, Michigan. Roadside exposure.
5. Exposure along both sides of the Escanaba River, Cornell, Michigan, north and south of the concrete bridge.
7. Exposure along the Escanaba River, 1½ miles east of Cornell, Michigan.
8. Dam No. 2 on the Escanaba River, 3 miles north of Escanaba, Michigan.
9. Bony Falls, Michigan. Exposure on the Escanaba River.
10. Groos Quarry at Groos, Michigan.
11. Quarry, 7 6-10 miles southeast of Cornell, Michigan, on the road between Cornell and Escanaba, Michigan.
12. Island in the Escanaba River, 14 mile northeast of the Groos quarry at Loc. 10.
13. Exposure north and south of the bridge across the Rapid River at Rapid River, Michigan. Loc. 47, Michigan trip.
14. Roadside exposure, 12 1-5 miles northwest of Escanaba, Michigan.
16. Roadside exposure, 2 1-5 miles northwest of Cornell, Michigan.
19. Exposure on the Ford River, 2 miles southeast of Hyde, Michigan.
22. Exposure just east of Bark River, Michigan, along the south side of the road.
23. Roadside exposure at Brampton, Michigan.
25. Quarry, 1/4 mile west of Perkins, Michigan, north side of the road.
26. Exposure in the quarry, along the highway, and along the railroad, 1/2 mile south of Trenary, Michigan.
27. Exposure along the Whitefish River, west of Trunk Line Bridge No. 64, on the road between Trenary and Rapid River, Michigan.
28. Quarry at Lathrop, Michigan.
29. Exposure on the Whitefish River, 7 miles northeast of Rapid River, Michigan. Loc. 38, Michigan trip.
30. Exposure on the Days River, west of bridge on road 2 miles south of Rapid River, Michigan.
31. Roadside exposure just north of Masonville, Michigan.
42. Roadside exposure, 3-10 mile northwest of Spalding, Michigan.
51. Roadside exposure, 8-10 mile northwest of Faunus, Michigan.
62. Roadside exposure 2 miles southeast of Schaffer, Michigan.
63. Roadside exposure, 1/2 mile west of Schaffer, Michigan.
85. Roadside exposure, ¾ mile east of Spalding, Michigan.
86. Roadside exposure, 7-10 mile northwest of Spalding, Michigan.

STATE OF MICHIGAN

DEPARTMENT OF CONSERVATION
P. J. Hoffmaster, Director

GEOLOGICAL SURVEY DIVISION
R. A. Smith, State Geologist