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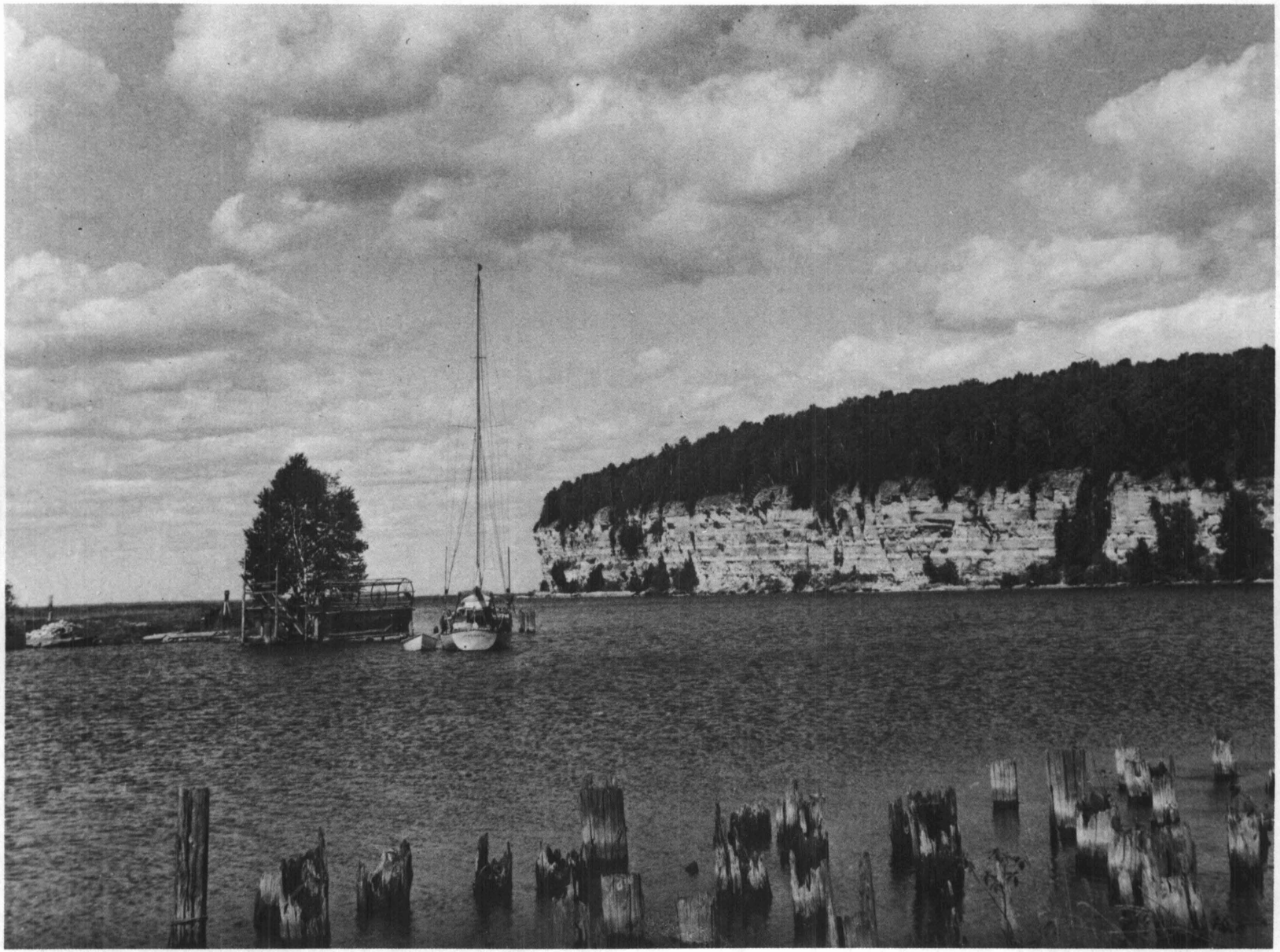
Stratigraphy of the Niagaran Series of the Northern Peninsula of Michigan

By

George Marion Ehlers



FRONTISPIECE -- Picturesque Middle Bluff, an escarpment of Niagaran rocks rising above the eastern shore of Big Bay de Noc, as seen from the village of Fayette. Nearly all strata of the Hendricks Member of the Burnt Bluff Dolomite are exposed in this bluff.

FOREWORD

Time slips swiftly along its dimension, perhaps imperceptibly but certainly irrevocably. In it we are borne through life as willing or unwilling passengers. On the way, we see many goals and we can successfully steer to only a few. So it happens that the monumental monograph may lie unfinished, still needing that one more season of field work, that extra search through the ever-growing literature, that new set of illustrations, and that final meticulous editing.

My very dear friend George Marion Ehlers has had many goals. With a clear vision of the importance of paleontology, he indoctrinated his students and colleagues with life-long dedication to betterment of this science. Believing sincerely in the value of museum collections, he spent years curating specimens and attending to accurate details, providing this service to all paleontologists of the future. In the classroom, the museum, and the field, he has lived paleontology, teaching by example as well as by word those who were fortunate enough to be with him.

For nearly sixty years he worked on the Silurian of Michigan. He is the greatest authority on this subject. With teaching, curating, and other research, however, he never brought his accumulated knowledge to publication. Time has now passed the point at which he could complete the work with the high standards on which he insisted.

On my own I decided not to let this lifetime of research be lost. After three weeks of careful searching, I assembled a nearly complete manuscript. Insofar as I can determine, this was the last written revision, completed around 1947. The photographs were beyond salvage, but with his customary thoroughness, Jim had filed negatives away with identifying notes on each; it was fortunate that he did, for many of the localities are changed by building and construction work, many of the old quarries are filled with water, and many of the natural exposures are now obscured by slumping strata and growth of vegetation.

The problem was to set the limits of my editing. Throughout the 1950's, Jim and I spent at least part of every summer studying the Silurian in northern Michigan. By 1957, when we wrote Silurian Rocks of the Northern Peninsula of Michigan, the guidebook for the annual field trip of the Michigan Geological Society, Jim had changed his idea about the classification of the lower beds. He came to the conclusion that the Cataract Group extended to the westernmost outcrops of Silurian in Michigan, and that the lower strata should be called Manitoulin Dolomite, Cabot Head Shale, and Moss Lake Formation instead of the downward continuation of the Mayville Dolomite. Should I completely revise this whole section and rewrite to conform with our 1957 interpretation?

For several reasons, I left the manuscript practically intact, introducing only such changes as were necessary for consistency. References to localities presented difficulty, because additions had been made as handwritten notes pinned to the typed sheets, and a box was found containing short sections marked "Add to Ms." To condense the long descriptions occurring wherever two or more localities were compared, I prepared a numerical list of localities and added more precise information on those I had visited and knew. This also eliminated some of the confusion from Marblehead on Drummond Island and Marblehead in Schoolcraft County, from Point Detour on Garden Peninsula in Delta County and Point Detour on Detour Passage opposite Drummond Island in Chippewa County, and from the several quarries operated at one time or other in Schoolcraft, Mackinac, and Chippewa Counties by the Inland Lime & Stone Company. Some modifications seemed to be warranted, in addition, to such references as "a recent communication from Doctor August Foerste."

Maps presented a special problem. Several maps were found, each incomplete but bearing numerous annotations for correction. Insofar as consistently possible, these suggestions have been incorporated in the maps redrafted for the work. Map 3 is a section of one of the original maps; map 4 was drafted under Professor Ehler's supervision many years ago, to which I added locality numbers.

The 1957 classification of Silurian formations was purposely avoided because all of Professor Ehlers' rationale is presented for the use of the term Mayville. Undoubtedly other systems of rock classification will eventually follow, and the present form of this paper serves as a consistent view of the problem at one moment in time. The value of the work -- careful stratigraphy, paleontology, and rock descriptions -- prevails in the essentially unchanged form of Ehlers' manuscript.

It is my hope that the information presented here will make the task of some future investigator of Silurian rocks much lighter.

Robert V. Kesling

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Stratigraphy of the Niagaran Series of the Northern Peninsula of Michigan

George Marion Ehlers

INTRODUCTION

Statement of the problem.-- The purpose of this paper is to explain the stratigraphy of the Niagaran rocks of the Northern Peninsula of Michigan. The problem involves firstly, the determination of the order of succession and classification of the Niagaran strata of the Northern Peninsula and secondly, an attempt to show the relationship of these strata to the better known Niagaran deposits of Wisconsin, Ontario, and more distant regions. The problem also involves the determination of the conditions under which the Niagaran strata were deposited, the source of the faunas which inhabited the seas at the time of their deposition and the direction of migration of these faunas.

All phases of the problem are considered in this paper; especial attention, however, is given to the superposition and classification of the Niagaran strata and their relationships to Niagaran rocks of Wisconsin, Ontario, New York, and more distant areas rather than to the description of the faunas.

Acknowledgments. -- During the course of the study of the Niagaran series the writer received the aid and counsel of several persons.

Special acknowledgments are due to Professor E. C. Case of the University of Michigan for indicating this study as a fruitful field for investigation, for kindly criticizing the paleontological and stratigraphic conclusions, and for suggesting numerous improvements in the composition of this paper. Professor Case also aided the writer by giving helpful advice and suggestions in the field during a part of one summer's field work.

Mr. R. A. Smith, State Geologist of Michigan, assisted very materially by loaning his field notes on the Niagaran rocks, by providing maps showing all known outcrops, and by supplying instruments and other data. With this assistance the work in the field was greatly facilitated, the stratigraphic succession and the limits of the formations in particular being determined more readily.

To Dr. E. O. Ulrich of the United States Geological Survey the writer is very heavily indebted for making a critical examination of most of the fossils collected during the course of the field work and for indicating certain stratigraphic relationships of the Niagaran faunas of the Northern Peninsula. Without Doctor Ulrich's knowledge of the stratigraphic and faunal relationships of the Silurian and other Paleozoic deposits of North America, the correlation of some of the divisions of the Niagaran series would have been left in doubt.

Dr. August F. Foerste has aided greatly by giving the writer much important information bearing on the faunal relationships and correlation of the Niagaran strata and by sending him for comparison several fossils from related Niagaran rocks of the other areas.

Much helpful information regarding the stratigraphic and faunal relationships of the Niagaran and Medinan rocks of Ontario was given to the writer by Prof. M. Y. Williams of the University of British Columbia. Many questions, raised by Professor Williams in his correspondence with the writer, resulted in a much better understanding of the relationships of the Niagaran formations of the two areas.

Prof. Charles Schuchert of Yale University kindly checked the writer's identifications of the brachiopods collected during the course of the field work and gave helpful information regarding the zoological affinities and stratigraphic range of the various species.

To Professor Savage of the University of Illinois the writer is indebted for the loan of fossils for comparison, and for his opinion regarding the writer's determination of certain fossils collected from the lower part of the Niagaran Series.

Dr. Rudolf Ruedemann of the New York State Museum aided materially in verifying the writer's determination of several Guelph species from the highest formation of the Niagaran.

Dr. W. A. Parks of the Royal Ontario Museum of Paleontology very kindly identified the stromatoporoids collected by the writer and gave helpful information regarding their zoological relationships.

Managers of limestone companies and others in the area visited assisted materially by granting permission to examine quarry sections, in giving the locations of outcrops and by supplying well records. To all these persons the writer wishes to express his appreciation.

Without financial assistance from the Michigan Geological Survey to carry on the field work the investigation could not have been undertaken. For this aid, therefore, the writer gratefully acknowledges his indebtedness.

DISTRIBUTION AND CLASSIFICATION OF THE NIAGARAN SERIES OF THE NORTHERN PENINSULA

Distribution. -- Two widely separated areas in the Northern Peninsula are underlain by rocks of Middle Silurian Niagaran age. The larger of these areas has the form of a broad, arcuate belt, extending from St. Martin, Poverty, Big, and Little Summer Islands at the entrance of Green Bay to the eastern side of Drummond Island. It borders the northern shores of Lakes Michigan and Huron except where it extends across the base of the large, triangular-shaped St. Ignace peninsula. This peninsula and the southern part of the St. Martin Point peninsula, located about 11 miles due northeast of the town of St. Ignace, are underlain by younger rocks belonging to the Upper Silurian Salina and Bass Islands groups and the Middle Devonian Mackinac breccia containing blocks of rock from Devonian formations as well as from the Salina and Bass Islands groups. The smaller area of Niagaran rocks is located near the railroad station of Hazel in southeastern Houghton County, about 117 miles distant from the nearest rocks of the larger area. According to E. C. Case & W. I. Robinson (1915, p. 167-173) the Niagaran rocks at this locality are exposed on the south slope of Big Limestone Mountain, an outlier of Paleozoic strata.

Previous classifications. -- As early as 1821 Dr. John J. Bigsby (1821, p. 265), a surgeon on the staff of the British army in Canada, divided the limestones of the northwest portion of Lake Huron into that of St. Joseph and the islets on the north shore, that of the Manitoulin Range (Fitzwilliam, Manitoulin, Cockburn- and Drummond Islands) and that of Michilimackinac (now known as Mackinac Island). He (1821, p. 267) described the rocks at Collier's Harbor, a small inlet of Lake Huron at the southwestern end of Drummond Island now known as Whitney Bay, and included them within the "limestone of the Manitouline Range."

In 1824, Bigsby (1824, p. 199, 200) described the outcrops of rock at Collier's Harbor more fully and also noted the presence of the "Manitouline limestone" at "the angle of Drummond, on the north of the False Detour," which is the promontory now known as Marblehead.

It is of interest to note that the fossils, which Bigsby described in this paper (1824, p. 202-204, pls. 28-30) and his earlier one (1821, p. 271, pl. 2, figs. 6, 7), are characteristic of a formation of the Niagaran series subsequently defined as the Cordell Member of the Manistique Dolomite.

In his annual report of 1840 Dr. Douglass Houghton (1840, p. 215-220), first State Geologist of Michigan, divided the limestones and shales of the eastern half of the Northern Peninsula into the "lower limerock and shales" and the "upper limerocks." The strata designated as lower limerock and shales are of Ordovician age and underlie a broad belt to the north of the belt of Niagaran strata. The upper limerocks were divided by Doctor Houghton into a lower or "Pentamerous portion," a middle or "Polypferous portion," and an upper or "Mackinac and Manitoulin portion." Most of the strata included in the lower and middle portions of the "upper limerocks" are of Niagaran age. Some beds of the lower portion, such as those which Doctor Houghton noted as capping the hills on the eastern side of Little Bay de Noc, are of Richmond

age. The strata underlying the Cheneaux and Mackinac Islands were assigned to the upper portion of the upper limerocks by Doctor Houghton. In the case of the Cheneaux Islands the underlying rocks are believed to be of Niagaran age. The underlying rocks of Mackinac Island, however, are younger than Niagaran and are now included by the Michigan Geological Survey in the Salina and Bass Islands groups and the Mackinac breccia.

There is reason to believe that Houghton did not clearly recognize the correct superposition of the lower and middle portions of the upper limerocks. On page 219 of his report he stated that the rock at Collier's Harbor, Drummond Island, belongs to the lower portion of the upper limerocks and that this rock is overlain by strata of the middle or coralline ("polypferous") portion. This order of succession of the strata as stated by Houghton is incorrect. The rock at Collier's Harbor, described later in the present paper as a part of the Engadine Dolomite, lies above instead of below the coral-bearing strata, which make up the major part of the Cordell Member of the Manistique Dolomite. Furthermore, it is not understood why Houghton (p. 219, 221) placed the rock at Collier's Harbor in the lower portion of the upper limerocks, and that which he described as occurring "on the westerly side of Pt. Seul Choix" and "in the vicinity of Pt. Detour of Green Bay" in the middle portion. The rocks noted by Houghton at these localities belong to the same formation, the Engadine Dolomite, and occupy a position above the coral-bearing Cordell strata.

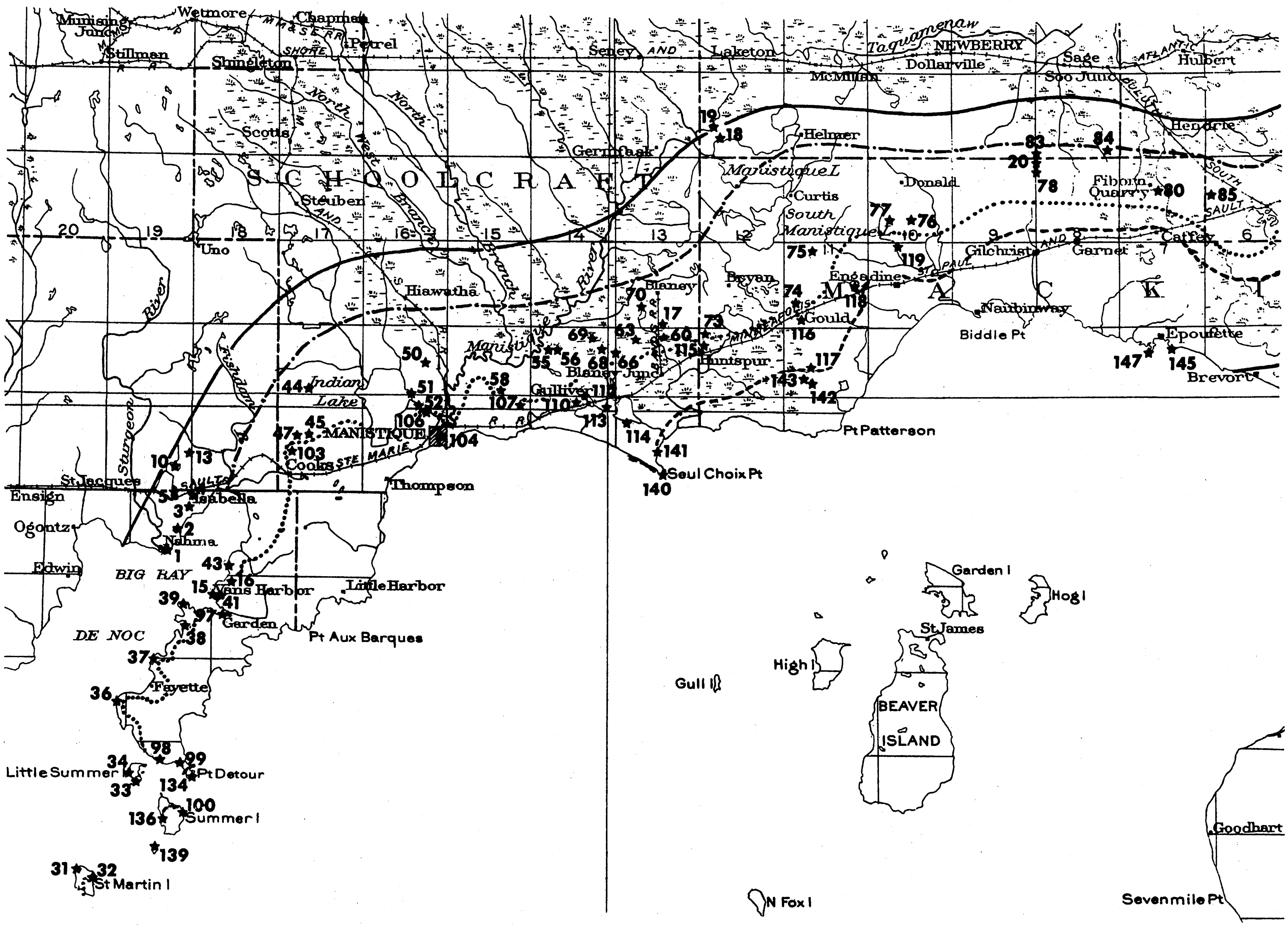
In 1843, Francis de Castelnau (1843, p. 11-12) proposed the name "huronienne" as a formation name for the Silurian deposits bordering the north shores of Lake Huron of which the Niagaran strata are a part. The name "huronienne" for these deposits, however, has not been recognized by later geologists.

The first important contribution to the classification of the Silurian deposits of the Northern Peninsula was made by James Hall, whose observations and conclusions are contained in a report on the geology of the Lake Superior land district by J. W. Foster & J. D. Whitney (1851, p. 153-163, 215-231). On pages 152 and 153 of this report, Hall divided the Silurian system (designated Upper Silurian by Hall) of the Northern Peninsula into the "Clinton group" at the base, the "Niagara group" above, and the "Onondaga Salt group" at the top. These groups were correlated by Hall with similarly named Silurian divisions of New York State.

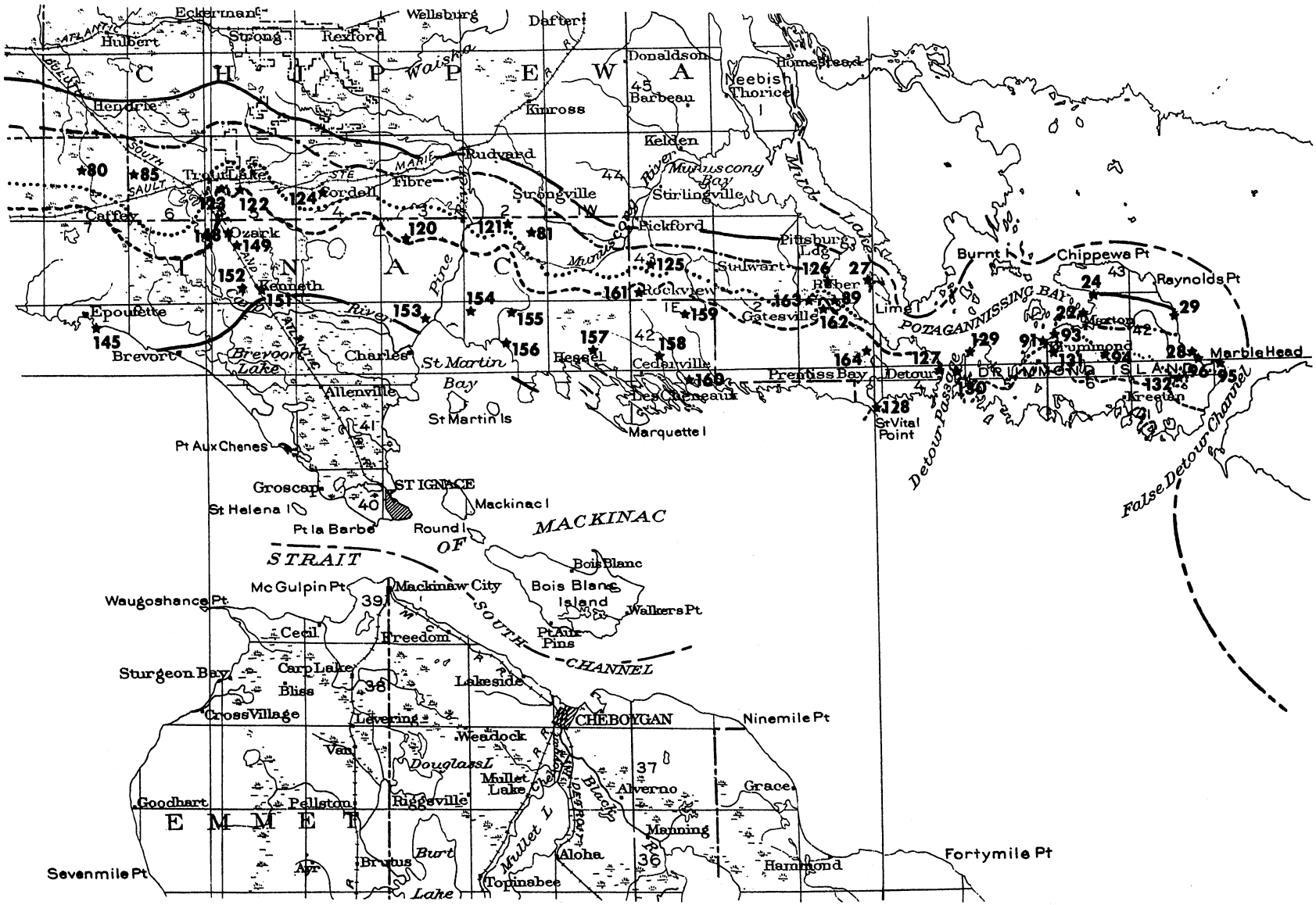
Hall (1851, p. 153-160) described several exposures of the Clinton and Niagara Groups, stating that these groups cannot be readily separated in the Northern Peninsula. He included in the Clinton Group the strata at lake level at the eastern extremity of Drummond Island (probably Marble Head), those along the base of a cliff about 250 feet in height and about 3 miles above the entrance to Little Bay de Noc (with little doubt Burnt Bluff on the eastern side of Big Bay de Noc), and beds at the level of St. Mary's River just above Lime Island. The higher strata at the first two localities mentioned and beds exposed at several places along the eastern, western, and southern shores of Drummond Island and at many localities on the north shores of Lake Huron and Michigan were assigned by Hall to the Niagara Group. The combined thickness of the Clinton and Niagara strata was estimated by Hall (1851, p. 160-161) at not more than 350 feet.

According to Hall (1851, p. 161-162), strata of the Onondaga Salt group, now known as the Salina Group, are exposed on Mackinac Island and on the mainland north of St. Ignace. On a geological map accompanying the Foster & Whitney report, strata of this group also are indicated as underlying the extremity of the St. Martin Point peninsula and parts of the St. Martin Islands.

Hall (1851, p. 158) and Charles Whittlesey (Whittlesey, 1851, p. 182), who cooperated with him in studying the geology of the Lake Superior land district, noted the occurrence of Pentamerus-bearing beds in the Niagara group and stated that these beds occupy a position below other strata of this group containing numerous coral remains. In their discussions, however, these writers also applied one or more or all of the terms "Pentamerus bed," "Pentamerus beds," "great Pentamerus bed," "Pentamerus member," and "Pentamerus limestone" (see pages 157-159, 179, 182, 196-198, and 200 of Foster Whitney's report) to rock above (the Engadine Dolomite) as well as to beds below the coral-bearing strata. The application of these terms to rock above the coral-bearing strata is clearly indicated by Hall's description of the "Pentamerus bed" on pages 196 and 197 of the Foster & Whitney report. His description agrees with



MAP 1 -- Western half of Niagaran exposures in the Northern Peninsula of Michigan. Stars and numbers identify principal listed localities. Maps 1, 2, and 5-15 show the bases of the following formations: Mayville (solid line), Burnt Bluff (dash-and-dot), Manistique (dotted), and Engadine (dashed); the top of the Niagaran Series is another solid line.



MAP 2 -- Eastern half of Niagaran exposures in the Northern Peninsula of Michigan. Stars and numbers identify principal listed localities. Stratigraphic boundaries as in Map 1.

the lithological composition, thickness and distribution of the Engadine Dolomite, which overlies the coral beds.

A few statements made by Hall show that he thought certain strata, lying at the top or above the Niagara strata of the Northern Peninsula, should be correlated in age with strata at Galt, Ontario, which now are included in the Guelph Formation by the Canadian Geological Survey. On pages 157 and 158 of Foster & Whitney's report, he stated that at certain localities in the Northern Peninsula "the rock has a lighter color than usually belongs to the Niagara group, and contains casts of a species of Pentamerus similar to one known at Galt, in Canada West." Pentamerus occidentalis, described by Hall in 1852 and subsequently designated as Conchidium occidentale, is with little doubt the species that Hall had in mind. This is indicated by Hall's statement (1852, p. 342) that the brachiopod Pentamerus occidentalis occurs "in the light colored limestone at Galt, Canada West, in the limestone on Lime Island, St. Mary's River, Point St. Vital, Lake Huron, at numerous points on the north shore of Lake Michigan, and on the peninsula between Green Bay and Lake Michigan." The occurrence of Pentamerus occidentalis at Lime Island, St. Mary's River, however, is exceedingly doubtful. A somewhat similar brachiopod, Virgiana mayvillensis Savage, is almost certainly the one noted by Hall at this locality. In 1859, Hall (1859, p. 30) again stated that "at some points on the northern shore of Lake Michigan...., there occurs a light-colored limestone, lying above the Niagara strata, containing generally few fossils and among them some forms not unlike those of Galt in Canada West."

In 1860, Alexander Winchell (1861, p. 54-60) obviously accepted Hall's classification, dividing the Silurian (Upper Silurian of Winchell) deposits of the Northern Peninsula into the Clinton, Niagara, and Onondaga Salt Groups.

Winchell (1861, p. 54-58, 140) noted several exposures of the Clinton, Niagara, and Onondaga Salt Groups, the respective thicknesses of which he estimated at 51, 97, and 37 feet. The lower 32 feet of strata in Dickinson's Quarry at the eastern extremity of Drummond Island (Marble Head) were described by Winchell and correlated by him with the upper portion of the Clinton Group of New York state. According to Winchell, the rocks outcropping along the shore of this island from Dickinson's Quarry to Pirate Harbor (known also as Pilot Harbor) occupy a lower position in the Clinton Group. He also assigned to the Clinton Group strata exposed in Brown and Seaman's Quarry in the vicinity of Drummond Village on the northwestern side of the Island, in an experimental quarry of a ship canal company near Drummond village, and "at numerous points as far south as the neighborhood of the old British fort." The higher beds at Marble Head, the rocks exposed on the south shore of Drummond Island, and those bordering most of the north shores of Lakes Huron and Michigan were assigned by Winchell to the Niagara Group. Strata, exposed at lake level on the east side of Little St. Martin Island, at the base of Mackinac, Round and Bois Blanc Islands, and in the vicinity of Little Pt. aux Chene, at Sitting Rabbit (Rabbits Back), and at other localities on the mainland west of Mackinac Island, were placed by Winchell in the Onondaga Salt Group.

In a later paper, Winchell (1873, p. 39, 50-54) divided the Niagara Group into the "Niagara limestone" and "Clinton Sub-group or limestone," describing in detail the exposures of these limestones at the eastern extremity of Drummond Island (Marble Head) and in the vicinity of the Jackson Iron Furnace, located on what now is known as Snail Shell and Fayette Harbor of Big Bay de Noc.

On page 51 of the above-mentioned paper, Winchell noted that "a portion of the mass (Niagara limestone) is generally very thick-bedded, more coarsely crystalline, vesicular, and abounding in Pentamerus oblongus, whence it was styled by Dr. Houghton the 'Pentamerus limestone'." Winchell was uncertain, however, as to the stratigraphic position of this part of the Niagara limestone, since, he stated in the next sentence, "these beds seem generally to occupy a middle position, but observations in the vicinity of Bay de Noc tend to indicate that the Pentamerus beds are not always in the same horizon."

In 1863 W. E. Logan and others (p. 320, 321) stated that

> it is probable that the Clinton formation extends through the length of the Grand Manitoulin Island, as well as that of Cockburn and Drummond Islands, striking across the various deep bays, which indent all of these islands on the north side.

They (1863, p. 321) furthermore noted that

> the probability of the continuance either of this (Clinton formation) or of the Medina formation, is supported by the reported occurrence of red strata on the Sucker River, on the Michigan side of St. Mary River, nearly opposite to the southern extremity of St. Joseph Island: this would be in the strike of the Clinton.

Logan and others (1863, p. 333) noted that limestones, which they assigned to the Niagara Formation, "come up to the south front of the Grand Manitoulin, Cockburn, and Drummond Islands; and form the Huron coast of the northern peninsula of Michigan, as far as Martin Bay." They also stated (p. 333) that the fossils of the Niagara Formation consist chiefly of corals and listed several species from the strata of the south side and west end of Drummond Island. Most, probably all, of the corals recorded by these geologists were obtained from strata subsequently placed in the Cordell Member.

Logan and his associates (1863, p. 344) noted that the Guelph Formation of Ontario, which they considered as a distinct unit overlying the Niagara Formation, "seems to thin out in Lake Huron, before reaching the northern peninsula of Michigan."

The distribution of the Medina, Clinton, and Niagara formations in the Northern Peninsula is shown by Logan and his associates on maps in the "Atlas of maps and sections" published in 1865 and intended to accompany their 1863 report on the geology of Canada. On map 1 of the atlas the Niagara Formation is indicated as underlying a narrow belt of land in the Northern Peninsula bordering the north shores of Lakes Huron and Michigan. On map 3 the Medina, Clinton, and Niagara Formations are shown as occupying belts trending east-west across Drummond Island. The Niagara Formation is shown as composing the surface rock of all of Lime Island in the St. Mary's River.

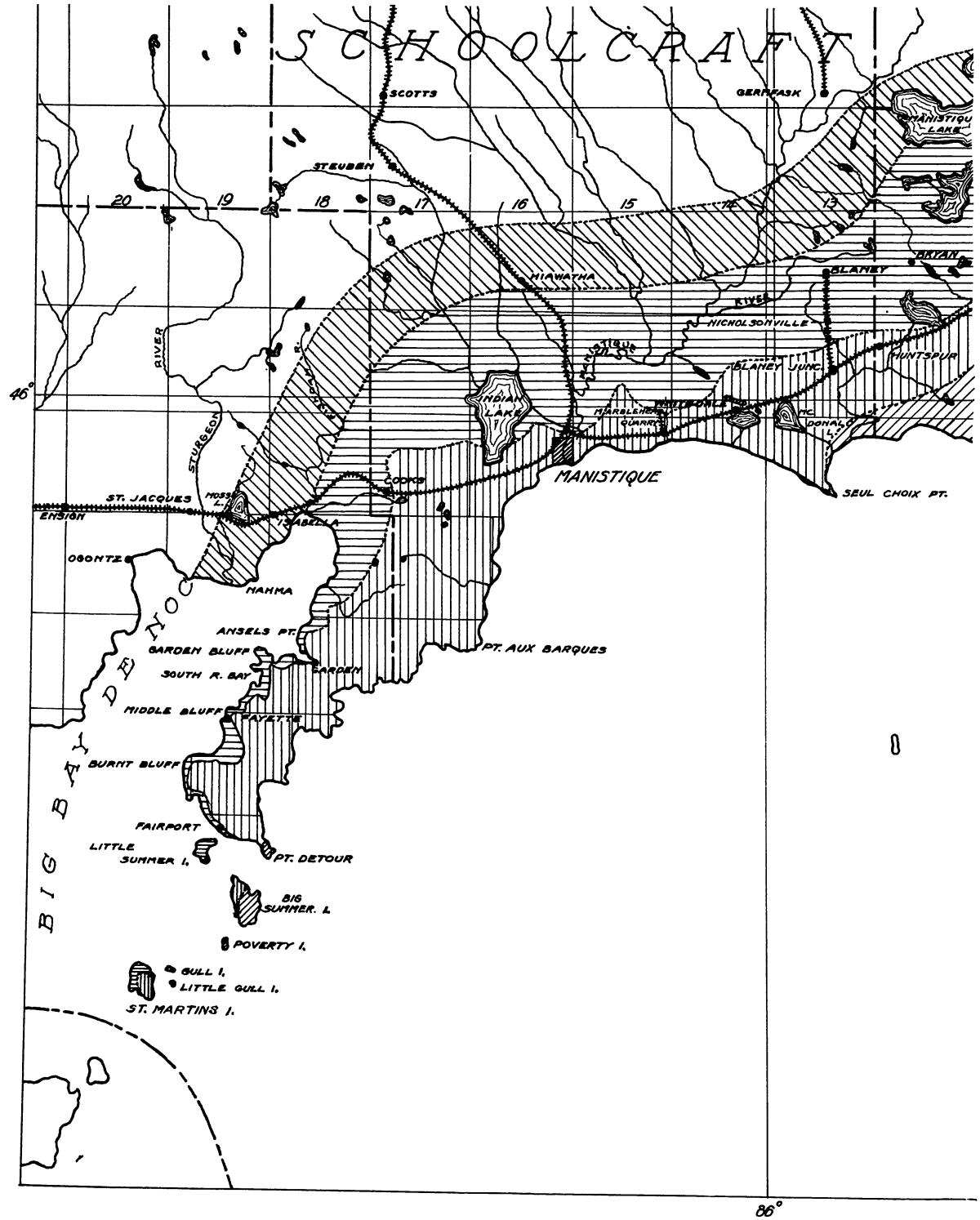
In 1870 Robert Bell (1870, p. 113-116) of the Geological Survey of Canada briefly described the Silurian rocks of Drummond Island and adjacent areas of Michigan to the west, assigning them to the "Clinton" and "Niagara formations." He stated that the Clinton Formation occupies a strip of land on Drummond Island about two miles wide, the base of the formation extending westward across the island from Colton Bay, adjacent to the center of sec. 4, T 42 N, R 7 E, to Vermont Harbor, just south of sec. 33, T 43 N, R 6 E. The Niagara Formation, according to Bell, "cuts off the northern part of Drummond Island, passes just south of the southern part of St. Joseph's Island and appears to enter the mainland of Michigan near Sucker Creek. Lime Island, on the American side of the International boundary, and a few of the small islands between St. Joseph's and Drummond Islands are situated upon the Niagara rocks."

The rocks of the Niagara Formation exposed in the cliff and subsequently abandoned quarry of Mr. Frazer at Marble Head on the eastern side of Drummond Island and those shown in a quarry on the western side of the island opposite Harbor Island, one of the abandoned quarries near Drummond village, were described by Bell in considerable detail. He also noted the presence of an escarpment of Niagara strata which extends westwards across the island from Marble Head to the vicinity of the last-mentioned quarry.

An item of stratigraphic importance is contained in a statement by Bell (1870, p. 113) that the top of the Clinton Formation on Drummond Island is marked by a "stratum of red marl which, on Grand Manitoulin (Manitoulin Island), has been taken as representing the iron-ore band..." The iron-ore band, which Logan and others (1863, p. 314, 320) had previously noted as occurring in the Clinton of Ontario, occupies a position, according to Williams (1919, p. 36), a little above the center of the Cabot Head Shale Member of the Cataract Formation, which is of Medinan instead of Clinton age.

According to Bell (1870, p. 113) the stratum of red marl "was found in one place a short distance east of Medford Bay," located on the west side of Drummond Island just north of the rural community of Maxton, and "probably follows the channel between St. Joseph's and Lime Islands." He (1870, p. 113) also noted the "existence of a similar marl further west at Sucker Creek, as referred to in the Geology of Canada (Logan and others, 1863, p. 321)."

The "red marl" noted by Bell a short distance east of Medford Bay may well be weathered Cabot Head Shale instead of a red glacial lake clay, which is present locally on



MAP 3 -- Western part of area, showing areal extent of formations in the region of Garden Peninsula, offshore islands, Manistique, and Manistique Lake. Original prepared under direct supervision of the author.

Drummond Island. An examination of the samples of a well drilled for oil near the southern shore of the island in the SW$\frac{1}{4}$ sec. 17, T 41 N, R 7 E, shows the existence of the Cabot Head Shale. If this shale reaches the surface of the island, as seems most likely, the locations of numerous outcrops of strata known to be above and below the shale indicate that the Cabot Head Shale must underlie the Medford Bay region and a narrow east-west belt along the valley of the Potagannissing River which empties into this bay.

In 1873 Carl Rominger (1873, p. 13, 14, 29-50) also accepted Hall's classification of the Silurian deposits of the Northern Peninsula, describing in much detail numerous exposures of the Clinton, Niagara, and Onondaga Salt Groups. He (1873, p. 37) classified the rocks of the Niagara group as follows:

> The rock beds of the Niagara group allow a subdivision in three well-marked sections. It is exclusively a limestone formation. The lower section is always very regular and even-bedded, composed of comparatively thin layers of a fine crystalline grain, or with a dull, more earthy fracture. In composition, most of the strata are dolomites, only a few layers are found to be a pure limestone. Fossils are rare in it. The middle division is made up by more massive highly crystalline dolomite ledges, which usually contain a large number of the casts of Pentamerus oblongus, and some ill-preserved corals. The third upper division is a series of thin, uneven layers, with intermixture of much silicious matter with the dolomite mass, and of seams and nodular concretions of hornstone. In this upper division, also, the greatest abundance of fossils is found.

Rominger misinterpreted the superposition of the strata of his middle and upper divisions of the Niagara group. The strata of the upper division, which contain numerous corals and other invertebrates, lie below instead of above the massive, highly crystalline dolomites of the middle division.

Rominger, Houghton, Hall, and Winchell may have assigned the coral-bearing strata of the Niagara group to a position above the massive, Pentamerus-bearing dolomites for one or more of the following reasons: firstly, they may have thought that the latter beds were the same as other Pentamerus beds occurring below the coralliferous strata; secondly, they may have found the coral-bearing strata at a higher elevation than the massive, Pentamerus-bearing dolomites and hence assumed that the former rest upon the latter; and thirdly, they may have thought that glacially-transported masses of coralliferous rock, lying on top of the massive, Pentamerus-bearing strata, were in place.

Rominger (p. 49, 50) stated that some of the lower strata at Marble Head, Drummond Island, were probably contemporaneous with the Clinton beds of New York state but were not separated by any line of demarcation from the overlying Niagara strata.

In a classification of the geological formations of the Northern Peninsula, published by M. E. Wadsworth (1893, p. 84), no Clinton rocks were noted and the Niagara Group was described as consisting of "100 feet of dolomite, argillaceous at the base, thick-bedded in the middle portion, and on the top, thin-bedded and siliceous."

A. C. Lane, former State Geologist of Michigan, classified the Niagaran strata which were penetrated in several deep borings in the northern part of Michigan. In the record of a boring, which was made near St. Ignace, this geologist (1895, pl. 63) designated certain strata as "Niagara" and others as "Clinton (?)-Medina (?)." In another record of a deep boring, which was made about two miles north of the one mentioned above, Lane (1902, p. 227, 228) noted 656 feet of Niagaran limestones and dolomites. He correlated the upper 510 feet of these strata with the Guelph Formation of Ontario and assigned the next lower 90 feet to the Lockport (?) and lowermost 56 feet to the Rochester (?) of Ontario and New York. In a record of a very deep well at Cheboygan about 25 miles southeast of St. Ignace, Lane (1902, p. 230-231) correlated certain strata with the Medina, Clinton, Rochester, Lockport, and Guelph formations of New York and Ontario. Lane (1905, p. 140) suggested that certain beds, penetrated in a deep well at Manistique, "... probably belong to Rominger's third or uppermost member of the Niagara, and to the Racine or upper Coralline of Wisconsin..." In describing the record of another well near Manistique this writer (1905, p. 141) stated that "apparently the well begins in the uppermost of Rominger's three fold division of the Niagara, and goes through the middle or coral beds of the Wisconsin Survey..." and that the bottom of the well "...

appears to be in Rominger's lowest division, or the Byron beds of the Wisconsin geologists."

In a table showing the correlation of Michigan, New York, and Ohio formations, Lane (1905, p. 288) indicated that the Niagara or Manitoulin (a name used by Lane as an equivalent term for Niagara) strata are to be correlated with the Clinton, Rochester, Lockport and Guelph rocks of New York and the Clinton and Niagara strata of Ohio.

In 1904, I. C. Russell (1905, p. 45-48) described several exposures of the "Niagara limestone" in the Northern Peninsula and stated that this limestone corresponds in age with the Niagara and Clinton formations of New York state.

In a paper describing the geological section of Michigan, A. C. Lane (1909, p. 53) defined the term Niagaran as applied to strata in Michigan as follows: "The term Niagaran as used in Michigan includes in mapping Clinton to Guelph, being exactly equivalent, so far as the strata occur, to the Niagaran of Clarke and Schuchert and Grabau, the lower Ontarian. In sections it has been used also in a slightly narrower sense, not including the Clinton."

Lane (1909, p. 53, 54, 56) indicated that the term Manitoulin limestone as used by Bigsby in 1823 was more or less equivalent to the term Niagaran but used it in a more restricted sense to include strata, which he correlated with the Lockport and Guelph formations of New York State.

The term Manitoulin as used by Lane and by Bigsby is not generally recognized and should not be confused with the Manitoulin Dolomite of the Cataract Group of Ontario.

Regarding the presence of strata of Clinton age in the Northern Peninsula, Lane (1909, p. 54) stated that

> while all writers recognize that the Clinton facies exists in the Upper Peninsula, Rominger does not consider it worth dividing, and none have tried to map it separately. A. Winchell makes it but 3 feet thick... At Pickford [Lane had reference to a deep boring at this locality] it can not be identified. The whole interval from Trenton to Niagara limestone is given as only 265 feet, and no subdivisions of this Manitoulin were reported and only one sample kept.

According to Lane, (1909, p. 54) about 60 feet of Clinton strata were penetrated in a deep boring at Cheboygan.

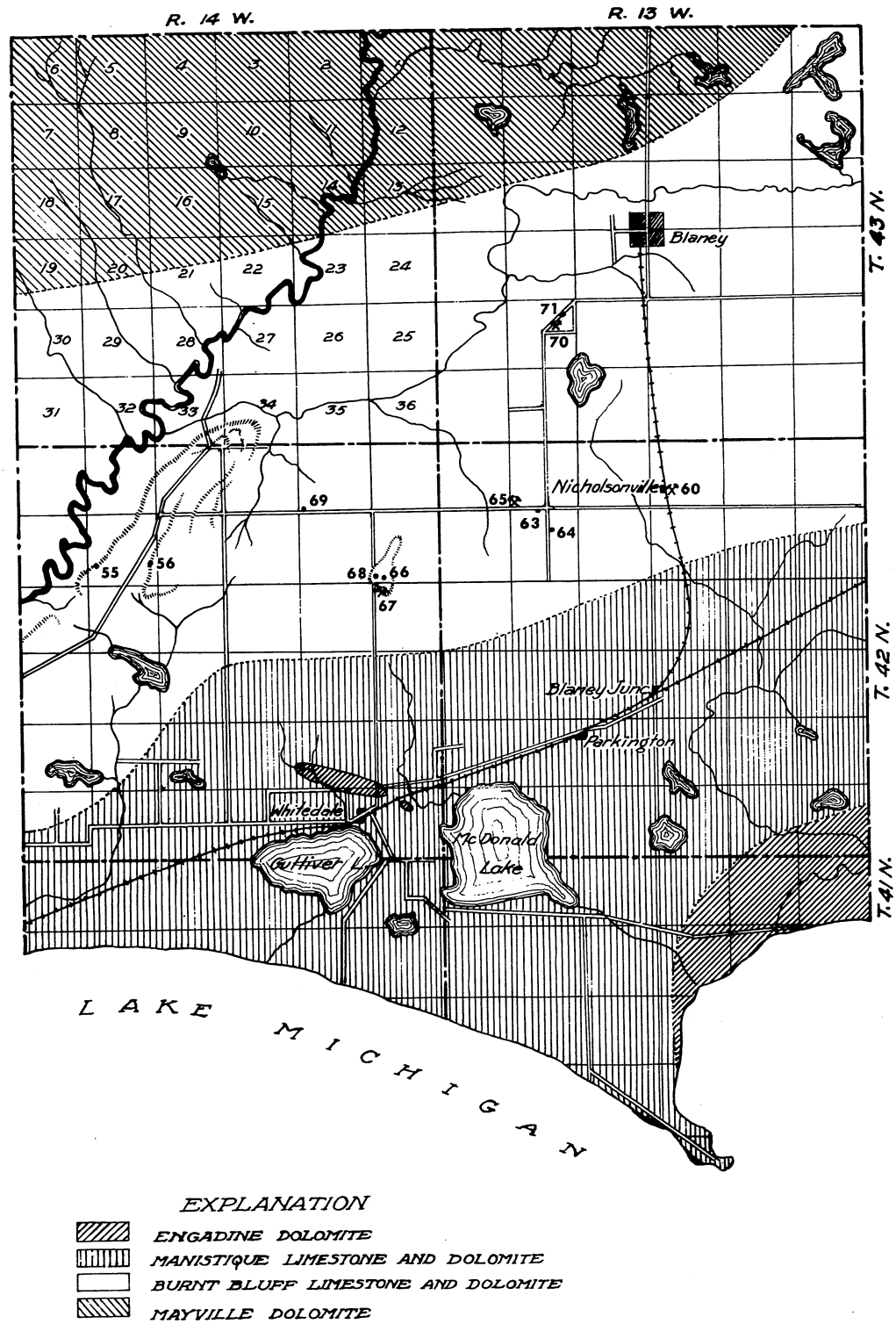
Lane (1909, p. 56, 57) described the Lockport and Guelph formations as follows:

> The Lockport and Guelph have different fossils but have never been separated paleontologically in Michigan. The upper limit against the Salina or Monroe is marked only in this way, that the Guelph is peculiarly hard and peculiarly white. One cannot absolutely depend upon the presence or absence of anhydrite as a dividing line. It is convenient at times to separate off the lower, less white, and uniform part as Lockport. The total thickness of the two at maximum seems fairly persistent and uniform, across the lower part of the state 350 to 270 feet. At the north part of the state it appears to be thicker. The well no. 2 St. Ignace gives just 600 feet, and at Cheboygan (1525-2123) the figures are almost exactly the same. Extreme whiteness of the upper part, occasional grains (1% or 2%) of sand as though wind blown in the dolomites, and occasional beds of sandstone are characteristic all over the state. It is exposed only in the Upper Peninsula. It forms the shore of Lake Michigan and Huron in a continuous ridge which rises to the north almost at the dip of the beds, which is about 50 feet to the mile, from the lake level 580 feet A. T. in somewhat less than 10 miles to an elevation of about 800 feet A. T. Here and there it outcrops and very often the soil over it is thin. While as a whole it is dolomitic there are horizons, notably that of the Fiborn and Rex quarries which run nearly pure calcium carbonate. They probably occur in the lower part beneath the Guelph.

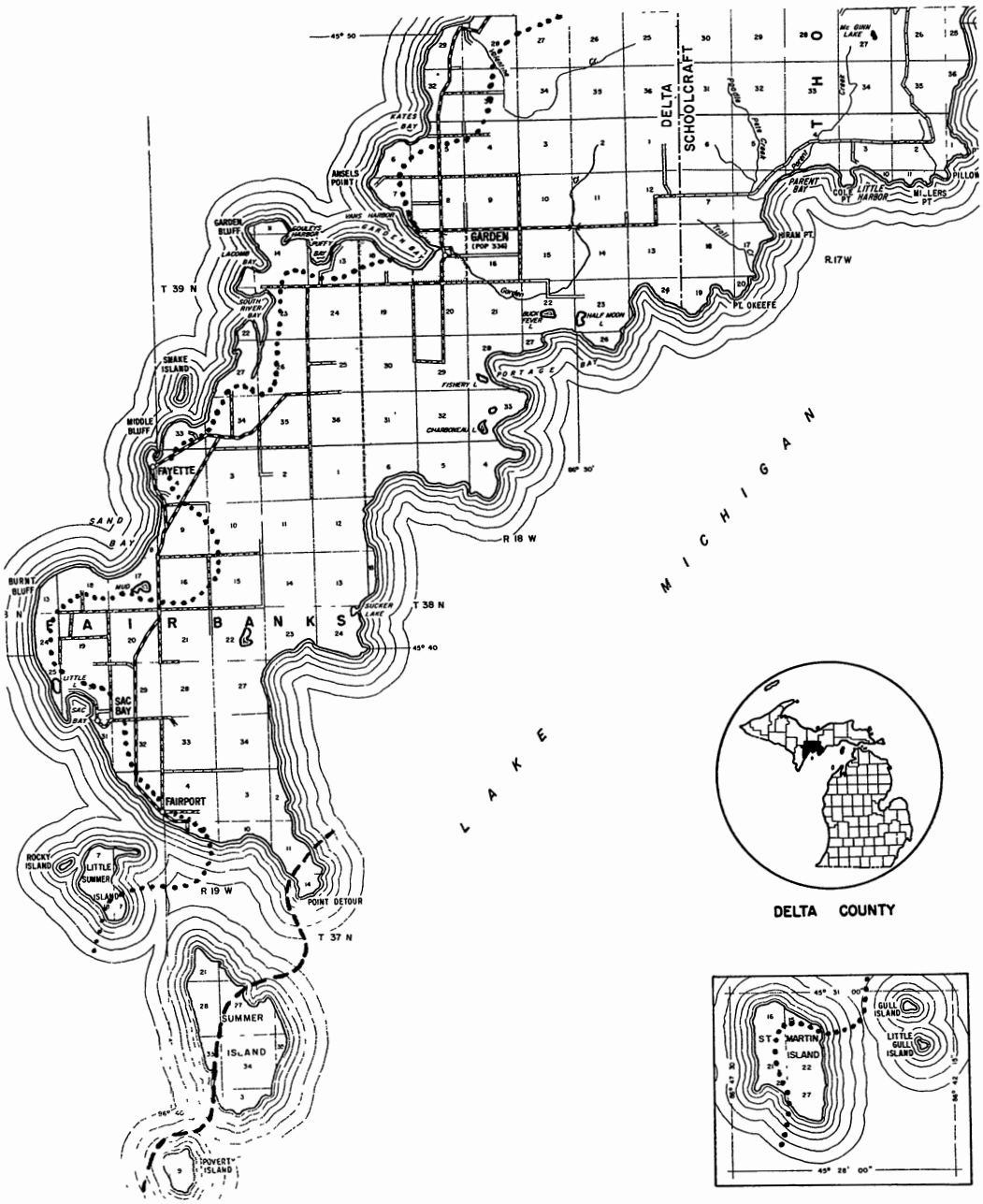
In a tabulation of well records, Lane (1909, p. 57) indicated that the lowest 90 and 71 feet of Niagaran limestones which were penetrated respectively in deep borings at St. Ignace and Cheboygan, are questionably equivalent to the Lockport and that the 232 and 185 feet of dolomites, which respectively overlie the lowest 90 and 71 feet of Niagaran limestones of these borings, are equivalent to the combined Coral and Byron beds of Wisconsin.

In 1915 R. A. Smith (1915, p. 150) briefly described and defined the "Niagara" limestone as follows:

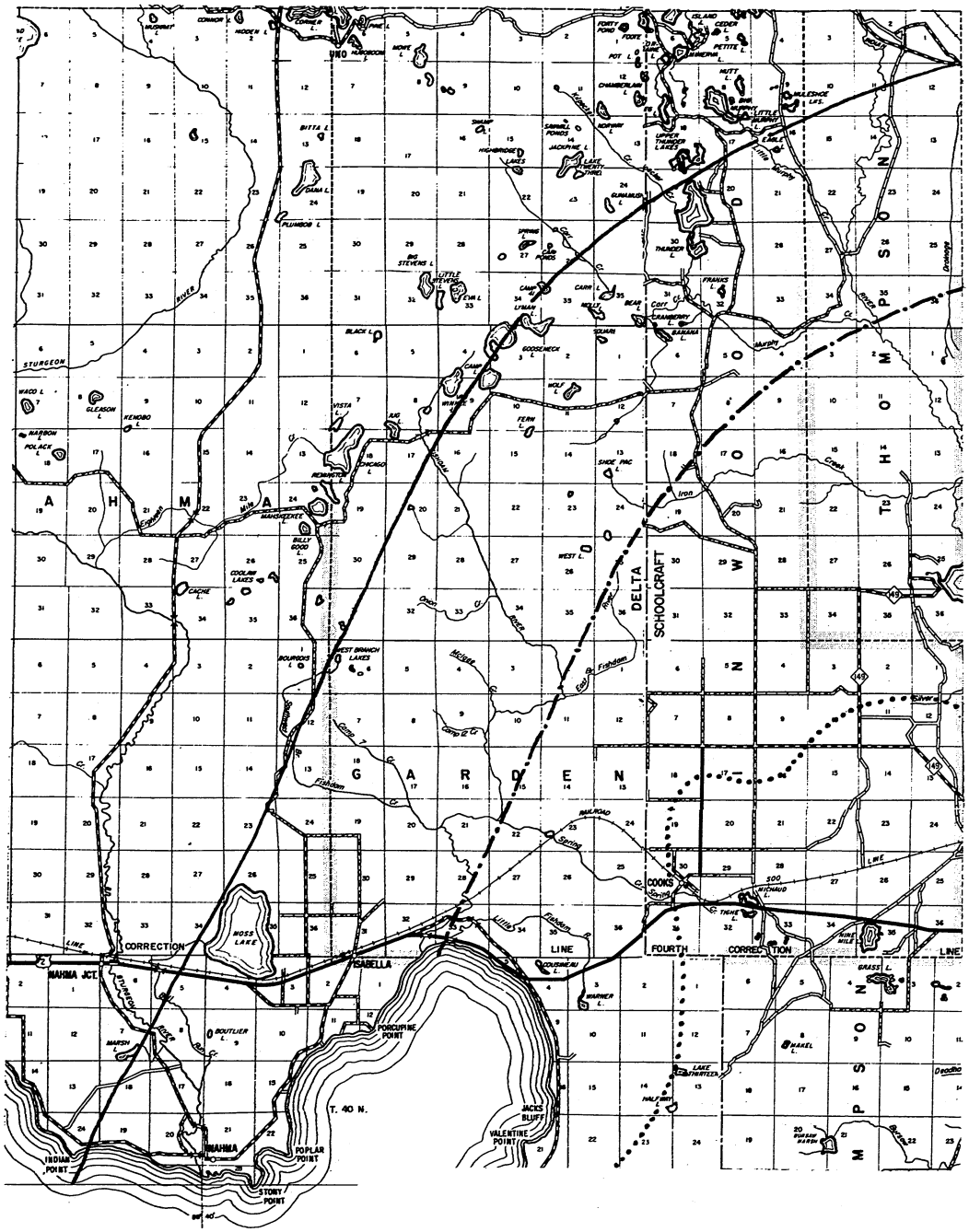
> The "Niagara" limestone is composed of an upper whiter and more crystalline portion called the Guelph dolomite, and a lower darker and generally less crystalline portion called the Lockport limestone, which is the Niagara proper. Since the two formations have not yet been certainly differentiated in Michigan and since quarrymen, lime burners, and lime users are habituated to the use of the term 'Niagara', the name is retained in this report to include both



MAP 4 -- Eastern Schoolcraft County, showing areal extent of formations and principal localities of Burnt Bluff exposures. Original prepared under direct supervision of the author.



MAP 5 -- Area of T 36-40 N, R 17-20 W, covering parts of Delta and Schoolcraft Counties. This up-to-date map shows current roads, towns, and place names. See explanation of Map 1 for stratigraphic boundaries. Square inset shows islands lying southwest of Poverty Island and circular inset shows the location of Delta County in Michigan.



MAP 6 -- Area of T 40-43 N, R 17-19 W, covering parts of Delta and Schoolcraft Counties. Map shows current geographic features. See explanation of Map 1 for stratigraphic boundaries.

the Guelph and the Lockport.

R. A. Smith (1915, p. 151-156) divided the Niagara Limestone into four units, which he provisionally designated the Engadine dolomite, Manistique series, Fiborn limestone, and Hendricks series.

Allen, Smith, & Barrett (1916) of the Michigan Geological and Biological Survey indicated in the legend of a geological map of Michigan published in 1916 that the Engadine Dolomite is of Guelph age, the Manistique Series of questionable Guelph age, and the Fiborn Limestone and Hendricks Series of doubtful Lockport age. The Hendricks Series was indicated as lying above older Niagaran strata, definitely assigned to the Lockport.

In January, 1918, T. E. Savage & H. F. Crooks (1918, p. 59) decided that the Hendricks Series and Fiborn Limestone are much older than Niagaran and are "equivalent in age to the Mayville limestone of Wisconsin," the lower and middle parts of which Savage (1916, p. 310, 311) had previously correlated with the Edgewood Formation of Illinois and Missouri. Savage & Crooks based this equivalence in age chiefly on the occurrence of the brachiopod Virgiana mayvillensis in certain strata of the Hendricks Series and in the uppermost beds of the Mayville Limestone. They stated furthermore (1918, p. 63) that

> the Hendricks dolomite and probably also the Fiborn limestone in Northern Michigan, including all of the Silurian strata between the top of the zone containing Virgiana barrandei var. mayvillensis and the top of the Maquoketa, and which contain fossils consistent with the Edgewood, are considered the time equivalents of some part of the Edgewood formation, and are thus much older than the Niagaran.

In 1920 G. M. Ehlers (1920, p. 87-90) suggested the use of the name Racine for the uppermost Niagaran Formation of the Northern Peninsula of Michigan previously designated as Guelph and Engadine. G. M. Ehlers (1921, p. 129, 130) also presented a short paper on the Niagaran rocks of the Northern Peninsula of Michigan before the Paleontological Society of America at its annual meeting in Chicago in 1920. On this occasion he proposed a classification of these rocks in which, beginning at the base, the strata are grouped under the Mayville, Burnt Bluff, Manistique, and Racine Formations. The lithologic and faunal nature of these formations and their stratigraphic relationships were noted at this time.

In 1923 E. O. Ulrich & R. S. Bassler (1923, correlation chart, p. 267) gave a classification of the Niagaran deposits of Michigan and southwestern Ontario in a correlation chart included in a report on the Silurian of Maryland, published by the Maryland Geological Survey. In this chart Ulrich & Bassler indicated the existence of the Cataract Formation, which they placed in the "Alexandria or Upper Medinan" group of the Lower Silurian "Medinan" Series. They noted the occurrence of the "Mayville and Dyer Bay dolomites," which they included in the "Clinton" Group of the Middle Silurian "Niagaran" Series. Younger rocks, designated by them as "Lockport dolomite with Guelph at top and Byron at base," were assigned to the "Lockport" Group of the "Niagaran" Series.

In February 1928 Walter A. Ver Wiebe (1928, p. 309-331) published a paper on the "Stratigraphy of Chippewa County, Michigan" in which the beds of the Niagaran series of this county are grouped, except for few minor differences, according to the classification proposed by G. M. Ehlers in 1921. Ver Wiebe indicated that certain beds of limestone on Drummond Island doubtfully represent an eastward extension of the Fiborn Limestone of R. A. Smith and included these limestones in the Burnt Bluff Formation as the "Fiborn member." He divided the Manistique into "Lower" and "Upper Divisions" and used the names "Racine" and "Engadine" in an interchangeable manner.

Ver Wiebe (1928, p. 319) stated that certain dolomites exposed on the west side of Drummond Island on the Walter Stevenson farm, $SW\frac{1}{4}$ sec. 3, T 42 N, R 6 E, "may be of Mayville age or possibly even of Richmond age though the writer believes this unlikely." He (1928, p. 319) also noted that these dolomites were similar in lithology to the Manitoulin Dolomite of Manitoulin Island.

Proposed classification. -- As the result of a further study of the stratigraphy of the Niagaran series of the Northern Peninsula, the writer believes that his former classification (Ehlers, 1921, p. 129, 130) of these rocks should be somewhat modified. The modified classification which the writer herewith proposes is presented below:

Silurian System	Niagaran Series	Lockport Group	Engadine Dolomite	
		Clinton Group	Manistique Dolomite	Cordell Member
				Schoolcraft Member
			Burnt Bluff Limestone & Dolomite	Hendricks Member
				Byron Member
			Mayville Dolomite	

The use of the name Mayville for the lowest known division of the Niagaran Series is proposed for the reason that the rocks of this division are continuous with the Mayville beds of northeastern Wisconsin, have the same lithologic character, and contain several fossils diagnostic of the latter beds. The term "Mayville beds" was proposed by T. C. Chamberlain for the lowest member of the Niagaran of Wisconsin (see Geology of Wisconsin, 1883, v. 1, p. 132, 183, 187, and 1878, v. 2, pt. 2, p. 335, 336.

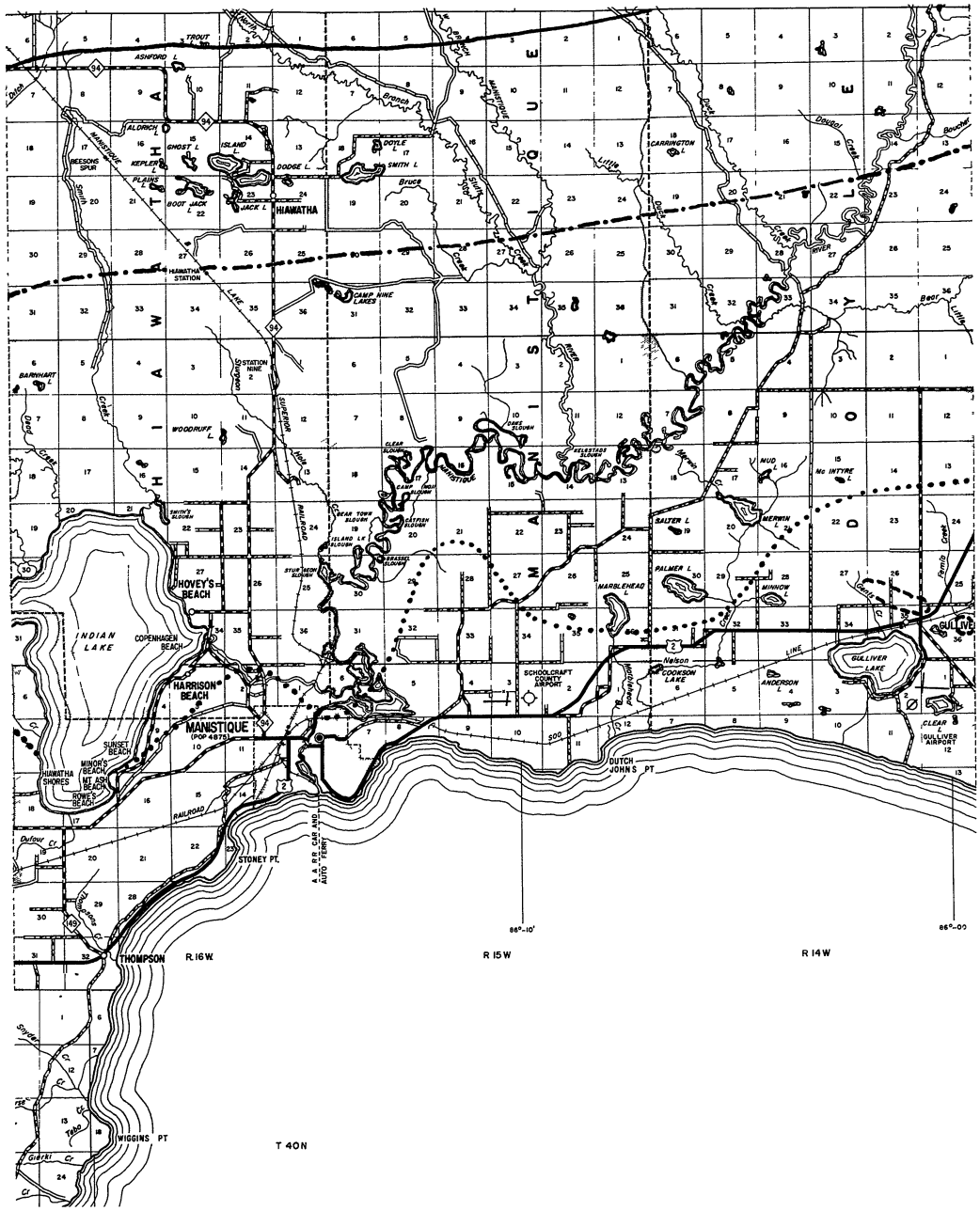
The Mayville, which is composed chiefly of dolomite, is with little doubt limited below by Richmond or Cataract strata. At Big Limestone Mountain, Houghton County, Niagaran strata, which the writer believes should be assigned in part or in whole to the Mayville Dolomite, seemingly rest on Richmond strata (see Case & Robinson, 1915, p. 173). Elsewhere in the Northern Peninsula there is a covered stratigraphic interval between the lowest exposed beds of the Mayville and the nearest outcrops of underlying strata. On Drummond Island the nearest exposures of underlying strata to the Mayville Dolomite are of Richmond age. The covered interval between these exposures, which is probably occupied by less than 100 feet of strata, may contain beds of the Cataract Formation. The reason for believing that the Cataract may intervene between the Richmond and Mayville is that on Manitoulin Island, Cataract strata immediately underlie Virgiana mayvillensis-bearing beds, marking the upper part of the Mayville. Farther westward in Delta County, Richmond beds are again the nearest rocks to the Mayville. In this area it is quite probable that the Mayville rests directly on the Richmond since such a stratigraphic relationship exists between these formations in the adjacent, northeastern part of Wisconsin and at Limestone Mountain to the northwest.

It is barely possible that unknown Niagaran strata may be present below the Mayville. However, since Mayville strata are the oldest Niagaran rocks of the adjacent areas of Ontario and Wisconsin, the possibility of the presence of older Niagaran strata in the Northern Peninsula seems remote.

The writer has been unable to obtain any faunal or physical evidence which would enable him to definitely determine the upper limit of the Mayville. For this reason, it seems best to place it provisionally at the horizon now indicated as marking the upper limit of the Mayville in Wisconsin -- namely, at the top of the beds containing numerous remains of the brachiopod designated by Professor Savage as Virgiana mayvillensis.

The writer proposes the name Burnt Bluff for a succession of limestones and dolomites occupying a position between the top of the Mayville Dolomite and a disconformity at the base of the overlying Manistique Dolomite. The name is taken from Burnt Bluff, a high cliff on the eastern side of Big Bay de Noc exhibiting the largest single exposure of the formation.

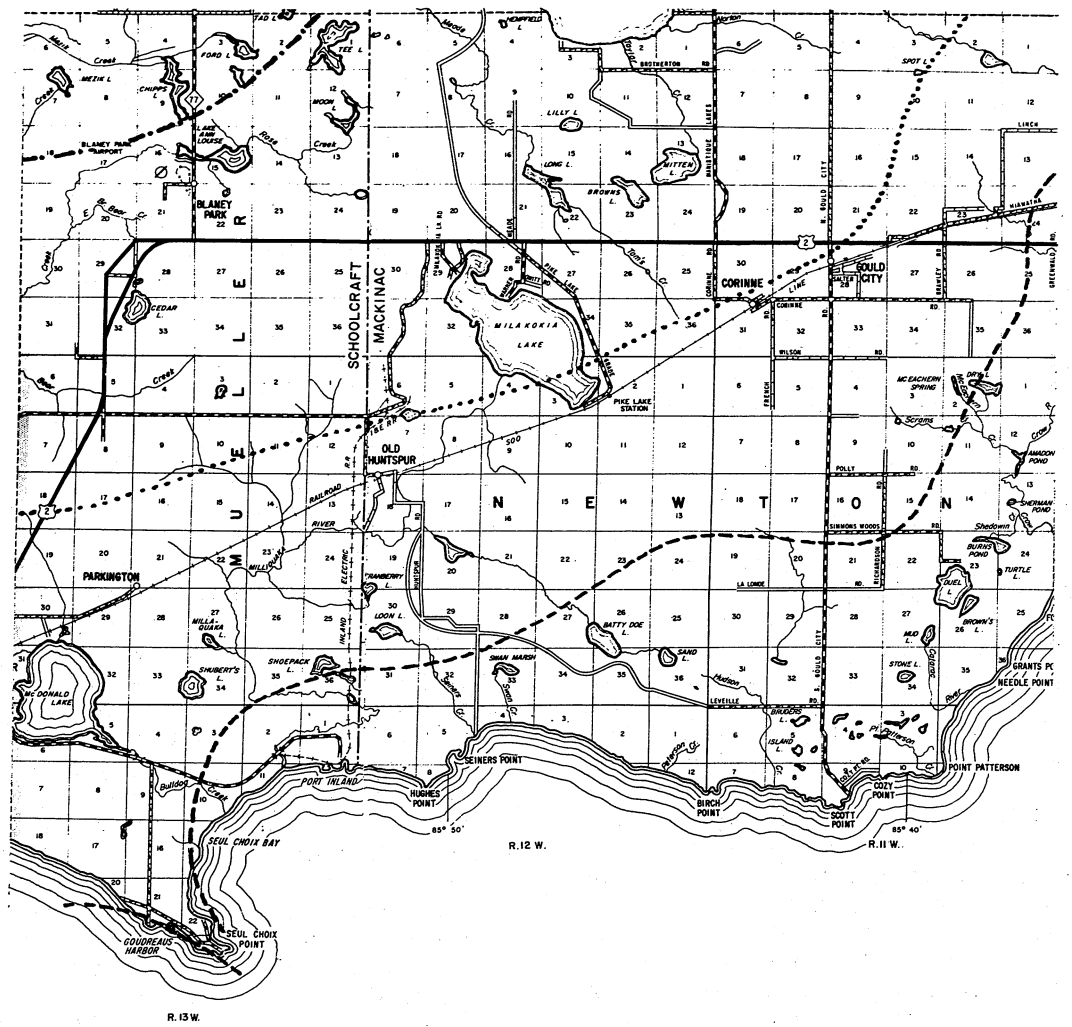
The disconformity between the Burnt Bluff and Manistique strata is indicated chiefly by a faunal break, which is best shown at localities where the uppermost strata of the Burnt Bluff are limestones. At these localities, the Burnt Bluff limestones contain a few diagnostic fossils, such as Camarotoechia winiskensis, Leperditia fabulina, and Isochilina latimarginata, and are overlain by a thick-bedded, coarsely crystalline, yellowish-gray to buff dolomite of the Manistique Formation containing numerous molds of the shells of the brachiopod Pentamerus. At most localities, however, the disconformity is very poorly indicated by a faunal difference. This is due to the fact that dolomitization has either destroyed the few fossils generally present in the uppermost strata of the Burnt Bluff Formation or has injured them sufficiently to make specific identification difficult. As a matter of fact the exact position of the disconformity seems practically impossible to determine at a few places, because the uppermost Burnt Bluff strata lack fossils and are indistinguishable lithologically from the lowest Manistique strata, which locally contain very few remains of Pentamerus. Although frequently obscured, the disconformity without doubt occupies a position



MAP 7 -- Area of T 40-43 N, R 14-16 W, in Schoolcraft County. Map shows current geographic features. See explanation of Map 1 for stratigraphic boundaries.

at or a very short distance below the base of the thick-bedded, buff, Pentamerus-bearing dolomite.

The writer proposes to divide the Burnt Bluff Limestone and Dolomite into two members, the lower one to be designated as Byron and the upper as Hendricks. The Byron is applied to the lower member for the reason that this member consists of beds, which seem to be continuous with the Byron strata of northeastern Wisconsin. The name Hendricks was proposed by R. A.



MAP 8 -- Area of T 41-43 N, R 11-13 W, covering parts of Schoolcraft and Mackinac Counties. At the lower left, the Seul Choix anticline is outlined by the base of the Engadine Dolomite. See explanation of Map 1 for stratigraphic boundaries.

Smith (Smith, 1916, p. 156) for limestones and dolomites occupying a position between the Rochester Shale below and a very pure limestone above, which he designated as the Fiborn. When thus defining the Hendricks strata, Smith doubtless decided to make the Rochester Shale the lower limit of these strata on account of the fact that Lane (1902, p. 227, 228, 230, 231) had reported the occurrence of this shale below the so-called Lockport or "Niagara" limestone in the records of the St. Ignace and Cheboygan wells. All available data now indicates that the

Rochester Shale is absent in the Northern Peninsula and that the Hendricks strata are most likely older than the Rochester Shale. As used by the present writer, the name Hendricks is applied to about 120 to 125 feet of limestone and dolomite occupying a position between the Byron and the disconformity at the base of the Manistique.

The Hendricks Member includes the Hendricks beds as typically shown at Hendricks Quarry, Mackinac County, some lower beds unexposed at this place but exposed elsewhere, the Fiborn Limestone, and the lowest beds of the Manistique as defined by R. A. Smith. The reason for including the Fiborn Limestone and the lowest beds of Smith's Manistique in the Hendricks is that these beds contain the same fossils as the typical Hendricks beds below the Fiborn Limestone.

The abandonment of the name Fiborn as suggested by the inclusion of the Fiborn Limestone in the Hendricks Member seems quite justified. The name was originally given by R. A. Smith (1916, p. 153-155) to a very pure limestone, which is well exposed in the Fiborn, Hendricks, and Nicholsonville (formerly known as Blaney) quarries and has a thickness ranging from 18 feet to 34 feet. Although this limestone is the thickest single bed of nearly pure calcium carbonate in the Niagaran series, it seems unwise to recognize it by name as a distinct unit, because the limestone may be easily confused with several lower and thinner beds having similar chemical and lithological composition. An instance of such confusion is shown by Mr. Smith's statement (1916, p. 154) that the Fiborn is present in the immediate vicinity of Lime Island, Chippewa County, and is possibly represented by a three-foot bed of limestone exposed at Marblehead on the eastern side of Drummond Island. According to Smith the presence of the Fiborn Limestone on Lime Island is indicated by numerous angular fragments of this stone in the drift. As the result of a few hours' examination of the drift on the eastern shore of the island the writer was unable to find a single fragment of unquestionable Fiborn Limestone. Instead, many fragments of a somewhat similar limestone were found which differ from the typical Fiborn in being darker gray, in practically lacking disseminated calcite crystals and in containing a few brachiopods of Trenton or Black River age. It seems quite likely to the writer that Mr. Smith may have confused these fragments of limestone with the Fiborn although some of the more numerous fragments of Burnt Bluff strata in the drift may have suggested the presence of this limestone to him. The three-foot bed of limestone at Marblehead, Drummond Island, although high in calcium carbonate, does not represent the much attenuated Fiborn Limestone. This bed, which will subsequently be discussed more fully in the description of the geologic section at Marblehead, can be readily distinguished from the Fiborn by certain lithologic characters and by the fact that it occupies a position below that of the Fiborn. The Fiborn itself is not present in its typical lithologic state on Drummond Island, in the adjacent part of Chippewa County to the west, in southeastern Delta County, or in the southwestern and south-central parts of Schoolcraft County. Its place in the geologic sections of these areas is occupied by one or more beds of massive, gray and buff dolomite. The fact that the Fiborn Limestone changes laterally into a dolomite in southeastern Schoolcraft County leads the writer to believe that one or more of the massive dolomites noted above probably represent the dolomitized Fiborn. As the result of a failure to recognize this lithologic change, it seems very certain that an error in mapping occurs on the latest geological map of Michigan, published by the Michigan Geological Survey in 1916. The Fiborn Limestone is indicated as underlying narrow, band-like areas in southeastern Chippewa County, south-central and southwestern Schoolcraft County, and southeastern Delta County. In the field the writer found that these areas are underlain by strata lower in the Niagaran Series than the Fiborn Limestone. Thick-bedded, buff and gray dolomites, occupying the stratigraphic position of the Fiborn Limestone and representing a dolomitized phase of it, are exposed in the previously mentioned counties at considerable distances south of the band-like areas, indicated on the map as the Fiborn Limestone. In view of the fact that the Fiborn is only a calcareous phase of certain dolomites of the upper part of the Hendricks Member (detailed evidence given on subsequent pages) and the fact that the Fiborn cannot be distinguished faunally from beds immediately above and below it, the writer is prompted to suggest that the name Fiborn be abandoned and has followed this course in his classification of the Niagaran Series.

The Hendricks Member rests with probable conformity on the Byron and contains many

beds of limestone and dolomite which are very similar lithologically to typical Byron strata. The Hendricks limestones and dolomites may usually be distinguished by their included fossils, some of the most characteristic of which are Clathrodictyon vesiculosum Nicholson & Murie var., Favosites n. sp. nos. 1 and 2 hemispheric forms, Camarotoechia winiskensis Whiteaves, Rhynchospira lowi Whiteaves, Stokesoceras romingeri Foerste, Leperdita fabulina Jones, and Isochilina latimarginata (Jones). The Byron beds, consisting chiefly of even-bedded limestones of very light-gray, cream and buff colors, are generally lighter colored than the Hendricks strata, somewhat more argillaceous, and in contrast with the latter seem to lack fossils. However, the limestones of the upper part of the Byron and lower part of the Hendricks are so similar lithologically that at many places the contact between these members can be drawn only arbitrarily.

The Byron and Hendricks strata are classed as members of the Burnt Bluff Formation because they seem related faunally as well as lithologically. In the Northern Peninsula the Byron beds have not yielded fossils and as a result lithologic similarity is the only basis for considering these beds and the Hendricks as members of the same formation. In Wisconsin, however, the Byron beds contain a few ostracods which suggest a faunal relationship to the Hendricks. A full presentation of the evidence indicating this faunal relationship seems unnecessary at this time and is reserved for subsequent discussion of the correlation of the Byron and Hendricks members.

The term "Manistique series" was proposed by R. A. Smith (1916, p. 151-153) for the dolomites occupying a position between the top of the Fiborn Limestone and the base of the overlying Engadine Dolomite.

The writer proposes to use the name Manistique for the dolomites between the top of the Hendricks, as re-defined above, and the base of the Engadine Dolomite. As thus defined the name Manistique applies to a lesser thickness of strata than designated by Smith, due to the fact that the lowermost Manistique beds of Smith have been assigned to the Hendricks on account of their contained Hendricks fossils.

The term "series" applied to both Manistique and Hendricks strata by Smith is rejected for the reason that these deposits do not represent stratigraphic divisions of the magnitude of series.

The writer proposes to divide the Manistique Dolomite into two members, the lower one to be designated as Schoolcraft and the upper as Cordell. The name for the lower member is taken from Schoolcraft County where numerous exposures of this unit are to be found. The type section, selected by the writer and described in detail on subsequent pages, is well exhibited in the quarry of the Inland Lime & Stone Company (formerly known as the White Marble Lime Company, and the Manistique Lime Company) at Manistique, Schoolcraft County. The name for the upper member is taken from Cordell, a station on the Minneapolis, St. Paul, & Sault Ste. Marie Railroad, about 13 miles east of Trout Lake, Chippewa County. The type section, which will be described more fully later, is exposed in the Inland Lime & Stone Company's quarry (formerly operated by the Scott Quarry Company), located in the face of an escarpment about three-quarters of a mile south of Cordell.

The Schoolcraft Member consists of massive, coarsely crystalline, brownish-gray to buff dolomites, thin-bedded, brownish-gray dolomites, and thin, even-bedded, finely crystalline, bluish-gray dolomites. The most conspicuous fossils in the Schoolcraft beds are replaced shells and molds of one or more species of the brachiopod Pentamerus. Remains of Pentamerus and other fossils are usually scarce in the thin, even-bedded, bluish gray dolomites but are generally present in greater abundance in the massive, brownish-gray to buff dolomites. The basal bed of the Schoolcraft Member as previously stated consists of a massive, brownish-gray to buff dolomite, which is usually filled with the molds of Pentamerus.

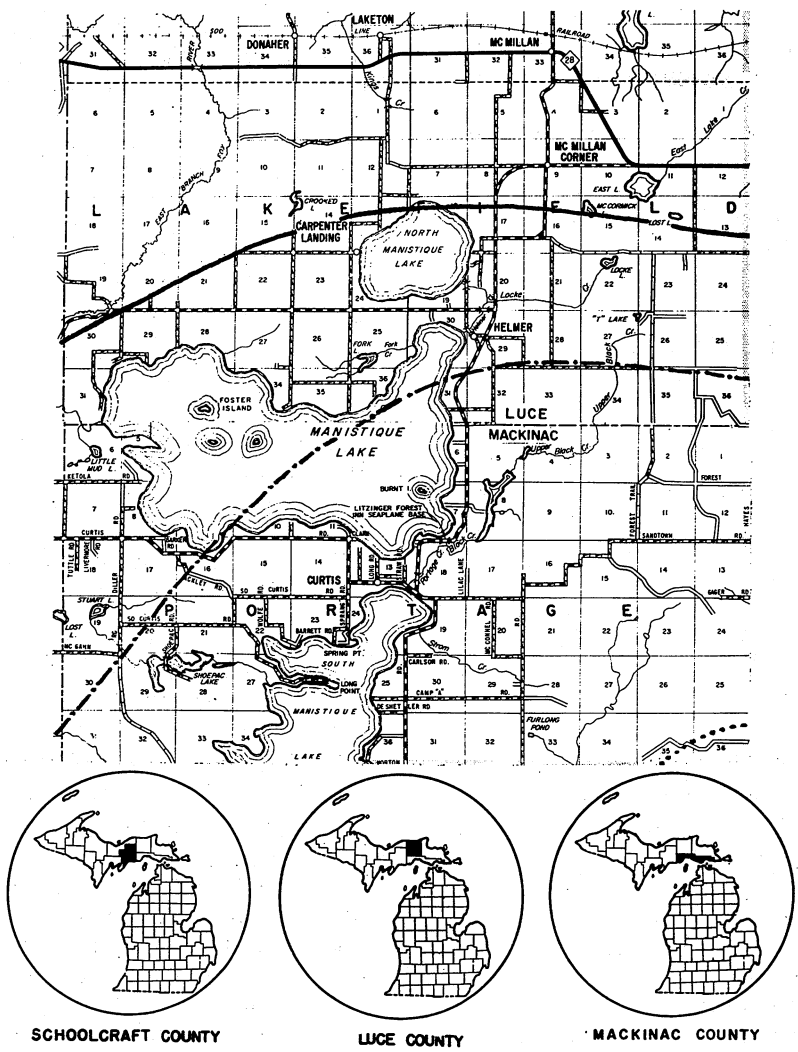
The top of the Schoolcraft Member is placed at the base of a thin, uneven-bedded, buff to brown dolomite, containing numerous layers of chert nodules, many remains of Pentamerus, and a few silicified corals and other brachiopods. The contact between this dolomite belonging to the Cordell Member and the Schoolcraft strata is very well shown in the now abandoned, southern part of the Inland Lime & Stone Company quarry at Manistique.

The Cordell Member of the Manistique consists almost entirely of thin, uneven-bedded, brownish-gray to buff, siliceous dolomites with interbedded layers of chert nodules, isolated

chert nodules, and silicified fossils. Silicified corals, consisting of several species of such genera as Alveolites, Amplexus, Arachnophyllum, Favosites, Halysites, Heliolites, Lyellia, Omphyma, Ptychophyllum, Streptelasma, Syringopora, and Zaphrentis, are very abundant in the middle and upper parts of the Cordell Member and are very useful in the recognition of this stratigraphic division.

For the thick-bedded, white and bluish-white dolomite at the top of the Niagaran the writer suggests the use of the name Engadine, the term proposed in 1915 by Mr. R. A. Smith (1915, p. 150, 151).

The name Guelph has also been applied to this dolomite. Dr. A. C. Lane (1908, p. 56, 57) referred to the dolomite as Guelph, correlating it with the formation of that name in Ontario. Smith (1915, p. 150, 151), when proposing the name Engadine for the dolomite, also



MAP 9 -- Area of T 44-45 N, R 11-12 W, covering parts of Mackinac and Luce Counties, just east of Schoolcraft County and north of the area shown in Map 8. Insets show locations of Schoolcraft, Luce, and Mackinac Counties in Michigan. The solid line marks base of Mayville, dash-and-dot line the base of Burnt Bluff, and dotted line the base of Manistique Dolomite.

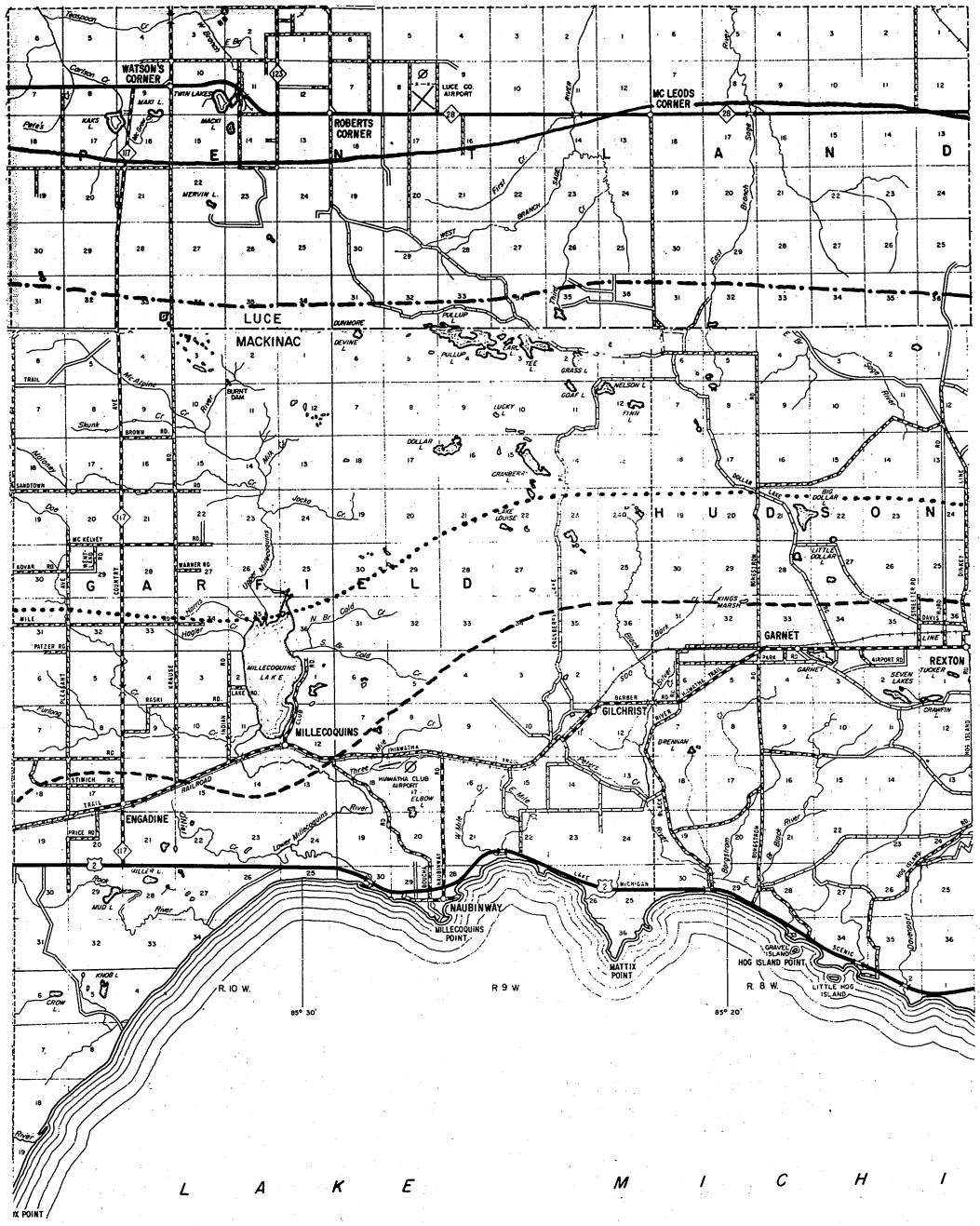
suggested its probable correlation with the Guelph. In 1916 the name Engadine was accepted by the staff of the Michigan Geological and Biological Survey (Allen, R. C., Smith, R. A., and others, 1916, Geol. Map -- legend), and the formation definitely correlated with the Guelph. In a classification of the Niagaran deposits of Michigan and southwestern Ontario, Drs. E. O. Ulrich & R. S. Bassler (1923, correlation chart, p. 267) used the name Guelph for the highest formation of these areas.

The name Guelph was apparently applied by Doctor Lane and other geologists to the uppermost Niagaran Formation on account of the fact that this formation seemingly occupies the stratigraphic position of the Guelph beds in Ontario. The somewhat similar lithological character of the rocks of the two formations may also have induced these investigators to apply the name to the Michigan formation. An even stronger reason for applying the name Guelph would seem to be indicated by the writer's discovery of a few species of Guelph relationship near the middle of the highest Niagaran formation of the Northern Peninsula (see Ehlers, 1920, p. 90).

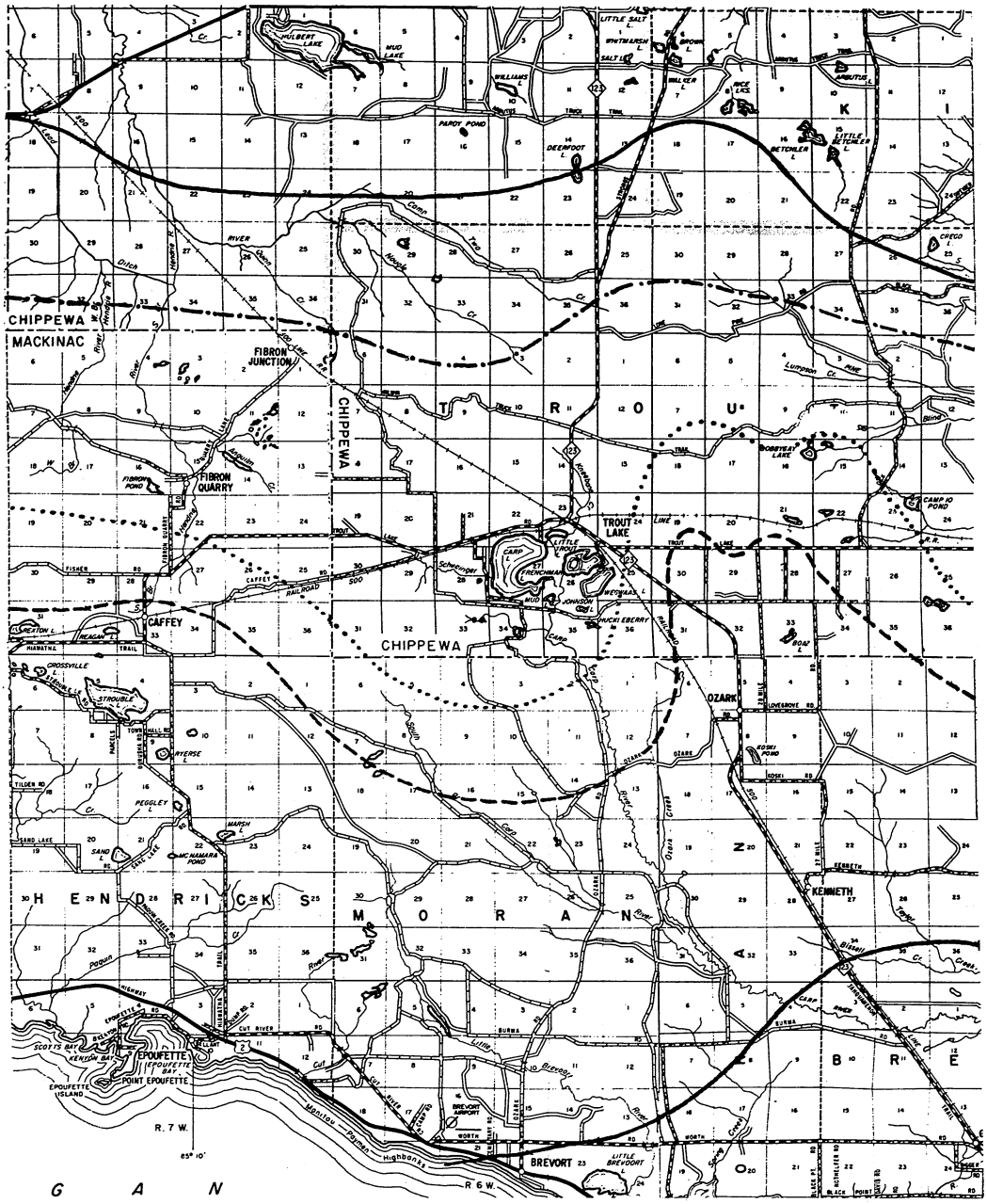
In spite of the apparently convincing evidence represented by this occurrence of Guelph species, the writer believes that the name Guelph should not be used as a formation name for the uppermost Niagaran strata of the Northern Peninsula. The Guelph fauna as shown by Clarke & Ruedemann (1903, p. 5-22) appears at least twice in the Lockport dolomites of New York State. These appearances of the fauna and the reported occurrences of some Guelph species in the Racine and still lower Niagaran formations of Wisconsin by Chamberlin (1878, p. 350, 369, 372-377; 1883, p. 183, 188) make it seem doubtful whether the term Guelph should be used in any other sense than a faunal one. Even though the typical Guelph beds may be represented in the uppermost Niagaran formation of Michigan, as the writer believes, the question remains whether somewhat older and perhaps younger strata are not also represented in the formation. In the writer's opinion it is quite possible that the formation contains somewhat older strata, which with little doubt are continuous with the dolomites of the upper part of the "undivided Lockport" of Cockburn and Manitoulin Islands. The probable presence of some of the "undivided Lockport" strata in the Engadine of the Northern Peninsula was suggested to the writer by Dr. M. Y. Williams' description of the Lockport of the Manitoulin Island region. His description (1919, p. 58, 60) of this formation, exclusive of the DeCew, Gasport, and Eramosa divisions, as a gray and bluish-gray dolomite, the composition of which is nearly that of pure dolomite and the weathered surfaces of which are nearly white, would also serve for the description of the Engadine Dolomite. Furthermore, hand specimens, taken from high Lockport strata at Quarry Point on the Lake Huron shore south of Meldrum Bay, on the western part of Manitoulin Island, and kindly sent to the writer for examination, are indistinguishable from samples taken from many beds of the Engadine of Michigan. In view of the fact that the uppermost Niagaran formation of the Northern Peninsula may contain beds lower than the Guelph, the writer believes that the name Guelph should not be applied to the highest Niagaran formation of the Northern Peninsula.

In 1920 the present writer (Ehlers, 1920, p. 87-90) suggested the use of the name Racine for the dolomite, designated Guelph by Lane and Engadine by Smith. He was prompted to use the name Racine chiefly because he found that strata composing the lower part of the Guelph or Engadine dolomite of the Northern Peninsula were with little doubt continuous with beds of dolomite in the vicinity of Sturgeon Bay, Wisconsin, referred by Chamberlin (1878, p. 368) to the Racine.

A consideration of the usage of the term Racine and the nature of the fauna of the Racine deposits of Wisconsin gave the writer further reason for applying the name Racine to the previously designated Guelph and Engadine of Michigan. As originally used by James Hall (1862, p. 67), the name Racine was applied to the highest Niagaran formation of Wisconsin. Chamberlin (1878, p. 335, 336), finding that the uppermost Racine strata of Wisconsin contained a fauna similar to that of the Guelph beds of Ontario, divided the Racine Formation of Hall into two parts, applying the name Guelph to the upper part and retaining the name Racine for the lower part. In their type exposures the beds, to which Chamberlin applied the name Racine, contain a fauna of numerous, well-known and characteristic echinoderms, cephalopods, and trilobites. At Sturgeon Bay, Wisconsin, and elsewhere in northeastern Wisconsin, however, the Racine beds do not have this typical fauna. Likewise, the Guelph or Engadine strata of the Northern Peninsula, which seem to be continuous with the Racine beds of the Sturgeon Bay region, also



MAP 10 -- Area of T 42-45 N, R 8-10 W, covering parts of Mackinac and Luce Counties. Solid line marks base of Mayville, dash-and-dot line the base of Burnt Bluff, dotted line the base of Manistique, and dashed line the base of Engadine Dolomite.



MAP 11 -- Area of T 42-45 N, R 5-7 W, covering parts of Mackinac and Chippewa Counties. This map shows full width of Niagaran outcrop belt, 12 to 18 miles in this area.

lack undoubted characteristic, Racine fossils. The absence of unquestioned Racine forms in the Michigan strata at first seemed to the writer to be good reason for rejecting the name Racine for these deposits. This course, however, was not taken by the writer for several reasons. In his description of the Niagaran rocks of Wisconsin, Chamberlin (1883, p. 183-186, 196) pointed out that the characteristic echinoderms, cephalopods, and trilobites of the Racine were associated only locally with reefs and that these animals exhibited distinct colonial tendencies. The absence of the characteristic Racine echinoderms, cephalopods, and trilobites in the Racine of northeastern Wisconsin and in the Guelph or Engadine of the Northern Peninsula did not therefore seem to be a serious objection to the use of the name Racine for these deposits. The recognition of Guelph species in the Guelph and Racine beds of Wisconsin by Chamberlin (1878, p. 377, and faunal lists, p. 384-389) and his statement (1878, p. 377) that there is a mingling of the Racine and Guelph faunas at many localities in Wisconsin led the writer to believe that there was no real stratigraphic nor faunal break between the Racine and Guelph beds of that state, that these beds should be considered as a single stratigraphic unit, and that the name Racine should be applied to this unit in the sense used by Hall. The continuity of the lower beds of the highest Niagaran formation of the Northern Peninsula with the so-called Racine strata of the Sturgeon Bay region consequently seemed to be sufficient reason for using the name Racine in a similar sense for this formation.

After examining several exposures of Niagaran strata in eastern Wisconsin in company with Dr. A. F. Foerste and studying the fossils collected from these outcrops, the writer now believes that the beds containing the well known Racine echinoderms, cephalopods, and trilobites may belong to a distinct formational unit.

In a conversation with the writer, Dr. A. F. Foerste expressed the same opinion regarding the distinctness of the Racine fauna and beds. Furthermore, Doctor Foerste believes it is very doubtful whether the Racine fauna ever reached northeastern Wisconsin and the Northern Peninsula and whether there was a mingling of typical Racine and Guelph faunas in Wisconsin as stated by Chamberlin.

On account of the fact that no undoubted representatives of the Racine fauna have been found in the highest Niagaran formation of the Northern Peninsula, it seems best to reject the use of the name Racine for this formation. The writer believes it would be better to use the name Engadine rather than Guelph for this formation because, as previously stated, the formation seemingly contains strata somewhat older than the Guelph as well as beds of Guelph age.

GENERAL DESCRIPTION OF NIAGARAN SERIES

Lithologic character and continuity of the strata. -- The Niagaran Series of the Northern Peninsula consist almost entirely of limestones and dolomites of various lithologic character. A few thin beds of shale have been reported in the records of deep borings. In the field the writer has seen only few, small lenses of bluish-gray shale, ranging from a fraction of an inch to an inch in thickness.

When traced from one locality to another, most of the limestones and dolomites show little variation in lithological character. The strata of the upper half, or more, of the Hendricks Member of the Burnt Bluff Formation represent the only notable exception to this persistency in lithologic composition. These strata where they underlie a narrow strip of land between the southeastern part of Schoolcraft County and the region a few miles south of Pickford, Chippewa County, are chiefly limestones of high calcium carbonate content; elsewhere in the Northern Peninsula these same rocks are chiefly dolomites.

The Niagaran rocks are remarkable for their continuity, very few strata being interrupted in their continuity from Delta County to the eastern part of Chippewa County. Several beds of the series continue into Wisconsin and Ontario. In the writer's opinion a close examination of the sections of the three areas would show the existence of a much larger number of continuous beds. The unusual continuity of the beds has been of much assistance in determining the superposition of the Niagaran strata of the Northern Peninsula and in correlating these strata with those of Wisconsin and Ontario.

Thickness of the Niagaran Series. -- It is impossible by the direct measurement of rock

sections alone to determine the exact thickness of the Niagaran series on account of the fact that many of the Mayville, Burnt Bluff, and Engadine strata are unexposed. However, the records of a few deep wells are available that give considerable information as to the thickness.

Dr. Lane (1902, p. 228, 230, 231) indicated that 656 and 740 feet of Niagaran strata were encountered respectively in deep borings at St. Ignace and Cheboygan. Unfortunately, the base of the Niagaran was not reached in the St. Ignace well, thus making it impossible to obtain the total thickness of the series from this boring. In the Cheboygan well, however, the complete thickness of the series was obtained, so-called Medina (more likely Cataract) and Lorraine strata being encountered below the Niagaran.

In the writer's opinion the thickness of 740 feet, indicated by the Cheboygan well, is not the maximum thickness of the Niagaran Series of the Northern Peninsula. My measurements of the thickness of the section between the base of the Engadine and the lowest beds of the Burnt Bluff, exposed Burnt Bluff, Big Bay de Noc, show a minimum thickness of about 392 feet and a maximum thickness of 416 feet. In his discussion of the geological section of Michigan, Lane (1909, p. 57) indicated that the uppermost Niagaran strata encountered in the St. Ignace and Cheboygan wells consist almost entirely of white dolomites, which are underlain by strata similar to the Coral and Byron beds of Wisconsin. According to Lane the white dolomites penetrated in the St. Ignace well have a thickness of 278 feet and in the Cheboygan well 320 feet. These dolomites, which Lane assigns to the Guelph, are, for reasons previously given, designated Engadine. If these dolomites of the Engadine are added to those of the underlying Niagaran beds noted above, a minimum thickness of 670 feet and a maximum thickness of 736 feet are obtained. To these must still be added the thickness of the largely unexposed Burnt Bluff and Mayville strata beneath the lowest exposed beds at Burnt Bluff. Measurements based on the knowledge of the dip of the Niagaran series indicate that these Burnt Bluff and Mayville strata of the Big Bay de Noc region have a thickness of not less than 150 feet and probably not more than 200 feet. These added to the overlying Niagaran beds indicate that the total thickness of the series is about 820 feet as a minimum and 936 feet as a maximum.

The thickness of the Niagaran as calculated above is somewhat less than that indicated in the record of a deep well located in the railroad yards at Gilchrist, Mackinac County. This record, which is presented below as given the writer by Mr. R. A. Smith of the Michigan Geological Survey, shows that 850 feet of Niagaran strata (designated as Niagara limestone) were penetrated.

Record of Gilchrist Well

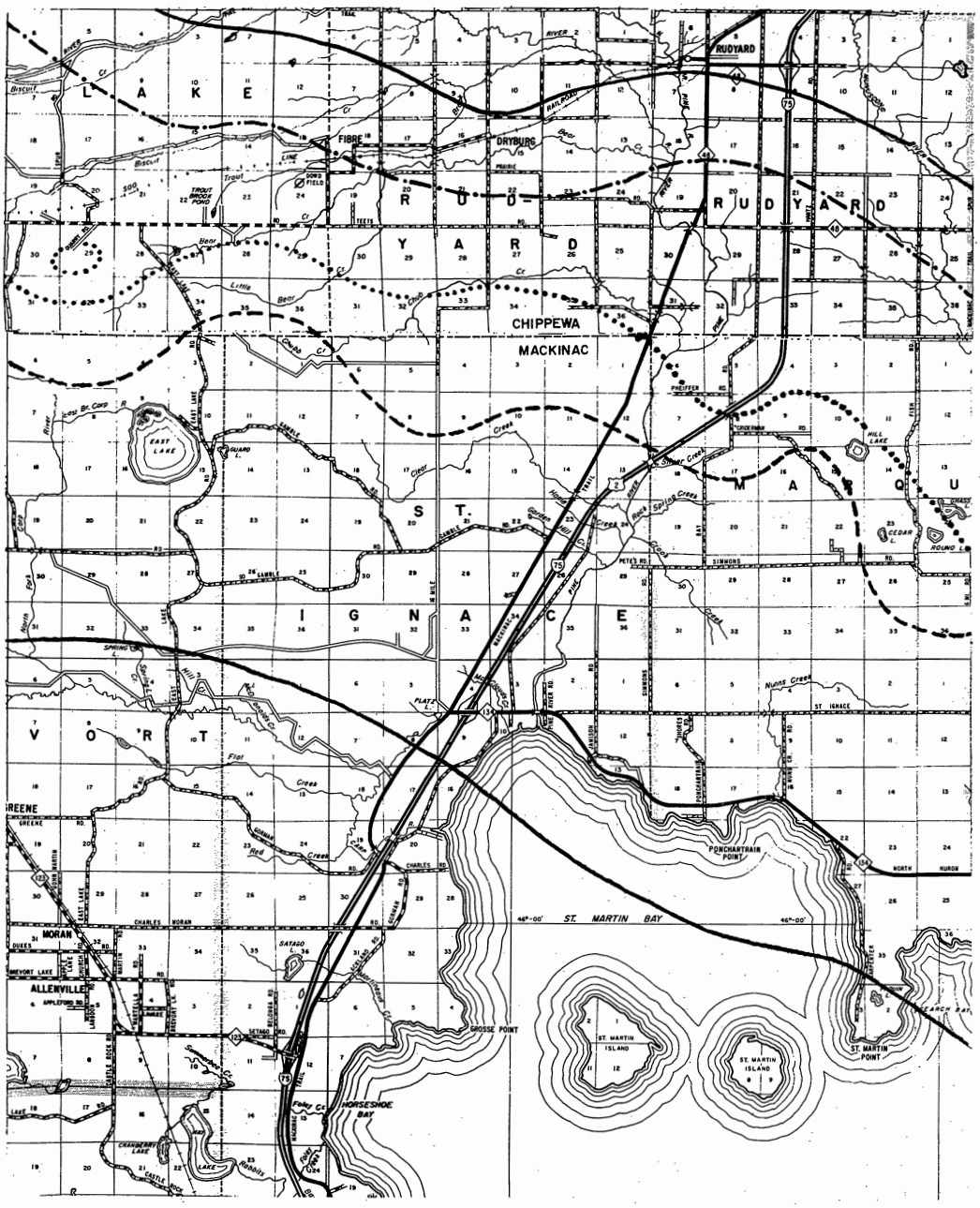
Location: Railroad yards of Minneapolis, St. Paul, & Sault Sainte Marie Railway Co. at Gilchrist, Mackinac County.

Elevation: About 780 A. T.

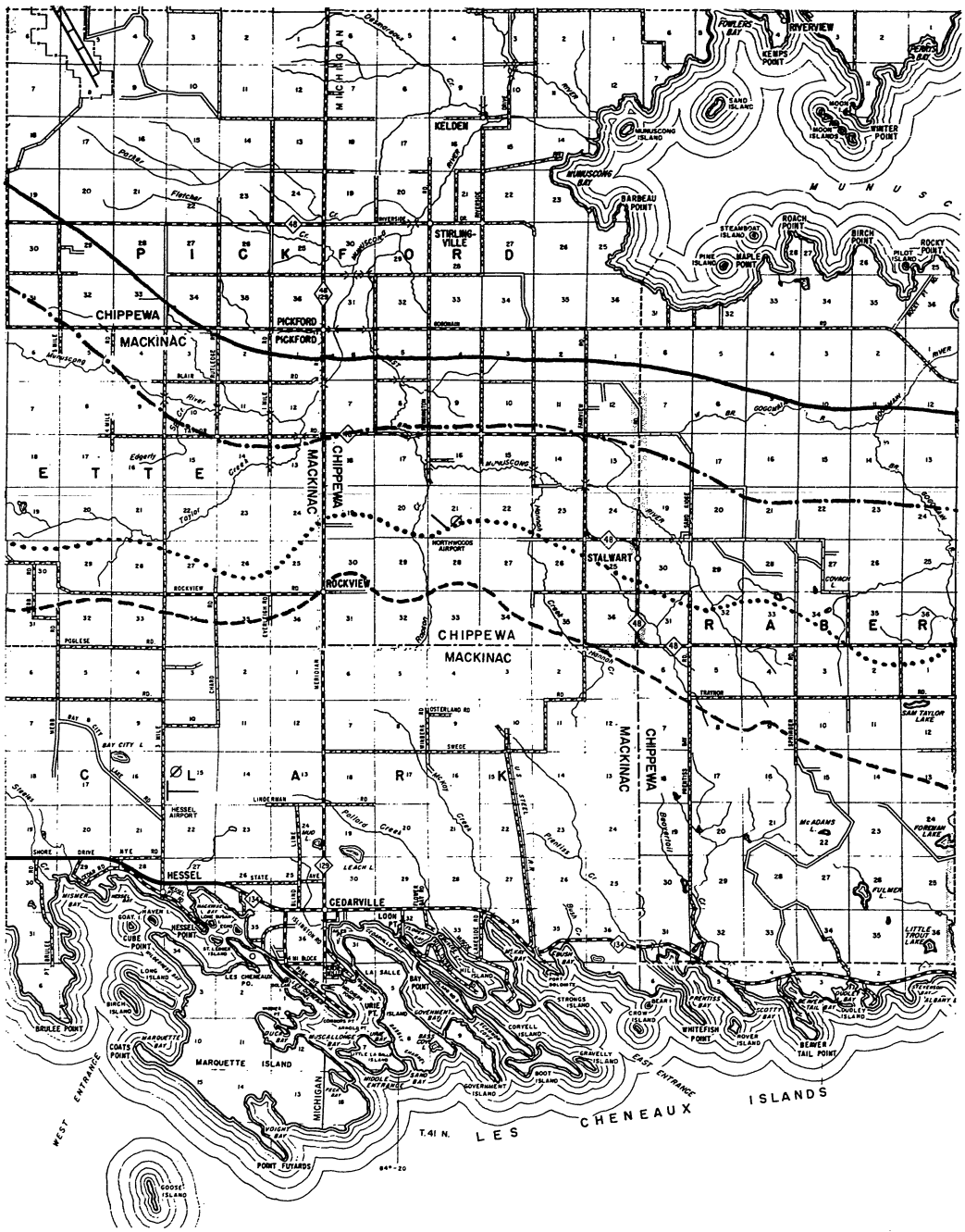
Record from log and data supplied by Mr. H. Whitman, Asst. Chief Engineer, Feb. 17, 1917.

Correlations and notes in parentheses by R. A. Smith.

	Thickness in feet	Depth in feet
Pleistocene or surface deposits		
Pit of old dug well (probably through sand).....	15	15
Fine sand.....	105	120
"Niagara" Limestone		
Lime-rock (upper at least largely dolomite or high magnesian limestone). Crumbly limestone at 258 feet which caused the drill to stick. Cased to below crumbly limestone.....	430	550
Streak of shale.....	1	551
Lime-rock (probably with many beds of high calcium limestone).....	279	830
Streak of shale.....	1	831
Lime-rock.....	139	970
Cincinnati shales		
Hard shales with many strata of limestone. Apparently most of the water supply		



MAP 12 -- Area of T 41-44 N, R 2-4 W, covering parts of Mackinac and Chippewa Counties north and east of the St. Ignace Peninsula. See Map 2 for location of Cordell, which has since disappeared as a station on the old Minneapolis, St. Paul, & Sault Ste. Marie Railroad (now the Soo Line Railroad). In this area, the full width of Niagaran outcrop is probably less than 15 miles.



MAP 13 -- Area of T 41-44 N, R 1 W - R 2 E, covering parts of Mackinac and Chippewa Counties. The Engadine Dolomite occurs in an extensive area around Cedarville and Les Cheneaux Islands.

comes from about 970 feet. Had some water from crumbly limestone but this was cased off and the water level remained the same down to 970 feet. At that point the water lowered one foot but the next day it came up to 63 feet of the surface, the present elevation. The well tested 200 gallons per minute with the cylinder 85 feet below the surface. Head did not lower two feet....	141	1111

With little doubt, the uppermost rock encountered in drilling this well is the Engadine Dolomite. It is quite certain that the upper part of the Engadine is missing at Gilchrist; in the writer's opinion it is very doubtful whether there is as much as 150 feet of the formation present beneath the drift at this locality. Assuming, however, that the Engadine at Gilchrist has a thickness of 150 feet and that the total thickness of the formation is either 278 feet or 320 feet, as respectively indicated by the St. Ignace and Cheboygan well records, it then appears evident that the addition of the differences between these thicknesses to the thickness of the strata encountered in the Gilchrist well gives a total for the entire Niagaran of 978 or 1020 feet.

It should be recognized that the information given Mr. Smith for the purpose of correlating the rocks of the Gilchrist well is very meager. So far as the writer can determine, no set of well drillings, carefully taken at close intervals, were available for Mr. Smith's examination. In view of these facts the thickness of the Niagaran series as determined on the basis of the Gilchrist well record can be accepted only with some reservation.

A more dependable estimate of the thickness of the Niagaran is obtainable from the record of a well, drilled for oil by the Schoolcraft Development Syndicate, about 2 miles northwest of Seul Choix Point, Schoolcraft County. This record, which is given in considerable detail on pages 106 and 107 of Publication 34 of the Michigan Geological Survey, represents the result of a thorough examination of a carefully kept set of well drillings by Dr. W. I. Robinson, a former member of this Survey. The writer, who is indebted to Doctor Robinson for the privilege of examining the drillings from the upper part of the well, suggested the Silurian divisions of the well record. In view of the fact that this record is based on a more carefully kept set of well samples than has heretofore been obtained from wells penetrating the Niagaran strata in the Northern Peninsula, it seems best to present the record in this paper in order to give an idea of the lithological character of the Niagaran and underlying strata in the Seul Choix Point region, as well as the thickness of the Niagaran. As presented below the record gives detailed descriptions of the Silurian subdivisions only.

Record of Schoolcraft Development Syndicate Well No. 2

Location: ½ mile north from well No. 1 which was drilled at the SW corner of the NE¼ sec. 21, T 41 N, R 13 W, Mueller Township.

Elevation: 642 feet (estimated) above sea level.

Samples furnished by Benjamin Gerow, Manistique.

	Thickness in feet	Depth in feet
Pleistocene: lacking		
Silurian:		
Manistique Formation:		
Buff mixed with gray and white dolomite (cherty).....	30	30
Buff cherty dolomite.....	10	40
Buff mixed with gray dolomite and white chert.....	110	150
Burnt Bluff Formation:		
Buff dolomite.....	25	175
Buff mixed with gray dolomite and white chert.....	25	200
Buff mixed with gray dolomite.....	50	250
Buff limestone.....	5	255
Buff and gray limestone.....	5	260
Gray dolomitic limestone.....	10	270
Bluish-gray calcareous shale.	5	275

Buff and gray shaly limestone.	15	290
Gray shaly dolomitic limestone	5	295
Gray limestone	5	300
Gray and dark-gray shaly limestone	5	305
Mayville Formation:		
Buff dolomite	35	340
Cream dolomite	15	355
Cream and light-gray dolomite	5	360
Dark bluish-gray shaly dolomite	5	365
Greenish-gray plastic shale	5	370
Gray shaly dolomite	5	375
?Cataract Formation:		
(Cabot Head Member)		
Reddish-gray plastic shale	5	380
Gray and buff mixed shale and shaly dolomite with gypsum; some purple shale	50	430
Greenish gray shale	5	435
Greenish plastic shale	5	440
Greenish gray shale	10	450
?Cataract Formation?:		
(Manitoulin Member)		
Buff dolomite	15	465
Light gray shaly dolomite	20	485
Gray shaly dolomite	15	500
Ordovician:		
Queenston-Richmond Formation	165	665
(?Lorraine)	80	745
Lorraine	245	990
Collingwood	15	1005
"Trenton" Formation: Black River)	287.5	1292.5
St. Peter Formation	32.5	1325
Ordovician and Cambrian (Undivided):		
Beekmantown and Lake Superior Formations	385	1710

Since interpreting the Silurian section of this well the writer has found that the Cataract is very thin or absent on Drummond Island. On account of the thinning of the Cataract in passing westward from Manitoulin Island and on account of the absence of this formation in northeastern Wisconsin the writer now doubts whether the strata called Cataract are really Cataract. In order to indicate this doubt, a ? mark is now placed before the name Cataract in the record. A further study, particularly a study of the fossils found in drillings from deep borings in the Seul Choix Point region may indicate definitely the age of the strata doubtfully assigned to the Cataract.

The 375 feet of Niagaran strata indicated in this record represent very nearly the total thickness of the section between the top of the Manistique and the base of the Mayville, since beds high up in the Manistique were the first rocks encountered in drilling the well. If the thickness of the Engadine of 278 or 320 feet, as suggested respectively by the St. Ignace and Cheboygan well records, is added to the 375 feet of Manistique, Burnt Bluff, and Mayville strata, a thickness of 653 or 695 feet is indicated for practically the entire Niagaran series.

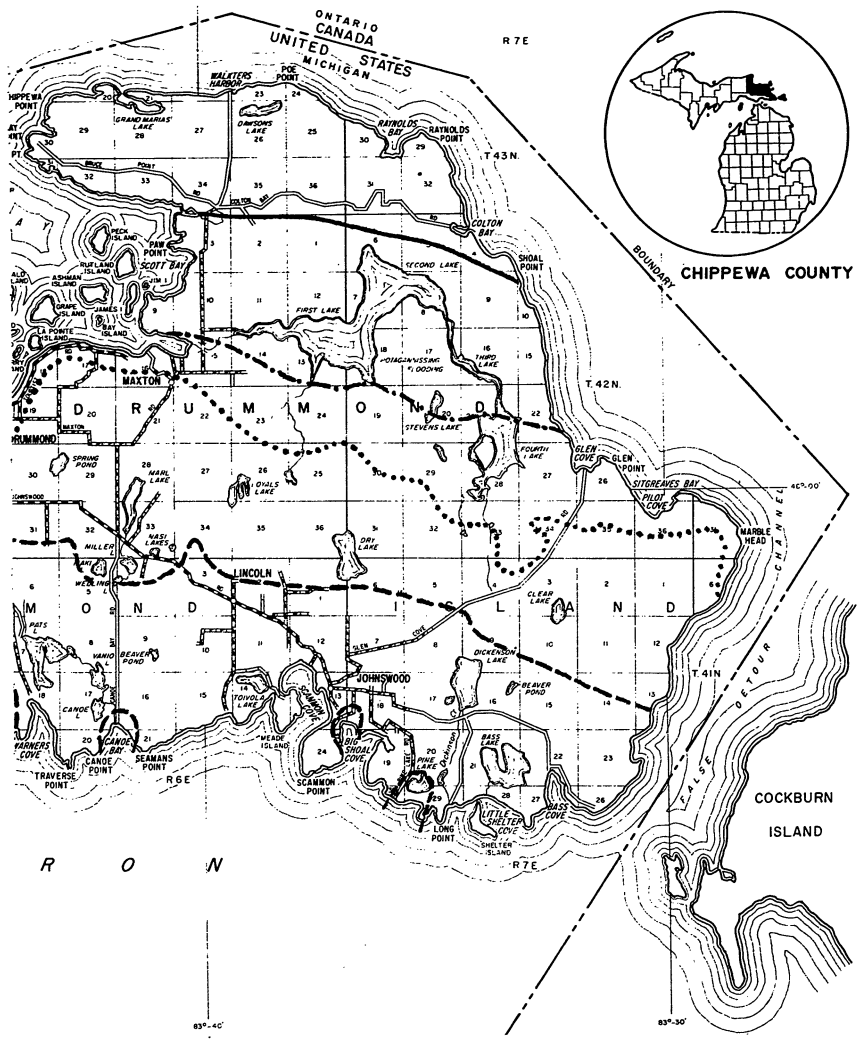
From the preceding statements it is evident that the thickness of the Niagaran Series, as determined from the record of the Schoolcraft Development Syndicate well, agrees very closely with the thicknesses indicated by the St. Ignace and Cheboygan wells and is less than the thicknesses suggested by the Gilchrist well and the writer's field observations. The considerably greater thickness indicated by the Gilchrist well record may, as already stated, be inaccurate since this record is based on very meager data. The slightly greater thickness, suggested in large part by the writer's measurements of sections in the field, may be accounted for by a thickening of the Niagaran Series towards northeastern Wisconsin, where the series is 900 or more feet in thickness.

The Niagaran Series when traced from the Delta County region to the eastern end of the

MAP 14 -- Area of T 41-43 N, R 3-5 E, covering parts of Chippewa County around Detour, Lime Island, and the western part of Drummond Island. Many islands in Potagannissing Bay have not been examined for outcrops.

Northern Peninsula shows a decided decrease in thickness. Information obtained from well records and field observations indicates that the series is 800 to 900 feet thick in the Delta County region, 650 to 750 feet in south-central Mackinac County, and probably between 500 and 600 feet in the Drummond Island region.

Structure of the Niagaran Series. -- The major structural feature of the Niagaran rocks bordering the north shores of Lakes Michigan and Huron is a monocline, with a very gentle dip or inclination towards the lakes. The general dip seemingly ranges from 40 to 60 feet per mile; many dips of less than 40 and more than 60 feet per mile are present in local undulations of the strata. A dip of 50 feet per mile, which A. C. Lane (1908, p. 21) noted for the Niagaran deposits of the Northern Peninsula, probably represents the average inclination of the series.



MAP 15 -- Area of T 41-43 N, R 6-8 E, covering the eastern part of Drummond Island, Chippewa County. Inset map shows location of Chippewa County in Michigan. Map shows bases of the following formations: Mayville (solid line), Burnt Bluff (dash-and-dot), Manistique (dotted), and Engadine (dashed).

The major monoclinal structure is modified by minor structures. One of the more striking of these minor structures is the Seul Choix Point anticline of southeastern Schoolcraft County. The crest-line of this anticline, which was noted by Charles Whittlesey (1851, p. 179, 180) as early as 1851, and more recently described by the writer (Ehlers, 1918, p. 59) and R. A. Smith (1923, p. 270-272), has a northwest-southeast orientation coinciding more or less with the northwest-southeast axis of the Seul Choix Point peninsula. The crest-line dips to the southeast at a very low angle, indicating that the structure is a plunging anticline. The southwest and northeast sides or limbs of the fold are formed by the Engadine Dolomite, the thin-bedded dolomites of the Cordell Member of the Manistique being exposed along the crest.

The structure appeared so favorable for the accumulation of petroleum that the Schoolcraft Development Syndicate recently drilled a few wells; unfortunately, the Ordovician rocks, particularly the Trenton Limestone, which were considered to be likely reservoirs of petroleum, proved to be non-oil-bearing. Several minor undulations, some of which may be of the size of the Seul Choix Point structure, are present along the southern shore of Drummond Island. As one proceeds in a boat along this shore, the undulations are easily recognized by changes in the strike and dip of the Engadine-Manistique contact. Numerous variations in direction and degree of the general lakeward dip of the Niagaran rocks at other places indicate the presence of other minor structures. A detailed structural study would doubtless reveal the location, type and extent of many of these structures.

In the writer's opinion the Seul Choix Point and Drummond Island structures and probably a large number of other minor structures, whose locations and relationships will doubtless be determined, belong to a type designated by Dr. W. I. Robinson (1923, p. 336-343) as "radial linear folds." Such folds, according to Doctor Robinson, are found near the periphery of large basin structures with their axes pointing toward the center of the basin; they are the result of the subsidence of a central area resulting in a crinkling of the peripheral portion just as an unfolded filter paper crinkles when pressed into a funnel. The axis of the Seul Choix Point anticline and apparently the axes of the Drummond Island folds point towards the more or less central part of the basin-like structure of the Southern Peninsula of Michigan. As the result of the subsidence of the deposits in this basin, especially during Paleozoic times, the radial linear folds of Seul Choix Point and Drummond Island were produced as peripheral structures.

Topographic features. -- Because they were more resistant to erosion by pre-glacial streams than the underlying Medinan and Cincinnatian and overlying Monroe-Salina strata, the Niagaran rocks stand in relief as a cuesta, a type of ridge characterized by a steep descent on one side and a long, gentle slope on the other. The cuesta has a general east-west orientation more or less parallel to the strike of the Niagaran strata. Its steep slope or escarpment faces northward. Its gentle back slope descends southward to Lakes Michigan and Huron, the descent at many places conforming closely to the dip of the strata.

Immediately north of the escarpment the pre-glacial streams excavated a broad lowland in the less resistant Medinan and Cincinnatian rocks which subsequently became more or less completely filled with glacial and fluvio-glacial deposits. Other pre-glacial streams removed the Monroe-Salina strata from the gently sloping surface of the cuesta and carved a wide valley in the Monroe-Salina and overlying Devonian strata to the south of the cuesta. This valley, which subsequently was partly filled with Pleistocene drift, now makes up the northern parts of the basins of Lakes Huron and Michigan.

Superimposed on the large cuesta of the Niagaran Series are smaller cuestas, residuals of more resistant, Niagaran strata. One of the most conspicuous of these smaller cuestas extends eastward with few interruptions from the region three miles east of Trout Lake, Mackinac County, to Drummond Island. This ridge with its high, northward-facing escarpment is capped by the hard, thick-bedded, white and bluish-white Engadine Dolomite, the most common escarpment-maker of the Niagaran Series. Another very striking example of these smaller cuestas, which is capped by thick beds of dolomite of the upper part of the Burnt Bluff and lower part of the Manistique formations, is present on the Garden Peninsula between Big Bay de Noc and Lake Michigan. The steep slope of this cuesta forms high, picturesque, northwest-facing cliffs of limestone and dolomite, rising vertically from the shore of Big Bay de Noc. The bases of some of these cliffs are submerged beneath the water of the Bay. In pre-glacial times the cliffs bordered a deep valley, which was excavated chiefly in the Cincinnatian rocks. This valley now forms the basin of Big Bay de Noc. From the tops of the cliffs the gently sloping surface of the cuesta descends southeastward towards Lake Michigan almost at the dip of the strata. The Garden Peninsula cuesta continues northeastward into Schoolcraft County, where it is an important topographic feature. A very poorly defined cuesta is present in the area west of Indian Lake and north of Cooks on the Minneapolis, St. Paul, & Sault Ste. Marie Railroad. East of the northern part of Indian Lake there is an escarpment of considerable height; the main road leading northward

from Manistique to Shingleton and Munising crosses this escarpment, exposing an excellent section of the Burnt Bluff strata in a road cut. Indian Lake, which is situated between this cuesta and that on the west side of the lake north of Cooks, is located in the valley of a pre-glacial stream, which probably flowed southward into a larger stream, then occupying the future basin of Lake Michigan. Another escarpment is parallel to the general course of the Manistique River between points about six miles and twelve miles northeast of the city of Manistique. This escarpment with little doubt was at one time continuous with that immediately east of Indian Lake. The continuity is broken by a pre-glacial stream, the valley of which is now traversed by the lower course of the Manistique River. Another minor cuesta with a fairly high northward-facing escarpment is present immediately north and west of Hendricks quarry (NW$\frac{1}{4}$ sec. 6, T 44 N, R 8 W, and NE$\frac{1}{4}$ sec. 1, T 44 N, R 9 W, Mackinac County), adjacent to the boundary line between Mackinac and Luce Counties. The rocks of this escarpment consist entirely of Burnt Bluff strata but are in large part covered by drift and talus. A more or less continuous escarpment composed of Manistique and Burnt Bluff strata crosses Drummond Island from Drummond village to Marble Head. Other minor cuestas will be discussed on subsequent pages in connection with the description of the rocks composing them. The cuestas noted above are the principle topographic features developed on the major Niagaran cuesta, which is the most striking and conspicuous relief form of the entire eastern half of the Northern Peninsula.

DETAILED DESCRIPTION OF FORMATIONS

Mayville Dolomite

Exposures and lithologic character of the formation. -- The Mayville Dolomite, so far as known, is exposed only at Big Limestone Mountain, Houghton County, and at a few places in Delta, Luce, and Chippewa Counties. Outcrops are few in number owing to the fact that the formation is covered by drift of considerable thickness at most places. The formation consists chiefly of dolomite and some magnesian-limestone.

The most conspicuous and easily recognizable rock of the Mayville occurs at the top of the formation; it is a thick-bedded, coarsely-crystalline, yellowish-gray dolomite, filled with the molds of the shells of Virgiana mayvillensis. This dolomite, which extends northeastward from eastern Wisconsin to Michigan and thence eastward to Fitzwilliam Island, Ontario, is, so far as known, exposed only on Lime Island in Potagannissing Bay and possibly at Big Limestone Mountain, Houghton County. Detached blocks, however, are found in the drift at several places within the area underlain by the Niagaran Series.

Thickness of the formation. -- The maximum thickness of the Mayville Dolomite in the Northern Peninsula is not definitely determined because most of the formation is covered by drift, and information given by the records of a few deep wells is not reliable. However, the fact that both lower and upper strata of the Mayville of Wisconsin are represented in outcrop in the Northern Peninsula indicates that the Mayville not only extends northeastward into Michigan but retains its thickness. This thickness, as suggested by Professor Savage's (1916, p. 308) measurement of the Mayville of Wisconsin, is 100 to 175 or more feet.

The record of a well, drilled by the lumber company of Nahma, Delta County, Michigan, on its farm about 2$\frac{1}{2}$ miles northeast of this village (NW$\frac{1}{4}$ SE$\frac{1}{4}$ sec. 15, T 40 N, R 19 W), indicates that the thickness of the Mayville in Delta County corresponds very closely to the thickness of the Mayville in northeastern Wisconsin. According to this record, given to the writer by the lumber company, 171 feet of "limestone" were encountered below 4 feet of clay loam, the bottom of the well being located in limestone. The magnesian composition of this limestone and the absence of shales and argillaceous limestones, suggesting the presence of Richmond strata below the Mayville, indicates that the entire 171 feet of limestone belongs to the Mayville Formation. In the writer's opinion the uppermost beds of limestone encountered in this well probably occupy a position below the Virgiana-bearing dolomite at the top of the Mayville. If this dolomite has a thickness of about 30 feet as is the case in Wisconsin, then the thickness of the Mayville of the Nahma region would be at least 201 feet. To this thickness, however, must be added the thickness of the beds intervening between the base of the Virgiana-bearing dolomite and the uppermost rock encountered in the well, and the thickness of the remaining part of the

Mayville below the bottom of the well. With these additions the total thickness of the Mayville in Delta County may exceed that in Wisconsin.

In passing eastward from Delta County the Mayville decreases in thickness. In southeastern Schoolcraft County a thickness of only 70 feet is shown by the previously noted record of well number 2, drilled at Seul Choix Point by the Schoolcraft Development Syndicate. On the eastern side of Drummond Island the thickness is probably less than 50 feet and may not be more than 25 feet.

Detailed sections. -- Exposures are discussed under the county in which they crop out.

Delta County

Nahma and vicinity: At the head of the Big Bay de Noc is a broad, southerly projecting peninsula, which divides it into a larger bay on the east and a smaller bay, named Ogontz, on the west.

The eastern half or more of this peninsula, near the extremity of which is the village of Nahma, is underlain by rocks occupying a position in the lower part of the Niagaran Series. This is indicated by the fact that these rocks have a position below the lowest Burnt Bluff strata exposed at Burnt Bluff and other headlands on the eastern shore of Big Bay de Noc and by the fact that underlying Richmond strata are at the surface near Ogontz, about 5 miles west of Nahma, and along the Sturgeon River, about 8 miles north of the village (Hussey, 1926, p. 117, 145, 147). The resemblance in lithologic character of the rocks exposed in the area a few miles northeast of Nahma to that of Mayville beds exposed at other places in the Northern Peninsula suggests furthermore that probably the eastern half of the Nahma peninsula is underlain entirely by Mayville strata.

On page 47 of volume 1 of the Michigan Geological Survey, Rominger described the occurrence of Niagaran strata near the mouth of Sturgeon River, which empties into Big Bay de Noc at Nahma, as follows:

> On the west side of the bay (Big Bay de Noc), near the mouth of Sturgeon River, the lowest beds seen in the section at Burnt Bluff seem to continue. Ledges of them are visible in the shoals surrounding the headlands on the north, and on the south side of the mouth of Sturgeon River. The rock specimens from both sides of the bay do not differ lithologically.

The writer was unable to find the exposures near the mouth of Sturgeon River or to observe strata in nearby shoals of Big Bay de Noc. It is quite possible that the exposures, especially if they were of small extent, may have been covered in the course of building operations at Nahma. At low level stages of Big Bay de Noc, ledges may also be visible in the shoals as Rominger reported.

The records of two flowing wells, published by Mr. Frank Leverett on page 44 of Water-Supply Paper No. 160 of the United States Geological Survey, would seem to indicate that Niagaran strata occur at considerable depth below the surface at the village of Nahma. According to these records, one well was sunk to a depth of 80 feet without entering rock and the other to a depth of 133 feet, ending in a limestone.

The records of two flowing wells, which were given to the writer by officials of the lumber company at Nahma, suggest on the contrary that Niagaran strata are relatively near the surface. The record of one of these wells, which was sunk on the north side of the main east-west street of the village, shows that the drill passed through only 20 feet of sand before penetrating 70 feet of limestone. The record of the second well, which was put down to a depth of 120 feet at a point one village block north of the former well, also shows that the drill passed through 20 feet of sand before penetrating 30 feet of limestone, then "gravel" (probably a granular or readily broken limestone), and then limestone.

LOC. 1. The close proximity to the surface of Mayville strata is further suggested by the presence of several blocks of brownish-gray, siliceous dolomite along the shore of Stony Point, situated only two-thirds of a mile east and one-quarter of a mile south of Nahma. The angular surfaces of these blocks of dolomite, which is similar lithologically to certain beds of Mayville Dolomite, suggest that the blocks were transported from a nearby ledge such as may occur in the shoals off this point. The masses of dolomite, loosened from the ledge, could have been frozen in the ice and carried upon the shore in ice-jams. It is also possible that the blocks of dolomite were brought to this locality by the Pleistocene

glacier from some near-by ledge on the Nahma peninsula.

LOC. 2. About 2 miles northeast of Nahma in the central and southern parts of sec. 15, T 40 N, R 19 W, Mayville strata appear at the surface in a field bordering both sides of the Nahma-Isabella road. The strata consist of hard, thick-bedded, finely to coarsely crystalline magnesian-limestones and dolomites of gray to brownish-gray color.

A gray, finely crystalline magnesian-limestone, filled with disseminated crystals of calcite, is exposed as a rock pavement along the east side of the Nahma-Isabella road near the center of sec. 15. The pavement-like surface of the limestone shows numerous sun-cracks or desiccation fissures, which testify to the deposition of the limestone in very shallow water and the exposure of the rock material to the drying action of air before solidification.

The limestone resembles a certain dolomitic phase of the Fiborn Limestone exposed a few miles west of the quarry at Nicholsonville, Schoolcraft County. This resemblance might lead one to believe that the limestone is the Fiborn, which occupies a much higher position, however, in the Niagaran series.

As previously noted in the discussion of the thickness of the Mayville Formation, 117 feet of limestone of probable Mayville age were encountered in sinking a well on the nearby farm of the Nahma Lumber Company in the NW$\frac{1}{4}$ SE$\frac{1}{4}$ sec. 15, T 40 N, R 19 W.

Isabella and vicinity:

LOC. 3. A thin-bedded, finely-crystalline, buff dolomite is exposed as a pavement beside the Nahma-Isabella road about 1$\frac{1}{2}$ miles south of Isabella. Two very poorly preserved brachiopods, a questionable Orthis and Dalmanella, were collected from this dolomite. According to information received from residents of Isabella, Mayville dolomites and limestones seem to be at or near the surface of a large part of the NW$\frac{1}{4}$ sec. 11 of T 40 N, R 19 W, in which the outcrop noted above is located.

LOC. 4. An abandoned quarry, a test pit, and an old lime-kiln are located in sec. 2, T 40 N, R 19 W about one-half mile south of Isabella. In the abandoned quarry, near the lime-kiln, 9 feet of massive, white to very light gray dolomite, containing a few poorly-preserved crinoid stems, are exposed. Another foot of this dolomite occurs in the higher parts of the meadow adjoining the quarry on the north. In the pit about 200 feet north of the quarry, about 6 feet of the same dolomite are overlain by 6 inches of thin-bedded, buff dolomite, which represents either a weathered phase of the underlying rock or a higher bed.

LOC. 5. A low, westward-facing escarpment, having an average height of 10 to 15 feet, can be traced northward along the east side of Moss Lake, about one and one-half miles west of Isabella, from a point a short distance south of the north line of the SW$\frac{1}{4}$ sec. 3, T 40 N, R 19 W to a point just west of the center of the east line of sec. 35, T 41 N, R 19 W. North of this point the escarpment passes into a gentle westwardly inclined slope, which continues northward just west of the east lines of sec. 35 and 36, T 41 N, R 19 W to a point near the center of the east line of sec. 26. The escarpment also passes into a gentle, westwardly inclined slope at its southern end; according to the statement of some settlers at Isabella this slope extends southward for nearly three-quarters of a mile beyond the north line of the SW$\frac{1}{4}$ sec. 3, T 40 N, R 19 W.

Strata which the writer assigns to the Mayville are at or near the surface of this escarpment and of the land adjoining it on the east. Most of the outcrops are to be found in the escarpment, especially where it appears as a cliff on the east side of Moss Lake.

LOC. 6. About 8 feet of thin-bedded, buff to brown dolomites are exposed in the escarpment near the southeast corner of the lake and only a few yards north of the track of the Minneapolis, St. Paul, & Sault Ste. Marie Railroad. Some of the same beds are also exposed in the escarpment immediately south of the railroad.

In passing it is of interest to note that the surface of the uppermost beds exposed south of the track contains two sets of glacial striae, indicating an earlier and later movement of the Pleistocene ice. The earlier movement, as determined from the orientation of striae, was about S. 79° to 82° W and the later one about S. 22° to 30° E.

LOC. 7. In a cut made by the railroad company a short distance east of the above mentioned outcrops, about 3 feet of thin-bedded, dark gray,

siliceous dolomite are exposed. These strata are separated from the highest beds shown in the escarpment just north of the track, by 1 to 2 feet of unexposed strata.

LOC. 8. A few feet of thin-bedded, brown dolomite, containing small, irregularly shaped cavities appear in the escarpment about one-third mile north of the railroad. These beds probably underlie the lowest strata exposed in the escarpment at the railroad.

LOC. 9. About one-third mile farther north, still lower strata consisting of 3 feet of thin-bedded, buff dolomite with nodules of gashed chert are exposed in a very small road quarry, excavated on the top of the escarpment beside a little used north-south road.

About one-third mile farther north and a short distance east of the escarpment, Mayville strata were apparently encountered below 7 feet of sandy-loam in sinking a well near the house of Mr. E. D. Lindstrom (exact location -- SW$\frac{1}{4}$ NW$\frac{1}{4}$ sec. 36, T 41 N, R 19 W). According to Mr. Lindstrom, 119 feet of limestone, probably dolomites and magnesian-limestones, were penetrated below the sandy-loam. The color of most of the powdered rock, brought to the surface when putting down the well, was bluish-gray.

LOC. 10. Two feet of thin-bedded, buff dolomite, containing a few fragments of brachiopods, are exposed in the gentle, westwardly-inclined slope a very short distance southeast of the center of the east line of sec. 26, T 41 N, R 19 W.

A few outcrops are shown in secs. 25, 24, and 13, T 41 N, R 19 W.

LOC. 11. A buff dolomite may be reached by a little digging in the bottom of a spring, located in sec. 25 a short distance east of the last-described exposure.

LOC. 12. A similar dolomite is present in the bottom of another spring in the NW$\frac{1}{4}$ NW$\frac{1}{4}$ sec. 25, about $\frac{1}{2}$ mile farther north.

On an abandoned farm about one-quarter mile northeast of the last mentioned spring, masses of hard, thick-bedded, bluish-gray dolomite, containing some argillaceous material and showing questionable bryozoan remains on its weathered surfaces, were brought to the surface in digging a shallow well.

LOC. 13. In a third spring, situated in the NE$\frac{1}{4}$ sec. 24, a thin-bedded, finely crystalline, gray dolomite is exposed.

LOC. 14. A hard, thick-bedded, light bluish-gray dolomite, containing a simple coral and a Hormotoma ? sp., is at the surface of 4 or 5 acres of land, located in the NE$\frac{1}{4}$ SW$\frac{1}{4}$ sec. 13 just east of a branch of the Nahma & Northern Railroad.

Vicinity of Garden:

LOC. 15. Blocks of yellowish-gray dolomite, containing numerous remains of Virgiana mayvillensis, are present in the drift along the shore of Garden Bay about one-quarter mile southeast of Ansel's Point, a headland on Big Bay de Noc about two miles northwest of Garden.

Savage & Crooks (1918, p. 63) noted the occurrence of Virgiana mayvillensis in the drift on the "Garden Peninsula north of Van's Harbor." This locality is probably not more than one-half mile distant from that mentioned above.

LOC. 16. The writer also found a few blocks of yellowish-gray dolomite with numerous molds of Virgiana mayvillensis in the drift along a north-south road 2 miles north of Garden Village, the exact locality being just north of the center of sec. 5, T 39 N, R 18 W.

The blocks of Virgiana-bearing dolomite at all these localities were carried southeastward by the Pleistocene glacier from the Virgiana bed of the Mayville, which, with little doubt, is now covered by the water of Big Bay de Noc.

Schoolcraft County

Vicinity of Nicholsonville: So far as known no exposures of the Mayville occur in Schoolcraft County. The area, where the formation would be expected to appear at the surface, is deeply covered with drift.

LOC. 17. Small, weathered blocks of Virgiana-bearing dolomite are present in the drift, however, about three-quarters of a mile north of the quarry of the Inland Stone & Lime Company (formerly operated by Manistique Lime Company) at Nicholsonville, which is located on the Blaney & Southeastern Railroad about two and three-quarters miles north of Blaney Junction. In addition to Virgiana mayvillensis these blocks of

dolomite contain a zaphrentid and a favositid.

Luce County

Manistique Lake and vicinity:

LOC. 18. Numerous slabs of a thin, uneven-bedded, gray dolomite, containing chert-nodules lie upon the northwest shore of Manistique Lake, adjoining the SW¼ sec. 29, T 45 N, R 12 W. These slabs with little doubt were carried to the shore from a ledge in the lake bottom by the shoreward expansion and push of the lake-ice in winter and early spring. At the time of the writer's visit the bottom of the lake was covered with sand and no ledge was visible. However, according to nearby residents, a ledge is visible at low water stages, at which time the covering of sand is removed by currents.

The following fossils were collected from the slabs of dolomite and especially from the chert nodules included therein.

Anthozoa

Favosites sp.

Zaphrentis? sp.

Brachiopoda

Atrypa n. sp. -- According to Dr. E. O. Ulrich, this species is related to Atrypa rugosa Hall and Atrypa calvini Nettleroth and is represented by specimens in the lower 10 feet of Mayville strata at Neda, Wisconsin.

Dalmanella ? sp.

Platystrophia sp. aff. P. daytonensis (Foerste)

Schuchertella subplana (Conrad) var. -- According to Dr. E. O. Ulrich, this species is indistinguishable from a variety of Schuchertella suplana (Conrad), which is abundant in the Waldron Shale of Indiana and Tennessee.

Gastropoda

Diaphorostoma sp. -- Identified by Dr. Ulrich as Diaphorostoma sp. aff. D. niagarense (Hall).

It seems very likely that the locality, from which the fossils listed above were obtained, is the same as that noted by Rominger (1873, p. 42) as the northwest corner of North Manistique Lake. In the rocks at this locality Rominger also found a few fossils, which he listed as Zaphrentis, Favosites, Leptaena similar to suplana (now designated as Schuchertella suplana), Conularia, and crinoid joints.

LOC. 19. Strata presumably of Mayville age are at or near the surface of a small area adjacent to the northwest shore of Manistique Lake. About 1 mile northwest of the locality mentioned above a very small exposure of brown dolomite is present on the east side of a small brook in the SE¼ SE¼ sec. 19, T 45 N, R 12 W. The records of nearby wells, which were kindly given to the writer by Mr. Frank Leverett of the United States Geological Survey, indicate that Mayville strata are close to the surface. The record of a well, located a short distance west of the SE corner sec. 19 and at a higher elevation than the last mentioned outcrop, shows the presence of 46 feet of limestone beneath 40 feet of drift. Just across the road from this well, in the NE¼ NE¼ sec. 30, is another well, which has a depth of 85 feet; the record of this well, which was put down on lower ground than the former, shows 67 feet of limestone and a covering of drift of only 18 feet. The record of a third well, located at the schoolhouse near the northeast corner of sec. 29 about 1 mile farther east, shows 56 feet of limestone below 40 feet of drift. About one-quarter mile farther east in the SW¼ SE¼ sec. 21, rock, presumably limestone or dolomite, was struck at the bottom of a well, which was put down to a depth of 76 feet.

Vicinity of Hendricks Quarry:

LOC. 20. About one-half mile north of Hendricks Quarry, located in Mackinac County in the NW¼ sec. 6, T 44 N, R 8 W, and the NE¼ sec. 1, T 44 N, R 9 W, is a northward-facing bluff composed of limestones of the upper member of the Burnt Bluff Formation. In the drift immediately north of this bluff are many blocks of yellowish-gray dolomite with numerous remains of Virgiana mayvillensis, indicating the presence of this zone of the Mayville as far eastward as the region north of Hendricks Quarry.

Mackinac County

Hendricks Quarry and vicinity:

LOC. 21. Many blocks of yellowish-gray dolomite bearing molds of Virgiana mayvillensis are present in the drift in the vicinity of Hendricks Quarry, as well as beyond the escarpment a few miles to the north in Luce County.

Chippewa County

LOC. 22. On the northwest side of Drummond Island, in sec. 9, T 42 N, R 6 E, dolomite forms a headland projecting into Potagannissing Bay. This headland is the south shore of Scott Bay, and lies about one mile north of the village of Maxton.

Very recently this exposure was visited by Dr. Walter A. Ver Wiebe while engaged in a geological study of Chippewa County for the Michigan Geological Survey. According to information which Dr. Ver Wiebe kindly gave the writer, the dolomite at the headland may be traced eastward as a series of low mounds for a distance of about $1\frac{1}{2}$ miles.

A small number of silicified fossils were found in the dolomite on the headland and sent to Dr. Ulrich of the United States Geological Survey for examination. Dr. Ulrich's identification of these fossils and his comments regarding their occurrence in other strata are listed below.

Anthozoa

Eridophyllum ? sp. -- Similar to a species, occurring in the lower part of the Mayville in Wisconsin.

Favosites sp.

Paleofavosites aspera (D'Orbigny)

Bryozoa

Hallopora sp.

Pachydictya cf. P. famelica (Foerste)

Pachydictya aff. P. crassa (Hall).

These three species occur in lower part of Mayville in Wisconsin.

Pachydictya sp. (small-celled form) -- A very similar species occurs in lower part of Mayville in Wisconsin.

Brachiopoda

Rhynchonella (? Camarotoechia) n. sp. near Camarotoechia (Stegerhynchus) whitei (Hall). -- The same species occurs in lower part of Mayville in Wisconsin.

The fact that most of the species listed above also occur in the lower part of the Mayville in Wisconsin or are represented by very similar species, suggests a possible continuity of the dolomite on the headland with some lower Mayville dolomites of Wisconsin. Such a continuity of beds is to be expected since the entire Niagaran Series of northeastern Wisconsin and the Northern Peninsula is to a large extent continuous.

LOC. 23. Numerous blocks of hard, light brown dolomite, which were very probably dislodged from a nearby ledge by the Pleistocene glacier, are scattered on the surface of the low-lying land just east of the base of the above-mentioned headland (this locality may be in the $NE\frac{1}{4}$ $SE\frac{1}{4}$ sec. 9, T 42 N, R 6 E).

Several fossils were collected from these blocks of dolomite and were identified as follows:

Anthozoa

Two indeterminable zaphrentids

Bryozoa

Chasmatopora ? angulata? (Hall)

Brachiopoda

Atrypa n. sp. -- The same species occurs in slabs of dolomite on northwest shore of Manistique Lake and in rocks of lower part of Mayville in Wisconsin.

Dalmanella sp.

Leptaena rhomboidalis (Wilckens)

? Linguloid (may be a gastropod)

Orbiculoidea n. sp.

Orthis flabellites Foerste

cf. Platystrophia daytonensis (Foerste)

Schuchertella aff. S. subplana (Conrad). -- Similar to a species in the lower third of the Mayville of Neda and Peebles, Wisconsin.

Trilobita

Bumastus n. sp.

Encrinurus cf. E. tuberculifrons Weller

Illaenus sp.

The few Mayville species listed above indicate that the bed from which the blocks of dolomite were derived occupies a position in the lower part of the Mayville.

With little doubt the bed is at or near the surface a short distance north of the place where the blocks were found. Such a location seems necessary because the blocks must have been transported from the north by the more or less southerly moving Pleistocene ice and because Richmond rocks, underlying the Niagaran Series, appear at the surface only a few miles to the north along the northern shore of Drummond Island.

As a result of the more or less southerly dip of the Niagaran rocks on Drummond Island it seems likely that this bed dips beneath the massive, reef-like dolomite exposed on the headland. On the other hand it is possible that this bed may occupy a position on the side of the reef and dip away from the reef to the northward.

LOC. 24. According to Doctor Ver Wiebe (1928, p. 319) Silurian dolomites, having a probable thickness of 40 to 45 feet and resembling certain Niagaran strata, are present below the reef-like dolomite and are separated from the latter by a covered interval of possibly 15 feet. Only the lower and upper strata of these Silurian dolomites are exposed. The lower strata, composed of about 12 feet of dolomite, are exposed in a bluff on the south side of a marsh located in the north part of sec. 3, T 42 N, R 6 E, about $1\frac{1}{2}$ miles north of the last mentioned locality. As described by Ver Wiebe this dolomite is "greyish-blue on fresh exposure, but weathers very quickly to a dull yellow. It is medium-grained in texture and breaks into fairly regular pieces roughly 8 inches thick and rectangular. It is marred by small nodules of chert which also seem to decay rapidly on exposure to weathering."

LOC. 25. The upper strata of the 40 to 45-foot section of Silurian dolomites, according to Ver Wiebe, "crop out at lake level on Walter Stevenson's farm in the southwestern quarter of sec. 3, T 42 N, R 6 E." As described by this writer the upper strata consist of a very hard dolomite, which contains some fossil fragments and weathers deeply "with a brown concentric shell."

Ver Wiebe (1928, p. 319) is inclined to believe that the dolomites, composing the 40 to 45 feet of Silurian section of Drummond Island, are a westward extension of the Manitoulin Dolomite of Manitoulin Island, Ontario. This belief is based on the apparent similarity in lithologic character and stratigraphic position of the rocks of the two regions.

In the writer's opinion Doctor Ver Wiebe's description of these dolomites would seem to apply equally well to Niagaran and Richmond strata on Drummond Island. Without paleontologic evidence it would seem best to refer these strata tentatively to the Manitoulin Dolomite.

One mile south of Cordell:

LOC. 26. A few blocks of the Virgiana mayvillensis-bearing dolomite were found in the drift beside an abandoned railroad bed about one mile south of Cordell ($NE\frac{1}{4}$ $NE\frac{1}{4}$ sec. 29, T 44 N, R 4 W), a station on the Minneapolis, St. Paul, & Sault Ste. Marie Railroad, about 10 miles east of Trout Lake.

The presence of these blocks of dolomite indicates that the Virgiana zone at the top of the Mayville extends eastward into Chippewa County. The ledge from which these blocks were carried by the Pleistocene glacier is probably present a few miles to the north but covered by a considerable thickness of drift.

Lime Island in Potagannissing Bay:

LOC. 27. The only known exposure of the Virgiana beds in Michigan is on the west side of Lime Island adjacent to a small abandoned quarry located on the shore a little less than one-quarter mile north of the coaling wharf of the Pittsburg Coal Company. Seven feet are exposed, the total thickness being unknown because the base of the bed is beneath the bay. The rock, which is similar lithologically to the Virgiana-bearing blocks found in the drift at several localities, consists of a very thick-bedded, coarsely-crystalline, yellowish-gray dolomite filled chiefly with numerous molds of the shells of Virgiana mayvillensis. In addition the dolomite contains poorly preserved specimens of a Favosites and a zaphrentid and some molds of a brachiopod, which Dr. Ulrich has kindly identified as Virgiana major Savage.

In regard to the last mentioned species it is of interest to note that Dr. Ulrich in a communication to the writer is inclined to consider it the same as Conchidium greenii Hall & Clarke,

the type of which he states is imperfect in front and restored too roundly. Furthermore, he believes that both Virgiana major and Conchidium greenii may be the same as the earlier described Conchidium decussatum (Whiteaves).

The Virgiana-bearing bed at this locality is overlain by 17 feet of massive, buff dolomite, which the writer provisionally includes in the Burnt Bluff Formation. The contact between the two formations unfortunately is not shown; it seems to be about 1 foot below the floor of the quarry, which is excavated in the Burnt Bluff Dolomite.

Savage & Crooks (1918, p. 63) incorrectly state that the Virgiana bed at this locality is overlain by a bed of fine-grained limestone resembling the Fiborn Limestone described by R. A. Smith. The rock resting on the Virgiana-bed is, as stated above, a massive, buff dolomite and is decidedly unlike their description. Furthermore, this dolomite is not the dolomitized Fiborn because the Fiborn or its dolomitized equivalent occupies a position at least 200 feet above the Virgiana-bed.

Eastern side of Drummond Island:

LOC. 28. A few, scattered blocks of a yellowish-gray dolomite containing numerous remains of Virgiana mayvillensis and some poorly-preserved specimens of a Favosites and a zaphrentid were found along the shore at Glen Point, on the eastern side of Drummond Island about one-third mile north of the center of sec. 26, T 42 N, R 7 E.

LOC. 29. Loose blocks of the Virgiana-bearing dolomite were also observed on the shore about 3 miles north of Glen Point (southern part of sec. 10, T 42 N, R 7 E) by Drs. August F. Foerste and W. I. Robinson, who accompanied the writer on visits to Drummond Island.

As no blocks of this dolomite were found farther north along the shore it is logical to assume that the contact between the Mayville, which is marked at the top by the Virgiana zone, and the Burnt Bluff must intersect the shoreline near this locality.

Along the shore about 3 miles north of this locality is the most southern exposure of the Richmond formation on the eastern side of the island. A large number of fossils were collected from a thin-bedded, somewhat argillaceous, gray limestone at this exposure by Drs. Ulrich, Foerste, and Shideler, who accompanied the writer on a trip along the north shore of Drummond Island a few summers ago. The identification of these fossils indicates beyond question that the limestone at this place belongs to the Whitewater Member of the Richmond. According to Doctor Foerste a Stromatocerium-reef, which is just beneath the water of the lake at this place, is very likely a westward extension of the Gore Bay reef of the Richmond of Manitoulin Island.

On a subsequent brief visit to the eastern side of Drummond Island in September 1926, the writer discovered an exposure of Richmond strata on a ridge about 200 yards west of the shore of a small bay, located immediately south of the southern termination of the previously-mentioned Richmond outcrops.

The strata of the ridge, which apparently is just east of the center of sec. 32, T 43 N, R 7 E, consist of buff, sandy-appearing dolomites with silicified remains of undoubted Richmond corals, bryozoa, brachiopods, pelecypods and gastropods. The beds are about 35 feet above the lake level and may be as much as 50 feet above the Gore Bay Stromatocerium-reef, exposed along the shore a short distance to the northeast.

Dr. Foerste was very much impressed with the faunal similarity of the beds along the shore to the beds of the Kagawong member of the Richmond of Manitoulin Island. As the result of a brief examination of the fossils collected from the dolomites of the ridge, it seems to the writer that the limestone of the ridge is also of Whitewater age and with the limestones on the shore may be provisionally correlated with the Kagawong Member of the Richmond.

What strata intervene between the highest observed Richmond strata on the ridge and the Virgiana zone, which probably is near the surface about 3 miles to the south, is not known. It is possible that the Cabot Head Shale and Manitoulin Dolomite members of the Cataract Formation, which occupies a position between the Richmond and Niagaran strata on Manitoulin Island, may be present in this interval. Some of the interval, represented on the surface by the 3 miles of drift-covered shore, must be occupied by the 35 feet of Richmond composing the ridge. More of the interval is with little doubt occupied

by Mayville strata. In view of the fact that a considerable part of the interval may be occupied by observed Richmond strata and possibly unexposed Richmond and Mayville beds, it seems quite likely that the Cataract Formation, if present, must be thinner than shown in sections on Manitoulin Island. Moreover, it is possible that the Cataract is entirely missing, in which case the Mayville Dolomite probably rests directly on Richmond strata.

Houghton County

Big Limestone Mountain:

LOC. 30. According to Professor Case & Dr. Robinson (1915, p. 173), a badly broken bed of very siliceous material of Lockport age is exposed on the south slope of Big Limestone Mountain, an outlier of Paleozoic strata about 4 miles north of Hazel in southern Houghton County.

The fossils collected from this bed were identified by these writers (1915, p. 173) and Dr. Ulrich as follows:

Streptelasma spongaxis
Zaphrentis stokesi
Duncanella ? sp. ?
Clorinda cf. ventricosa
Pentamerus sp.
Conchidium decussatum ?
Dalmanella cf. elegantula
Leperditia aff. cylindrica
Loxonema sp.

After examining these fossils the writer is inclined to believe that the brachiopod identified as Conchidium decussatum ? is this species and that several molds of the shells of the brachiopod identified as Pentamerus sp. may also belong to the same species. According to Savage (1918, p. 335), however, Conchidium decussatum should be assigned to the genus Virgiana.

A few of the molds of the shells of the brachiopod, identified by Case & Robinson as Pentamerus sp., were loaned to Professor Savage and Mr. Crooks for study. As the result of their work, these writers (Savage & Crooks, 1918, p. 63) concluded that these molds belong to the species Virgiana mayvillensis.

The occurrence of Virgiana mayvillensis and the very closely related species Virgiana or Conchidium decussatum in the strata at Big Limestone Mountain indicates that the Virgiana-bearing dolomite at the top of the Mayville originally had a much wider distribution than exists at present.

It is possible that Mayville beds below the Virgiana mayvillensis-dolomite and other Niagaran strata are also present at Big Limestone Mountain. The possible occurrence of Manistique strata at this locality is discussed under the detailed sections of the Manistique Dolomite.

According to Case & Robinson (1915, p. 172, 173), the Niagaran beds of Big Limestone Mountain are underlain by Richmond strata and overlain by rocks of mid-Devonian age.

Correlation and faunal relationships of the Mayville Dolomite. -- The correlation of the Mayville Dolomite of the Northern Peninsula with the Mayville Dolomite of Wisconsin is well established. This correlation is based on the continuity of the strata -- the Virgiana mayvillensis-bearing dolomite in this respect being particularly striking, the lithologic similarity of the beds, and the occurrence of many species in the Mayville rocks of the Northern Peninsula which are characteristic of the Mayville beds of Wisconsin (see Table 1).

In 1916 Savage (1916, p. 310, 311) correlated the lower and middle portions of the Mayville Dolomite of Wisconsin with the Edgewood Formation of Illinois and Missouri. Professor Savage based this correlation on the finding of a few species in the Mayville rocks at Peebles, Wisconsin, which he identified as characteristic species of the Edgewood Formation.

In a paper, written jointly with Mr. Crooks in 1918 (Savage & Crooks, 1918, p. 63) Professor Savage stated that all of the Mayville beds of Wisconsin -- "... Silurian rocks included between the top of the Virgiana zone and top of the underlying Maquoketa ..." -- and equivalent beds in Michigan are the time equivalents of some part of the Edgewood Formation and are much older than the Niagaran. In a later paper Savage (1918, p. 337-339) again stated that the Mayville beds of Wisconsin and Virgiana zone of Michigan are of Edgewood age.

That the Mayville beds of Michigan and Wisconsin are younger than the Edgewood Formation is shown by certain stratigraphic relationships. The Edgewood Formation in Illinois and

Missouri is overlain by the Sexton Creek Limestone, which Savage (1917, p. 87, 88) considers the time equivalent of some part of the Brassfield Limestone of Ohio. The Brassfield Limestone in turn is regarded by Schuchert (1914, p. 291, 292) and other stratigraphers as a close correlate of the Cataract of Ontario. The Mayville beds, if they are to be correlated with the Edgewood Formation as Professor Savage has indicated, would have to be older than the Cataract. Such a relation is indicated by Professor Savage (1916, p. 313) in a statement to the effect that the Virgiana bed should possibly be correlated with the basal part of the Manitoulin Member of the Cataract Formation, although "it more probably belongs to a time shortly preceding the Cataract." That the Virgiana mayvillensis dolomite and probably all underlying strata of the Mayville are not as old as the basal part of the Manitoulin Dolomite, the lowest member of the Cataract, and hence are younger than the Edgewood Formation, is clearly shown, however, by Dr. M. Y. Williams' discovery (1919, p. 36) of the Virgiana mayvillensis dolomite on Cockburn, Manitoulin, and Fitzwilliam Islands at a higher position; namely, in the Dyer Bay Dolomite, which Williams defines as one of the uppermost divisions of the Cabot Head Shale Member of the Cataract.

According to Williams (1919, p. 36) the true Cataract age of the Dyer Bay Dolomite is demonstrated by Bassler's determination of the ostracods obtained from beds of this dolomite and by the identification of Alexandrian fossils in these beds on Fitzwilliam Island. From correspondence received from Doctor Williams on the one hand and Doctors Bassler and Ulrich on the other it seems that Doctor Williams' statement regarding Bassler's determination of the Cataract age of the Dyer Bay ostracods was made as the result of a misunderstanding. In a paper on Paleozoic Ostracoda, published as a part of a monograph on the Silurian of Maryland, Ulrich & Bassler (1923, p. 334-337) state that the Dyer Bay ostracods are closely related to forms found elsewhere in the Clinton Group of the Niagaran Series and hence do not indicate a Cataract age for the beds containing them.

On account of their very important and direct bearing on the question of the age of the Mayville as well as the Dyer Bay Dolomite, the views of these writers are given in full (1923, p. 335-337):

> In our opinion this reference of these dolomitic limestones (Dyer Bay and Mayville dolomites) to the Medinan is unwarranted. The problem is complicated and its full discussion is reserved for another occasion. It is mentioned here mainly because specimens of three of the Ostracoda described and illustrated in this volume come from the typical locality of the Dyer Bay dolomite and the desirability of some explanation for our reference of these species to a higher position in the time scale than that given them by Williams. Briefly, the evidence in the base is as follows: The senior author has collected more than 100 species of fossils from the Mayville dolomite, near Mayville, Wis. These fossils certainly are neither of 'Alexandrian' age, as Savage classified the formation, nor of the age of the Cataract or Upper Medina as Williams has it. They are Niagaran and probably represent some part of the Clinton, whether Lower, Middle or Upper Clinton need not be decided at present. The Dyer Bay dolomite being, as is generally admitted, of the age of the Mayville must there-

PLATE 1 -- CORALS

Figures x 1 except as noted

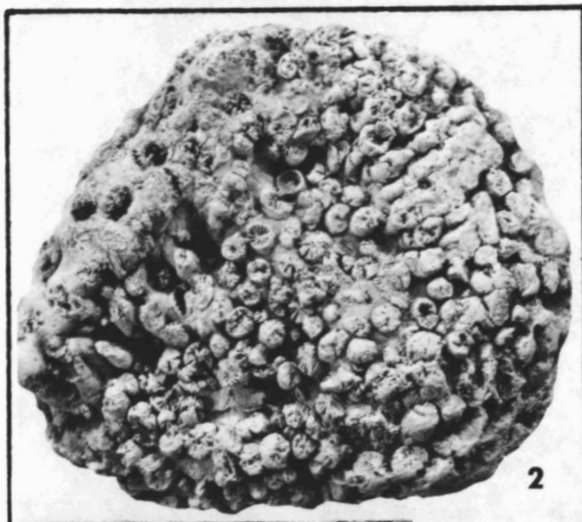
1-3 - Palaeophyllum williamsi (Chadwick). UMMP 31581. NW side Drummond Island, NW$\frac{1}{4}$ sec. 10, T 42 N, R 6 E, Chippewa Co. Side and two top views; 3, x 4.

4 - Arachnophyllum striatum (d'Orbigny). (= Strombodes striatus). UMMP 8602. Drummond Island.

5, 6 - Arachnophyllum pentagonum (Goldfuss). UMMP 8603. Drummond Island or Point Detour, Chippewa Co. 6, x 2.

7, 8 - Porpites michiganensis (Bassler). UMMP 31589. Scott Quarry. 8, x 2.

9-12 - Asthenophyllum patula (Rominger). (= Streptelasma patulum). 9, 10, UMMP 31577. About $\frac{1}{4}$ mi. S of NE corner sec. 30, T 44 N, R 5 W, 2 3/4 mi. SE of Trout Lake, Chippewa Co. 10, x 2. 11, 12, UMMP 8580. Point Detour, Chippewa Co. 11, x 2; 12, x 4.



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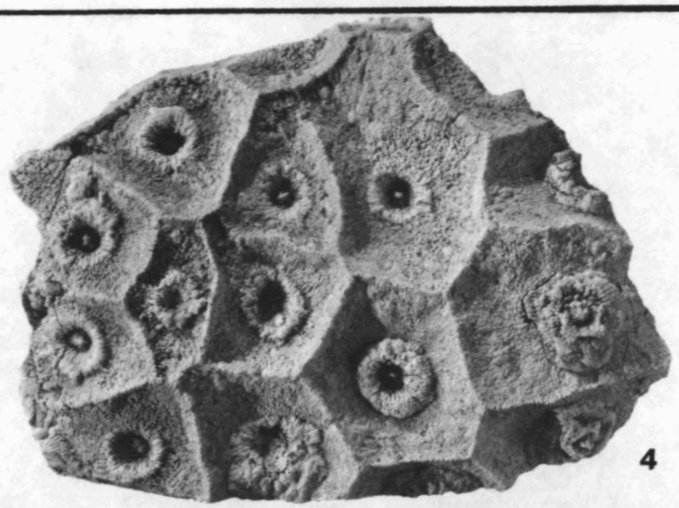

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Manistique-Cordell

Mayville

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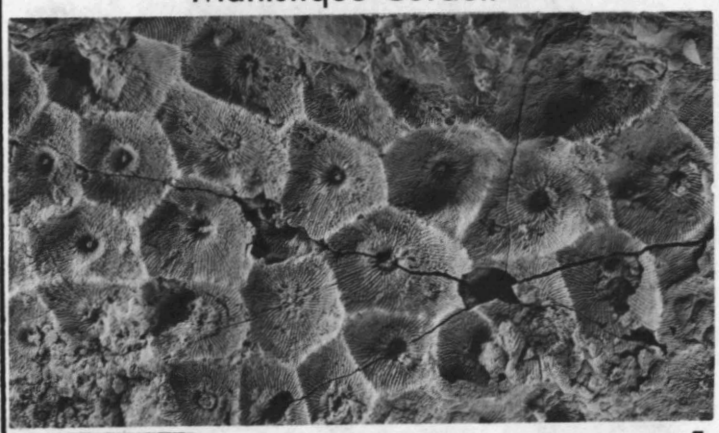

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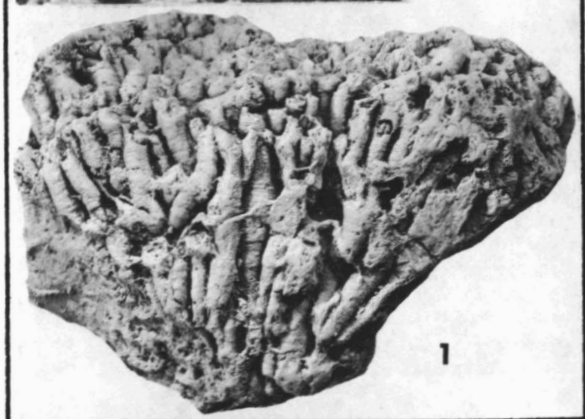

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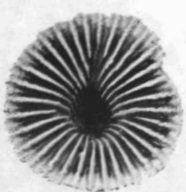

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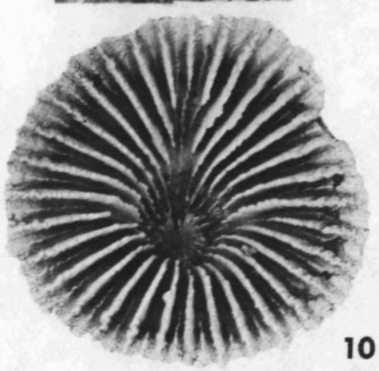

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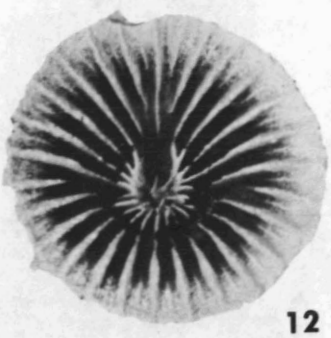

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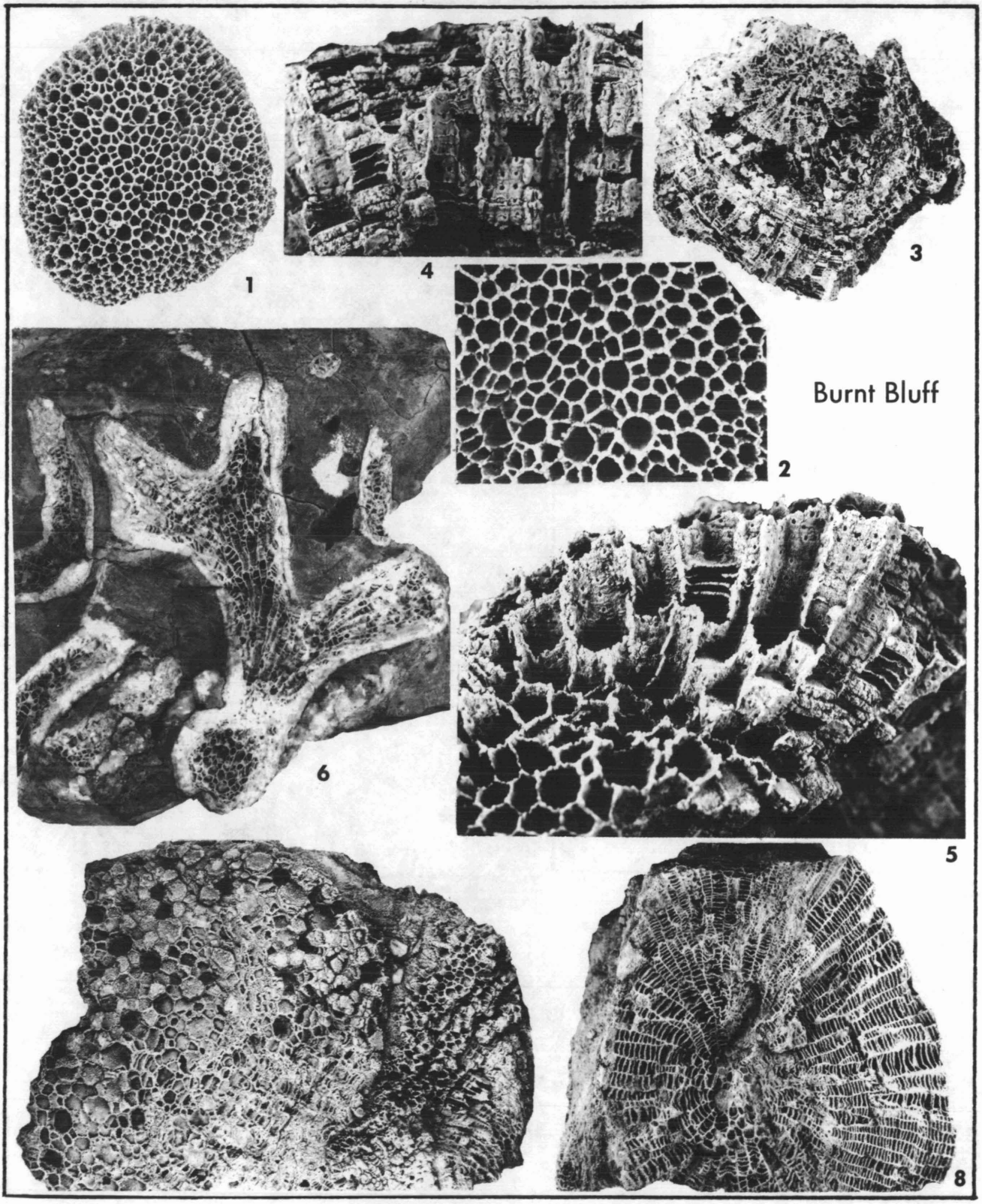
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fore also be of Niagaran and not Medinan age. Confirmation of this conclusion is found in the Dyer Bay Ostracoda that were studied by us for Doctor Williams and partially listed by him under the preliminary names then applied to them. In all, six species were distinguished: Chilobolbina billingsi, C. punctate, Zygobolba Williamsi, two species of Leperditia, neither of which has yet been described, and a species of Bythocypris that has no particular stratigraphic significance. The two species of Chilobolbina occur in both the Gun River and Jupiter River formations in Anticosti; and the longer of the two species of Leperditia is found above the middle of the Gun River formation at Hannah Cliff. Varieties of both of the Chilobolbinas occur in the Mastigobolbina lata zone at Cumberland, Md.

As shown on preceding pages the Gun River and Jupiter River formations are of lower Clinton age; and the Mastigobolbina lata zone is the most typical and persistent part of the Middle Clinton. According to this ostracod evidence, then, it appears that the Dyer Bay dolomite corresponds to the latter part of the Lower Clinton or the early part of the Middle Clinton with the former interpretation the more likely of the two. With the exception of the species collected on Fitzwilliam Island and referred by Williams to the Dyer Bay dolomite, there is nothing in the remainder of the fossils of this bed as listed by him that would not look as well or better in a Clinton fauna than a Medinan one. Indeed, where else does one see corals like Syringopora retiformis, Favosites cristatus, and F. obliquus, or brachiopods like Strophonella striata, and Rhynchonella bidens, or a pelecypod like Pterinea undata or a trilobite of the genus Liocalymene (Calymene cf. clintoni), in rocks of pre-Clinton age? And how are we to explain that of the 10 fossiliferous Dyer Bay exposures given in Williams' tabulated list of fossils the so-called 'Alexandrian' species occur only in the column of Fitzwilliam Island? Of the six fossils listed from this island only one (Virgiana mayvillensis) is noted as occurring in another of the 10 localities. The suggested possibility that the supposed Dyer Bay dolomite on Fitzwilliam Island is really an older bed should have been considered before Williams changed his belief regarding the post-Medina age of the Dyer Bay dolomite.

Just how this Clinton fauna got into the Michigan Basin is not easily explained. The Liocalymene and the Ostracoda at least, and less certainly also some of the Brachiopoda, doubtless are Atlantic types. But we see no possible chance of deriving them by direct migration from the Appalachian region across the Ohio Valley to the Great Lakes region. The only paths that now are suggested as probable are to the north from Lake Huron to Hudson Bay or in a more easterly direction across Quebec to the Gulf of St. Lawrence. Some definite basis for the belief that the Dyer Bay Ostracoda actually invaded the Great Lakes region from the northeast has come to us through a few slabs of fossiliferous limestone collected on the southeast branch of Blanch River north of Cobalt, Ontario. One of these pieces of limestone contains the Leperditia and Chilobolbina punctata which the Dyer Bay holds in common with the Gun River formation of Anticosti, and with them the Zygobolba williamsi which is so far known only from Ontario.

The facts in the case as above outlined may be summed up by saying that the trend of all the evidence -- physical and stratigraphical as well as the purely faunal -- now available is unqualifiedly opposed to the reference of the Dyer Bay dolomite of the Lake Huron region and also the in part contemporaneous Mayville dolomite in eastern Wisconsin to a pre-Niagaran age. The Mayville and Dyer Bay dolomites probably belong in the lower half of the Clinton group, but they certainly are neither "Alexandrian" nor Medinan in age.

An examination of the fossils collected from the Mayville Dolomite of Michigan leads the writer to agree with Ulrich & Bassler that this formation is of Niagaran (Clinton) age.

The fossils listed in Table 1 as Streptel-

PLATE 2 -- CORALS

Figures x 1 except as noted

1, 2 - Favosites sp. UMMP 12847. Small abandoned quarry in low ridge, S part sec. 28, T 42 N, R 17 W, Schoolcraft Co. 2, x 2.

3-5 - Favosites sp. UMMP 12848. Small abandoned quarry, same as above. 4, 5, x 4.

6 - Favosites sp., digitate variety. Hendricks Quarry.

7, 8 - Favosites sp. Top of bluff, sec. 35, T 45 N, R 8 W, Luce Co.

TABLE 1 -- Fossils Present in the Mayville Dolomite of Michigan.

Anthozoa

- Duncanella ? sp.
- Eridophyllum ? sp.
- Favosites sp.
- Paleofavosites aspera
- Streptelasma spongaxis
- Zaphrentis stokesi
- Zaphrentis sp.

Bryozoa

- Chasmatopora angulata ?
- Hallopora sp.
- Pachydictya aff. crassa
- Pachydictya aff. famelica
- Pachydictya sp.

Brachiopoda

- Atrypa n. sp.
- Clorinda cf. ventricosa
- Conchidium decussatum ? = Virgiana decussata
- Dalmanella cf. elegantula
- Dalmanella sp.
- Leptaena rhomboidalis
- Orbiculoidea n. sp.
- Orthis flabellites
- Platystrophia aff. daytonensis
- Rhynchonella n. sp. cf. whitei
- Schuchertella subplana var.
- Schuchertella aff. subplana
- Schuchertella sp.
- Virgiana major
- Virgiana mayvillensis

Gastropoda

- Conularia sp.
- Diaphorostoma aff. niagarense
- Diaphorostoma sp.
- Hormotoma ? sp.
- Loxonema sp.

Trilobita

- Bumastus n. sp.
- Encrinurus cf. tuberculifrons
- Illaenus sp.

Ostracoda

- Leperditia aff. cylindrica

asma spongaxis, Zaphrentis stokesi, Atrypa n. sp., Clorinda cf. C. ventricosa, Orthis flabellites, Rhynchonella (? Camarotoechia) n. sp. near Camarotoechia whitei, Schuchertella subplana var., Bumastus n. sp., and Encrinurus cf. E. tuberculifrons have decided Niagaran affinities. The corals Streptelasma spongaxis and Zaphrentis stokesi seem very similar to typical examples of these species found in the Cordell Member of the Manistique, which the writer will subsequently show is of Clinton age. The new species of Atrypa is related to Atrypa rugosa, a Rochester and West Union form and Atrypa calvini, a Louisville and Noblesville form. According to Dr. M. Y. Williams, to whom the Mayville fossils were sent with the view to determining whether they were related to Silurian species of Ontario, the brachiopod Orthis flabellites is identical with specimens of this species found in the Lockport of Ontario, and the trilobite Bumastus n. sp. resembles specimens found in the lowest beds of the Lockport at Limehouse, Ontario. The brachiopod Schuchertella subplana var., according to Doctor Ulrich, is indistinguishable from a form which is abundant in the Waldron shale of Indiana and Tennessee. The brachiopod Rhynchonella (? Camarotoechia) n. sp. near Camarotoechia (Stegerhynchus) whitei is also related to a Waldron form. The trilobite Encrinurus cf. E. tuberculifrons is quite similar to individuals of this species found in the Racine.

The fossils listed as Paleofavosites aspera, Pachydictya aff. P. crassa, Chasmatopora ? angulata ?, Dalmanella cf. D. elegantula, Leptaena rhomboidalis, and Diaphorostoma aff. D. niagarense are related to species which have been reported as occurring in both Niagaran and pre-Niagaran strata. Considered as a group and in connection with their association with the forms of definite Niagaran affinities, these fossils are more indicative of a Niagaran than a pre-Niagaran age for the Mayville.

The only forms suggesting a pre-Niagaran age for the Mayville are Pachydictya cf. P.

famelica, Platystrophia aff. P. daytonensis, Virgiana major, V. mayvillensis, V. decussatum, and Leperditia aff. L. cylindrica. The bryozoan Pachydictya cf. P. famelica and the brachiopod Platystrophia aff. P. daytonensis are provisionally referred to species which are especially characteristic of the Brassfield Limestone of Upper Medinan or Alexandrian age. A communication from Doctor Williams, stating that the Platystrophia is identical with specimens found in the Gasport limestone member of the Lockport at Thorold, Ontario, indicates, however, that brachiopods of the Platystrophia daytonensis type also occur in strata of Niagaran age. The ostracod noted above although not well preserved seems most closely related to the Upper Medinan species Leperditia cylindrica. It is possible that better preserved specimens of this ostracod, which is of simple construction and hence of doubtful value in correlation, may prove distinct from this pre-Niagaran species. The species of Virgiana, according to Professor Savage (1916, p. 312, 313) are indicative of the Alexandrian epoch, which included the time interval between the Richmond and Clinton. Savage originally described (1916, p. 312, 313, 321, 322) Virgiana major and V. mayvillensis as varieties of Virgiana barrandei, which is represented by numerous shells in the upper part of the Becscie River Formation of Anticosti Island. On the basis of this varietal relationship Savage (1916, p. 312, 313) correlated the Virgiana bed of the Mayville with the zone of Virgiana barrandei in the Becscie River. In a subsequent paper he (1918, p. 336, 337) pointed out that the two Mayville varieties of Virgiana were quite distinct from Virgiana barrandei and elevated these varieties to the rank of species. Even though Savage recognized this distinctness of the Anticosti and Wisconsin species of Virgiana, he still indicated (1918, p. 336, 337) that the Virgiana-bearing dolomite at the top of the Mayville "seems to occupy about the same position in the Silurian column as do the strata which contain Virgiana barrandei" in the Becscie River Formation of Anticosti Island.

In the writer's opinion it is unwise to correlate the Virgiana beds of the Mayville and Becscie River Formations on the basis of the occurrence of the genus Virgiana because this genus may have a range of considerable vertical extent. A consideration of the faunal and stratigraphic relationships of the Becscie River, Mayville, and related formations gives support to this opinion. In 1910, Schuchert & Twenhofel (1910, p. 707, 708) indicated that the Becscie River, which contains the genotype of Virgiana, is possibly older than the upper Medina of Ontario. In 1914 Professor Schuchert (1914, p. 292) stated that

> the absence in the Cataract of the Becsie River guide, Clorinda barrandei (=Virgiana barrandei), also seems to indicate that the former formation is of younger age. At the top of the Becsie River, however, the fauna is more like that of the Cataract, and this similarity continues in the succeeding 300 feet of the Gun River formation.

Twenhofel (1914, p. 19, 20) states that

> the Becsie River fauna shows its nearest relationships with that of the Cataract formation of Schuchert; but if the long ranging species be not considered, there are only three species common to the two formations, while most of the Cataract species make their first appearance in strata higher in the Anticosti section than the Becsie River formation, and, since the general expression of the Cataract formation is younger, it is concluded that there is little basis for equivalence and that the Cataract should probably be correlated with the lower portion of the succeeding formation (Gun River).

More recently Twenhofel (1928, p. 70) again points out that "the preponderance of evidence indicates that the Becscie fauna is older than the Cataract, and, therefore, any other known Silurian fauna of the Niagara-Ontario region." If Schuchert & Twenhofel are correct in concluding that the Becscie River is probably older than the Cataract, then the Virgiana bed at the top of the Mayville cannot be correlated with the Virgiana barrandei bed of the Becscie River; the Virgiana mayvillensis bed as previously shown is present in the Manitoulin Island region, where it was originally considered as a part of the Lockport but subsequently was included by Williams in the Dyer Bay Dolomite of the Cataract. The Dyer Bay Dolomite according to Ulrich & Bassler, however, contains ostracods which are identical with or very closely related to species found in the Gun River of Anticosti and the Clinton of Maryland. The Clinton age of the Virgiana mayvillensis bed is also suggested by Twenhofel in his recent report on the "Geology of Anticosti Island." In this report (1928, p. 72, 73) he states that the migration of the Virgianas into the Mississippi valley (Wisconsin-Michigan area) probably did not take place earlier than toward the end of Gun River time.

This statement has an important bearing on the age of the Virgiana mayvillensis bed in view of the fact that Twenhofel (1928, p. 73) finds Clinton types of brachiopods, Coelospira hemispherica, Hyattidina congesta junea, Orthis flabellites, Pentamerus oblongus (early form), and Plectambonites transversalis in the upper part of the Gun River and correlates this part of the Gun River with the lower zones of the New York Clinton, the Sodus Shale, Furnaceville ore bed, and the Walcott Limestone. All faunal and stratigraphic evidence, therefore, indicates that the Virgiana bed of the Mayville is of Niagaran and not Alexandrian age and is not to be correlated with the Virgiana barrandei bed of the Becscie River.

Granting that the Virgiana mayvillensis bed of the Dyer Bay Dolomite and Mayville Dolomite is of Niagaran age, the question may be raised whether the dolomites of the Mayville below the Virgiana bed are likely to be the more off-shore, calcareous equivalents of the Cabot Head Shale and Manitoulin Dolomite Members of the Cataract. In the writer's opinion this question is answered in the negative by the absence of Cataract fossils in the Mayville dolomites and the occurrence in these rocks of a fauna of Niagaran affinities.

Incidentally, it is the writer's belief that the Cataract becomes thinner and thinner in passing from Manitoulin Island to the Northern Peninsula and is overlain by progressively lower beds of the Mayville in this direction. On Drummond Island the Cataract, if present, is certainly much thinner than on Manitoulin Island; the Mayville beds, moreover, may overlap the Cataract and rest directly upon Richmond strata, which are well exposed in the northern part of the island. To the west of Drummond Island, strata resembling those of the Cataract have been encountered below typical Niagaran dolomites in drilling a few deep wells. In drilling the Schoolcraft Development Syndicate well about 2 miles northwest of Seul Choix Point, Schoolcraft County, 125 feet of reddish-gray and greenish-gray shale and argillaceous dolomite were penetrated, which the writer (1922, my interpretation of Silurian section of record of Schoolcraft Development Syndicate well no. 2 as given on p. 106 of Publ. 34, Geol. Ser. 28, Mich. Geol. Surv.) assumed to be Cataract. The decided thinning and possible absence of the Cataract on Drummond Island, which further field work made evident, and the absence of Cataract strata in northeastern Wisconsin, now leads the writer to believe that the supposed Cataract of this well may be of Niagaran or even Richmond age. Just where the Cataract pinches out in the area west of Manitoulin Island and permits the Mayville to rest directly upon the Richmond will not be determined until a series of deep borings are made through the unexposed lower Niagaran and underlying strata.

Returning to the matter of correlation, it would seem that Savage (1918, p. 336-339) and Savage & Van Tuyl (1919, p. 367) are correct in concluding that the Virgiana mayvillensis-zone of the Wisconsin-Michigan-Manitoulin Island area represents about the same stratigraphic horizon as the Virgiana decussata-zone of the Stonewall Limestone of the Grand Rapids of the Saskatchewan River, Manitoba, and the Port Nelson Limestone of the Hudson Bay region. Their conclusion is further supported by Savage & Crook's (1918, p. 63) identification of a few brachiopods as Virgiana mayvillensis, which were found with remains of Virgiana decussata at Big Limestone Mountain, Houghton County, and by the likelihood that Virgiana major, which is associated with V. mayvillensis, is the same as the previously described V. decussata as suggested by Ulrich.

The writer cannot agree with Savage & Van Tuyl, however, in the assignment of the

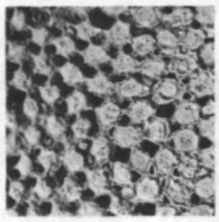
PLATE 3 -- CORALS

Figures x 1 except as noted

1-4 - Halysites compactus Rominger. UMMP 8543. Probably from near mouth of Manistique River, Schoolcraft Co. Two side and two top views. 4, x 2.

5, 6 - Halysites catenularia micropora (Whitfield). UMMP 28454. Drummond Island. 6, x 4.

7 - Halysites labyrinthicus (Goldfuss). UMMP 8541. Point Detour, Chippewa Co.



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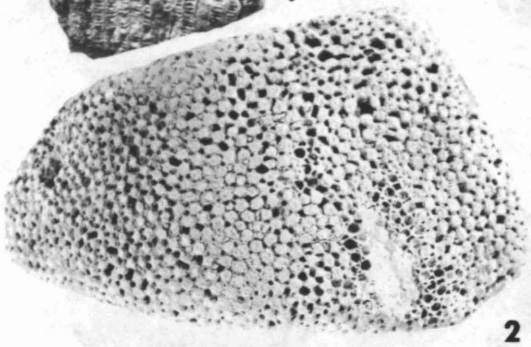
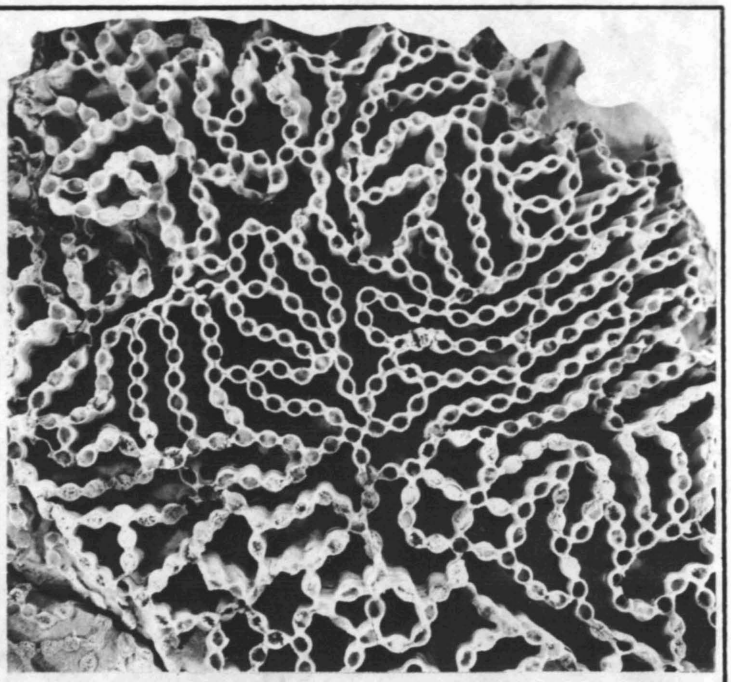
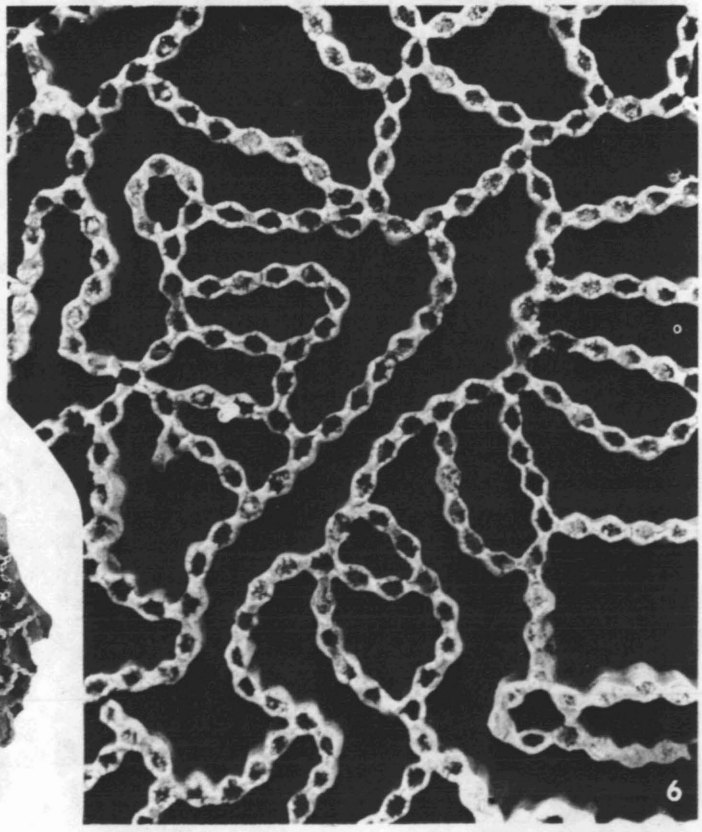
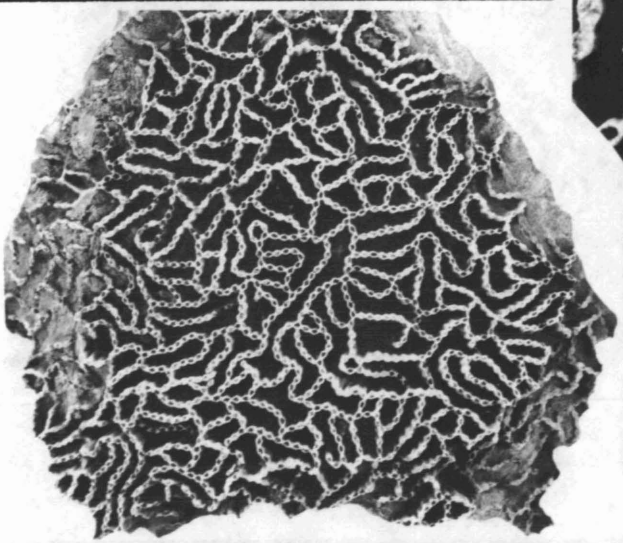
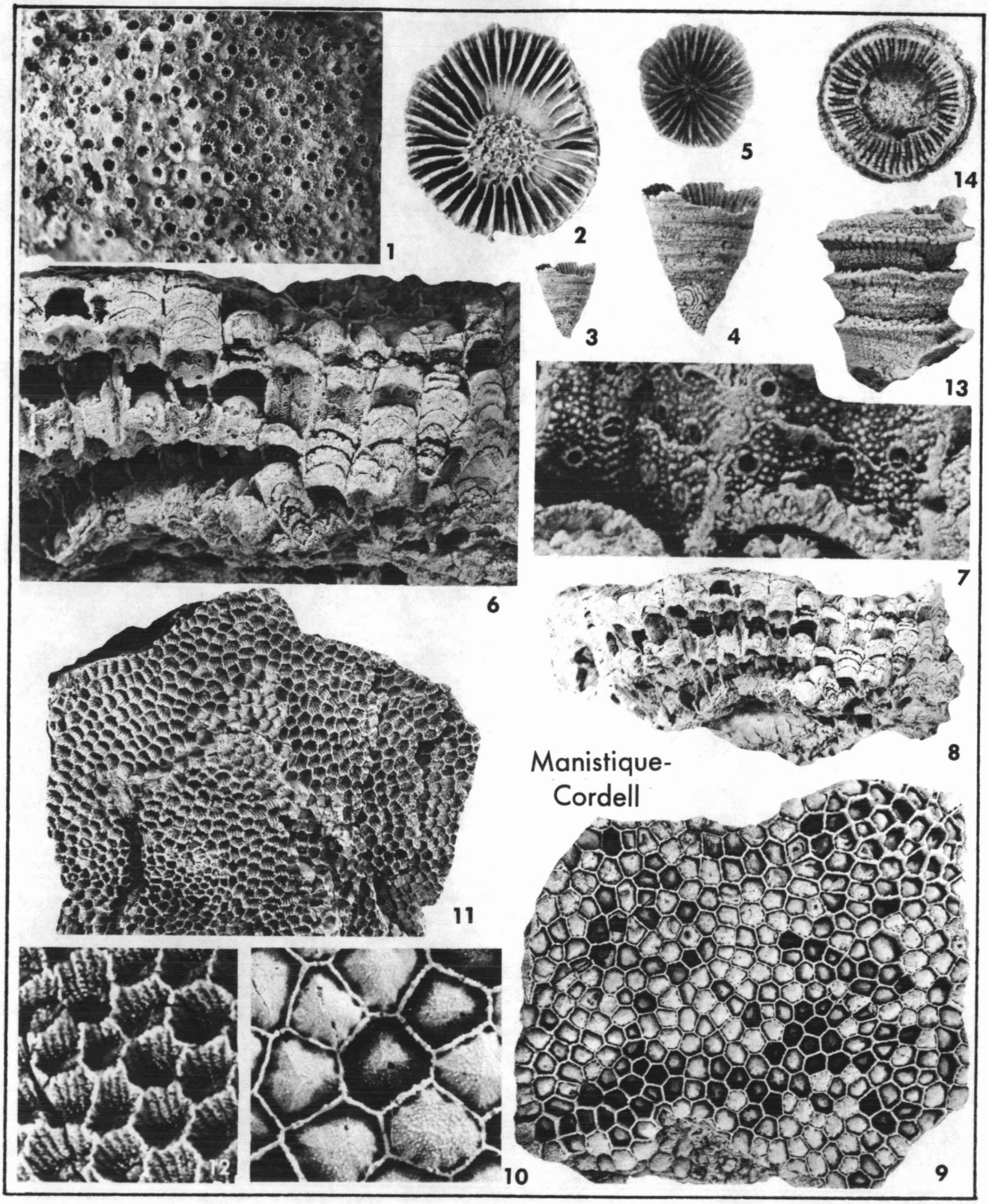




Manistique-Cordell



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Stonewall and Port Nelson Limestones to the Alexandrian series. If the Mayville is of Clinton age, then these formations are also of this age.

The Virgiana decussata bed at Big Limestone Mountain was deposited in a sea which probably invaded Michigan from the Arctic. This is suggested by the occurrence of Virgiana decussata in strata of the same age in the Hudson Bay region.

If Savage & Crooks are correct in identifying as Virgiana mayvillensis a few brachiopods, which were found with specimens of V. decussata at Big Limestone Mountain, it would then appear that the Virgiana mayvillensis-bearing dolomite of Wisconsin, the eastern half of the Northern Peninsula and Ontario, was deposited in the same sea and at the same time as the strata containing Virgiana decussata.

If the poorly preserved Big Limestone Mountain specimens of Virgiana mayvillensis should prove to be variants of V. decussata, as seems possible to the writer, then the Virgiana mayvillensis-bearing bed of Wisconsin, the eastern half of the Northern Peninsula and Ontario may have been deposited (1) in the same sea as the Virgiana decussata strata but probably at a different time, (2) in a sea representing another invasion from the Arctic, or (3) in a sea from the Gulf of St. Lawrence. An invasion of these areas by a sea from the Gulf of St. Lawrence is indicated by the occurrence of Anticosti types of ostracods in the Dyer Bay Dolomite. These ostracods according to Williams (1919, p. 63), are present in strata only a few feet above strata of this dolomite containing Virgiana mayvillensis. Since Williams has found no break in sedimentation between these strata, it seems likely that V. mayvillensis also reached Ontario, Michigan, and Wisconsin by a seaway extending southwestward from the Gulf of St. Lawrence. The presence of Virgiana in the Silurian strata of Anticosti Island indicates that this genus lived in the Atlantic as well as the Arctic Ocean and that Virgiana mayvillensis may have migrated to the interior by way of the Gulf of St. Lawrence.

The presence of Virgiana in both Atlantic and Arctic waters indicates the existence of a connecting seaway between them in Silurian time. Whether this connecting seaway was a direct one or along a trough extending southwestward from the Gulf of St. Lawrence to the Michigan Basin and thence to Hudson Bay remains to be determined.

In the writer's opinion a very careful discrimination of the various species of Virgiana and further study of more extensive collections of fossils from the entire Mayville Dolomite will be necessary to determine the exact direction of migration of the Mayville fauna.

Burnt Bluff Limestone and Dolomite

General description. -- Except for few, very thin beds of shale, the Burnt Bluff Formation consists entirely of limestones and dolomites, differing greatly in lithologic character.

With the exception of several limestones of the Hendricks Member, the strata of the Burnt Bluff Formation maintain their lithologic character when traced for long distances. The Hendricks limestones in the region between

PLATE 4 -- CORALS

Figures x 1 except as noted

1 - Lyellia americana Edwards & Haime. UMMP 8425. Point Detour, Chippewa Co.

2 - "Streptelasma" spongaxis Rominger. (= Kionelasma ? spongaxis). UMMP 26296. About $\frac{1}{4}$ mi. S of NE corner sec. 30, T 44 N, R 5 W, 2 3/4 mi. SE of Trout Lake, Chippewa Co. x 2.

3-5 - "Streptelasma" conulus Rominger. Point Detour, Chippewa Co. 4, 5, x 2.

6-10 - Favosites favosus (Goldfuss). Drummond Island. 6, x 2; 7, x 8; 10, x 4.

11, 12 - Favosites obliquus Rominger. UMMP 8538. Point Detour, Chippewa Co. 12, x 4.

13, 14 - Tryplasma radicula (Rominger). Lectotype UMMP 8582a. Drummond Island or Point Detour, Chippewa Co. Both, x 2.

southeastern Schoolcraft County and south-central Chippewa County are very high in calcium carbonate. Most of them when traced to the east or west of this region grade into dolomites.

The type section of the Burnt Bluff Formation, with which several sections of Burnt Bluff strata will be compared, is exposed at Burnt Bluff, Big Bay de Noc. This section, given below, was made with difficulty by descending the bluff at a place about 400 feet south of its highest point and thence proceeding northward along the face of the cliff to a point on the shore about one-eighth mile north of the boat landing.

Section of strata exposed at Burnt Bluff, Big Bay de Noc, Locality 36

		Thickness Feet	Inches
	Manistique Dolomite		
	Schoolcraft Member		
38	Dolomite, thin-bedded, gray and finely crystalline.....	2	
37	Covered - probably dolomite similar to that above.....	2	
36	Lower Pentamerus dolomite. Massive, coarsely crystalline, light-brown dolomite containing poorly preserved molds of the shells of Pentamerus. Weathers into layers 3" to 6" thick.....	6	
	Burnt Bluff Limestone and Dolomite		
	Hendricks Member		
35	Dolomite, uneven-bedded, light-brown, coarsely crystalline and cherty. Nodules of chert abundant in lower 2 feet. Few specimens of Favosites sp.....	14	
34	Dolomite, massive, coarsely-crystalline, light-brown, weathering into uneven layers 2" to 6" thick.....	7	
33	Dolomite, massive, light-brown to cream-colored and somewhat finer crystalline than overlying dolomite. Weathers into layers 1" to 3" thick.....	3	
32	Dolomite, massive, light-brown, coarsely-crystalline, with cavities due to the solution of stromatoporoids and Favosites.....	17	
31	Dolomite, gray, finely crystalline, massive in the ledge but weathering into layers ½" to 1" thick.....	8	
30	Dolomite, massive, light-brown, coarsely crystalline, somewhat sandy, with few cavities doubtfully formed by the solution of stromatoporoids and Favosites.....	7	
29	Dolomite, massive, light-brown, somewhat sandy and finer crystalline than that above; weathered surfaces showing laminae.....	6	6
28	Dolomite, massive, lighter brown and more coarsely crystalline than overlying rock.....	3	
27	Dolomite, massive, gray, very finely crystalline; weathered surfaces are bluish-gray and show laminae. Laminae of lower 2' undulatory and at intervals crumpled, the latter condition being most pronounced in an "edgewise conglomerate" at the base. The "conglomerate," about 3 to 6 inches thick, contains elongated, angular pebbles very similar in lithologic character to the matrix.....	3	
26	Dolomite, massive, coarsely crystalline, light-brown with lighter-brown to yellow, irregularly digitate areas of dolomite crystals and cavities formed by solution of typical Hendricks species of stromatoporoids and Favosites. Few		

		Feet	Inches
	silicified specimens of Rhynchospira lowi, Favosites sp. no. 1 - characteristic Hendricks form, and stromatoporoids	6	10
25	Dolomite, light-gray, thin-bedded, very finely crystalline with conchoidal fracture	4	
24	Dolomite, massive, light-gray and coarser crystalline than overlying dolomite	1	
23	Dolomite, massive, light-brown to cream-colored and corasely crystalline	2	
22	Dolomite, dark brownish-gray to chocolate-colored and finely crystalline. Beds 3" to 6" thick	2	2
21	Dolomite, massive, lighter gray and coarser crystalline than overlying rock	1	
20	Dolomite, thinner-bedded than overlying rock, darker gray and finer crystalline; weathered surfaces showing laminae	1	
19	Dolomite, massive, somewhat lighter gray and more coarsely crystalline than overlying rock; weathered surfaces showing laminae	2	9
18	Dolomite, massive, light-gray, very finely crystalline and laminated. Upon weathering, rock splits into layers $\frac{1}{4}$" to 1$\frac{1}{2}$" thick	10	6
17	Dolomite, massive, light brown, coarsely crystalline with few cherts and few silicified specimens of stromatoporoids, characteristic Hendricks corals, Duncanella sp. and Favosites sp. no. 1, and Whitfieldella (?) sp. Fossils occur chiefly in the uppermost 1 foot of dolomite	3	6
16	Dolomite, thick-bedded, light cream-colored and coarsely crystalline	2	
15	Covered	16	
	Byron Member		
14	Dolomite, thin-bedded and laminated and light- to dark-gray except for few layers which are cream-colored. Some beds argillaceous with an earthy feel; others finely crystalline and magnesian	32	
13	Dolomite, thin-bedded, light-brown and coarser crystalline than underlying rock	2	
12	Dolomite, thin-bedded, gray and argillaceous, with bluish-gray shale partings. Rock fractured by numerous, closely spaced joints	6	6
11	Dolomite, similar to that above but with thicker seams of bluish-gray shale. A shale seam, ranging in thickness from $\frac{1}{4}$" to 1", occurs at top	2	
10	Dolomite, similar to that of interval 8 and containing chert nodules like those of interval 7	1	6
9	Dolomite, laminated, finely crystalline and gray, weathering to a light-brown	1	
8	Dolomite, massive, gray, coarsely crystalline and brecciated, containing many cavities lined with drusy calcite and dolomite. On weathering rock becomes light-brown and white and very friable	2	
7	Dolomite, massive, gray and finely to coarsely crystalline, containing small lenses and nodules of nearly transparent		

		Feet	Inches
	chert. Lower 2' more finely crystalline than rock above. Weathered surfaces of rock show laminae, which are undulatory near the base of the dolomite.....	7	6
6	Talus-covered interval. The strata of this interval are exposed in a high cliff, which extends southward along the nearby shore of Big Bay de Noc as a continuation of Burnt Bluff. They consist of thin even-bedded and laminated, light-gray, light-brown, and cream-colored argillaceous and magnesian limestones.....	40	
5	Dolomite, gray, finely crystalline showing laminae on weathered surface.....	1	
4	Dolomite, thin-bedded, very light gray with pinkish tinge and small, irregular-shaped cavities.....	1	
3	Dolomite, light-gray and somewhat coarser crystalline than rock above.....		6
2	Dolomite, light-brown to cream-colored and thin bedded. Uppermost beds laminated.....	13	
1	Covered interval to Big Bay de Noc level. Shingle along shore consists of light-gray, cream, and light-brown, argillaceous and magnesian limestone, indicating that limestones of these compositions are probably present below the water....	7	
		248	3

As exhibited in this section, the Byron has a thickness of 117 feet and consists chiefly of thin-bedded and laminated dolomites, most of which are light-gray.

The Hendricks Member, which has a thickness of 121 feet,3 inches, contains more thick beds of dolomite than the Byron. Thick beds of light-brown dolomite are especially characteristic of the upper part. Thinner-bedded, laminated and gray to cream-colored dolomites, which are lithologically very similar to Byron strata, compose the lower part.

On paleontological evidence, the division between the Hendricks and Byron Members is placed at the base of the 16-foot covered interval, numbered 15 in the section. As stated in the description of the section, typical Hendricks fossils are present in the dolomite of interval 17. A partially dolomitized limestone, containing Hendricks fossils and occupying a position corresponding to the upper part of interval 15, is exposed near the base of a bluff about 11 miles northeast of Burnt Bluff. This limestone, noted below as interval 3 in the description of the strata of this bluff, is also exposed at other places along Big Bay de Noc. Because this limestone with Hendricks fossils is probably

PLATE 5 -- CORALS

Figures x 1 except as noted

1, 2 - Lyellia papillata Rominger. Point Detour, Chippewa Co. 2, x 4.

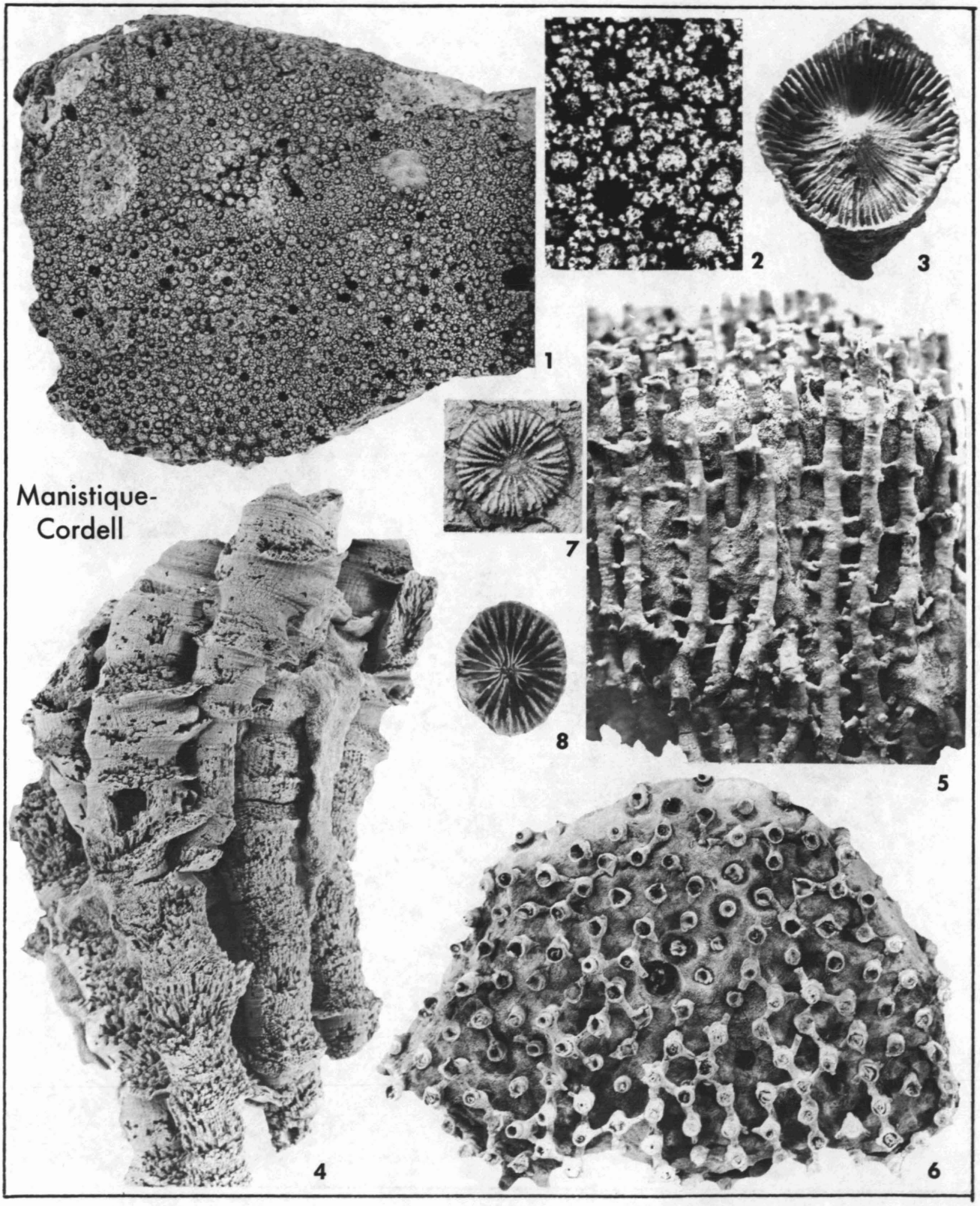
3 - Dinophyllum ? umbonatum (Rominger). Drummond Island or Point Detour.

4 - "Diphyphyllum" huronicum Rominger. Point Detour.

5, 6 - Syringopora verticillata Goldfuss. UMMP 8545. Drummond Island or Point Detour, Chippewa Co.

7 - Porpites michiganensis (Bassler). UMMP 31588. Scott Quarry. x 2.

8 - "Streptelasma" conulus Rominger. Point Detour, Chippewa Co.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Manistique-
Cordell
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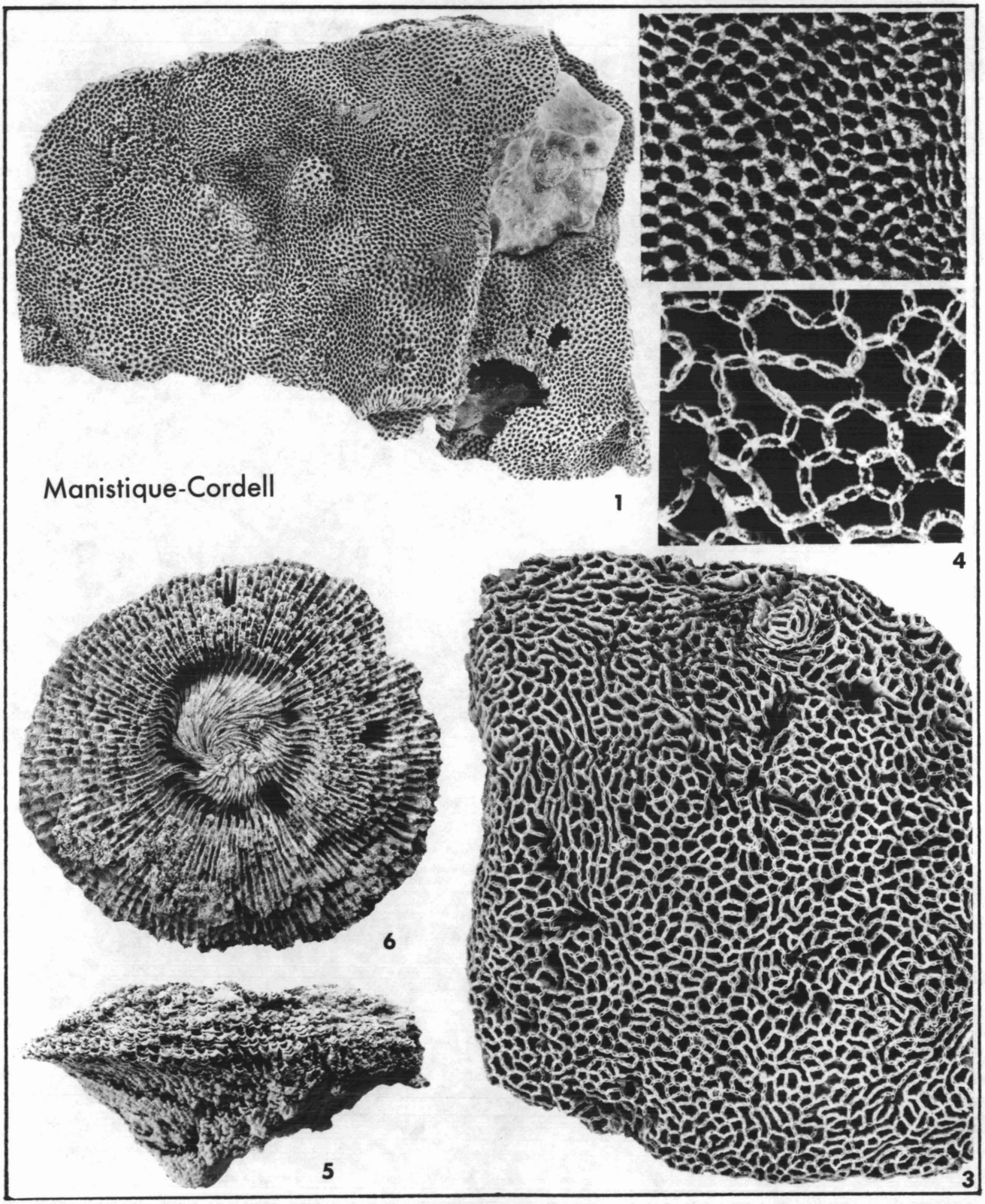
Manistique-Cordell
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6

present within interval 15 of the Burnt Bluff section and because Hendricks fossils are absent in the strata below interval 15, the writer is prompted to place the division between the Hendricks and Byron Members at the base of this interval.

It is quite possible that when all of the strata of interval 15 are observed in outcrop, it will be found that Hendricks fossils do not occur below the upper part of this interval. In this event the division between the Hendricks and Byron Members must be raised.

The contact between the Hendricks and overlying Schoolcraft beds of the Manistique is at or just below the base of a massive, brown, Pentamerus-bearing dolomite, designated in this paper as the lower Pentamerus dolomite. The reason for placing the division at this stratigraphic position is the presence at several localities of typical Hendricks fossils in strata just below this dolomite. The absence of Schoolcraft fossils below the lower Pentamerus dolomite and the striking difference between the faunas below and above this dolomite lend support to this location of the Hendricks-Schoolcraft contact and indicate that this contact is probably a disconformable one.

On account of their highly dolomitic character the Hendricks strata at Burnt Bluff may readily be confused with the lithologically similar Schoolcraft strata of the Manistique Formation. This lithologic similarity undoubtedly induced the staff (Allen, Smith & Barrett, 1916, Geological map of Michigan) of the Michigan Geological Survey to map incorrectly the Hendricks strata exposed at Burnt Bluff and elsewhere in the escarpment bordering the eastern shore of Big Bay de Noc as a part of the Manistique Formation. Fortunately, the recognition of a few fairly well preserved, diagnostic fossils which can usually be found in the Hendricks dolomites of this escarpment, make it possible to distinguish these dolomites from the faunally different though lithologically similar Schoolcraft beds.

One of the best places along the eastern shore of Big Bay de Noc to obtain an idea of the faunal and lithologic composition of the Hendricks strata is about 11 miles northeast of Burnt Bluff in the NW$\frac{1}{4}$ sec. 32, T 40 N, R 18 W, Delta County. At this place many Hendricks strata of the Burnt Bluff section are exposed in a westward-facing bluff, the base of which is about one-quarter mile east of the shore of the bay. On account of the fact that the face of the bluff is not so precipitous as at Burnt Bluff and other parts of the escarpment bordering the eastern shore of Big Bay de Noc, the Hendricks strata are more accessible for stratigraphic and paleontologic study.

Section of strata exposed in bluff 11 miles northeast of Burnt Bluff (hereafter referred to as the "11-mile bluff"), (NW$\frac{1}{4}$ sec. 32, T 40 N, R 18 W) Delta County, Locality 43

		Thickness Feet	Inches
	Burnt Bluff Limestone and Dolomite		
	Hendricks Member		
17	Interval consists of loose blocks of dolomite similar lithologically to dolomites of intervals 15 and 16. These blocks may have been dislodged by the Pleistocene ice from the ledges below....	5	
16	Dolomite, light-brown and coarsely crystalline.....	1	
15	Dolomite, massive, light-brown and very granular, con-		

PLATE 6 -- CORALS

Figures x 1 except as noted

1, 2 - Coenites crassus Rominger. UMMP 8493. Point aux Barques, Schoolcraft Co. 2, x 4.

3, 4 - Catenipora huronensis (Teichert). UMMP 8544. Point Detour, Chippewa Co. 4, x 4.

5, 6 - Ptychophyllum stokesi Edwards & Haime. UMMP 31571. Field in SE$\frac{1}{4}$ sec. 29, T 43 N, R 11 W, about $\frac{1}{2}$ mi. S of Gould City, Mackinac Co.

		Feet	Inches
	taining numerous, poorly preserved stromatoporoids.....	2	
14	Covered.....	7	
13	Dolomite, finely crystalline and gray; massive, splitting into slabs 1" thick on weathering.....	5	
12	Dolomite, massive, light-brown to cream-colored and coarsely crystalline, containing poorly preserved remains of Camarotoechia winiskensis at base. Weathered rock friable.....	10	
11	Dolomite, very light buff in upper part and light grayish-buff and finer crystalline in lower part. On weathering, rock splits into thinner, uneven beds 2 to 5 inches thick and becomes friable.....	6	
	Duncanella cf. D. sp. no. 1 of interval 9 Duncanella sp. Lyellia cf. decipiens Favosites cf. F. sp. no. 1 of interval 9 Cladopora sp. Trimerella sp. Camarotoechia winiskensis Whitfieldella sp. - small form, probably new and the same as that of interval 3 Hormotoma (?) sp. Eotomaria (?) sp.		
10	Dolomite, light-gray and very finely crystalline. Weathered surfaces show very thin and usually closely spaced bands of more resistant material, which stand in relief and give the dolomite a laminate appearance on account of their parallelism with the bedding planes. The thin bands on the lower 2 feet or less of the dolomite are undulatory and at intervals crumpled, the latter condition being most pronounced in an "edgewise conglomerate" at the base. The "conglomerate" is about 6 inches thick and contains angular "pebbles," which differ from the matrix in lithological character only by being slightly lighter gray in color. The pebbles, many of which are elongated, are inclined at various angles to the bedding planes. Immediately above the conglomerate, the dolomite contains numerous "sun-cracks" or dessication fissures.....	5	
9	Dolomite, massive, corasely crystalline, light-buff with lighter buff to yellow areas of small dolomite crystals. Weathered surfaces rough and pitted.....	6	6
	Duncanella sp. no. 1 Duncanella sp. no. 2 Streptelasma sp. no. 1 Streptelasma sp. no. 2 Streptelasma sp. no. 3 Amplexus severnensis Amplexus (?) sp. - small form Favosites sp. no. 1 -- characteristic Hendricks form Favosites sp. no. 2 -- characteristic Hendricks form Aulopora (?) sp. Ceratopora (?) sp. Halysites catenularia Cf. Rhynchospira lowi		
8	Dolomite, light-gray, very finely crystalline, with conchoidal fracture.....	4	
7	Dolomite, massive, light-gray and coarser crystalline than overlying dolomite.....	1	
6	Dolomite, thick-bedded, light-gray to light-brown and medium to coarsely crystalline.....	8	
5	Covered.....	13	
4	Dolomite, thick-bedded, very light gray to light-cream		

		Feet	Inches
	colored and coarsely crystalline	4	
3	Limestone, brownish-gray and very finely crystalline except for lighter brown, irregularly shaped areas of dolomite and calcite crystals Duncanella sp. no. 1 -- same as in interval 9 Duncanella cf. D. sp. no. 1 Amplexus (?) sp. -- small form, same species in interval 9 Whitfieldella sp. -- small form, probably new; same species in interval 11 Leperditia fabulina	2	
2	Limestone, magnesian, massive, darker brownish-gray than that of 3 above with poorly preserved simple corals in basal 3 inches	1	3
1	Dolomite, thin-bedded, very light buff to cream-colored and more finely crystalline at base	1	
		82	3

Small slabs and lenticular pieces of light-gray and very light buff, finely crystalline dolomite compose the material of a series of shingle beaches bordering the shore of Big Bay de Noc about one-quarter mile west of the bluff and about forty feet below the base of the above section. These slabs and lenticular pieces of limestone were cut by wave erosion from ledges of the Byron member which are at the surface of the land just back from the shore and in the bottom of the bay adjoining the shore.

A comparison of above section with that of Burnt Bluff shows very clearly that most of the Hendricks strata exposed along the eastern side of Big Bay de Noc between the two bluffs maintain the same lithologic characteristics and are continuous. This fact becomes evident by placing the base of interval 10 of the above section opposite the base of interval 27 of the Burnt Bluff section and then comparing the beds of the two sections. The "edgewise conglomerate," noted in the sections immediately above the matched bases of these intervals, is the same bed. The massive, light-buff to brown, coarsely crystalline, fossiliferous dolomites, present below the "edgewise conglomerate" at both localities, is another continuous bed. Further comparison of the descriptions of the strata of the two sections and more especially personal examination of the strata in the field will convince one that other beds are common to the two exposures.

By matching the sections as suggested above it will also be seen that neither the lowest nor highest Hendricks strata are exposed in the bluff 11 miles northeast of Burnt Bluff. The strata of intervals 1, 2, and 3 and the lower part of the dolomite of interval 4 are unexposed at Burnt Bluff but with little doubt are within the upper 4 to 5 feet of the 16-foot covered interval of the Burnt Bluff section numbered 15. The base of interval 1 therefore is 11 to 12 feet above the base of the Hendricks Member, which is provisionally placed at the base of interval 15 of the Burnt Bluff section. The gray dolomite of interval 13 is a northeastward continuation of the dolomite of interval 31 of the Burnt Bluff section, the upper part of the dolomite possibly being covered within interval 14 of the former section. The remaining strata of interval 14 and the dolomites of intervals 15, 16, and 17 are present in interval 32 of the Burnt Bluff section. If the dolomite of interval 17 is assumed to be in place and not transported from the underlying ledges of intervals 15 and 16 by the Pleistocene glacier, then the top of the section is about 26 feet below the top of the Hendricks Member.

Several characteristic Hendricks fossils are present in the strata described in the section above. The most characteristic and common ones are Duncanella sp. no. 1, D. sp. no. 2, Favosites sp. no. 1, F. sp. no. 2, Camarotoechia winiskensis, and Leperditia fabulina. Rhynchospira lowi, a very diagnostic and common brachiopod of the Hendricks, is doubtfully represented by a poorly preserved specimen from the dolomite of interval 9.

The presence of Trimerella in the dolomite of interval 11 is of considerable interest and significance in view of the fact that remains of this brachiopod are found in strata of the type section of the Hendricks Member at Hendricks Quarry, Mackinac County.

A comparison of the Hendricks Quarry

section described below with the two preceding sections of the Big Bay de Noc region shows that the Hendricks strata of these two distant areas are quite different lithologically but contain a similar fauna.

Section of strata at Hendricks Quarry, Mackinac County, Locality 78 (NW¼ sec. 6, T 44 N, R 8 W and NE¼ sec. 1, T 44 N, R 9 W)

		Thickness Feet	Inches
	Burnt Bluff Limestone and Dolomite		
	Hendricks Member		
15	Magnesian-limestone, thin-bedded and light-gray.....	4	
14	Magnesian-limestone, light-gray, finely to coarsely crystalline, cherty, much weathered and containing many stromatoporoids and corals..	3	6

Clathrodictyon vesiculosum var.
Syringostroma sp. -- probably new
Stromatoporoids -- several other unidentified species
Zaphrentis cf. Z. stokesi
Favosites -- 2 species
Favosites n. sp. -- digitate form
Parastrophia (?) sp.
Camarotoechia winiskensis
Spirifer (Delthyris) crispus n. var.
Whitfieldella sp.
Stokesoceras romingeri
Encrinurus ? sp.
Leperditia fabulina -- 2 varieties
Isochilina sp. -- probably I. latimarginata

13	Limestone (Fiborn Limestone of R. A. Smith), thick-bedded, gray to grayish-buff, very finely crystalline, with small disseminated crystals of calcite and small geodes of calcite, a conchoidal fracture and vertical and oblique jointing. Chemical analysis (after R. A. Smith) shows CaO, 55.05 per cent and MgO, 0.81 per cent	18	

Clathrodictyon aff. C. fastigiatum
Clathrodictyon vesiculosum var.
Stromatopora n. sp.
Simple coral
Favosites n. sp. -- digitate form similar to or identical with digitate form of interval 14
Dinobolus ? sp.
Orthis flabellites
Camarotoechia winiskensis
Spirifer (Delthyris) crispus n. var.
Rhynchospira lowi
Hormotoma n. sp.
Hormotoma ? sp.
Ormoceras sp.
Stokesoceras romingeri
Stokesoceras cf. S. romingeri
Goldius n. sp.
Leperditia fabulina
Leperditia fabulina -- several varieties
Isochilina latimarginata
Aparchites sp.
Bythocypris sp.

PLATE 7 -- CORALS

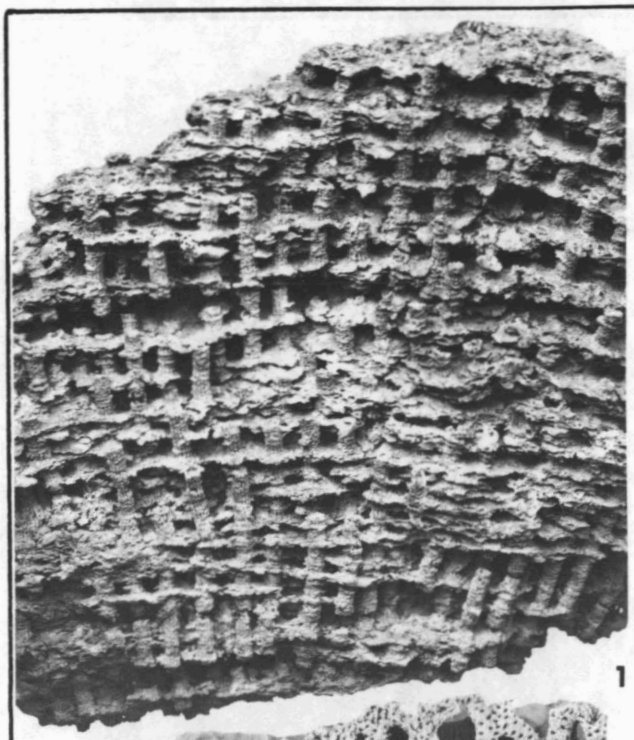
Figures x 1 except as noted

1 - Lyellia americana Edwards & Haime. UMMP 8426. Point Detour, Chippewa Co.

2 - Cladopora laqueata Rominger. UMMP 8495. Near Seul Choix Point, Schoolcraft Co.

3 - Cystiphorolites major (Rominger). UMMP 8606. Drummond Island.

4 - Cystiphorolites variolosus Rominger. UMMP 8609. Point Detour, Chippewa Co.



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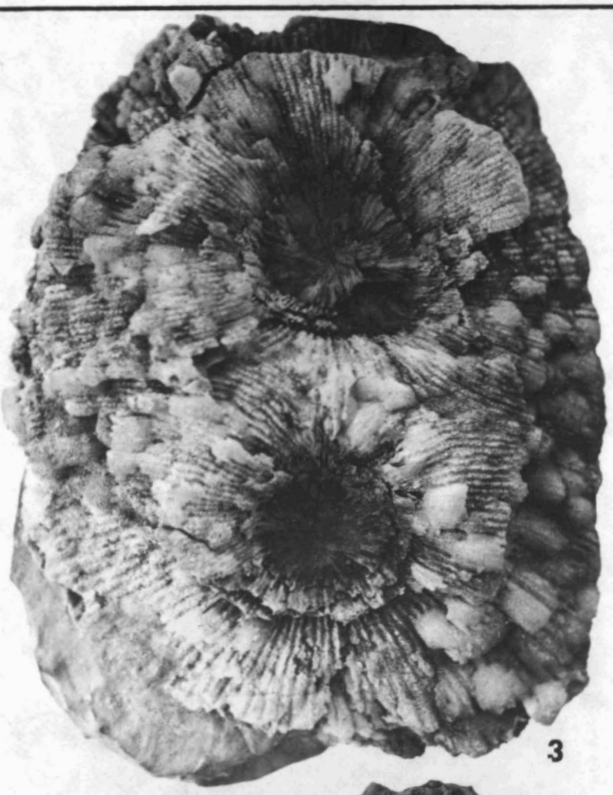

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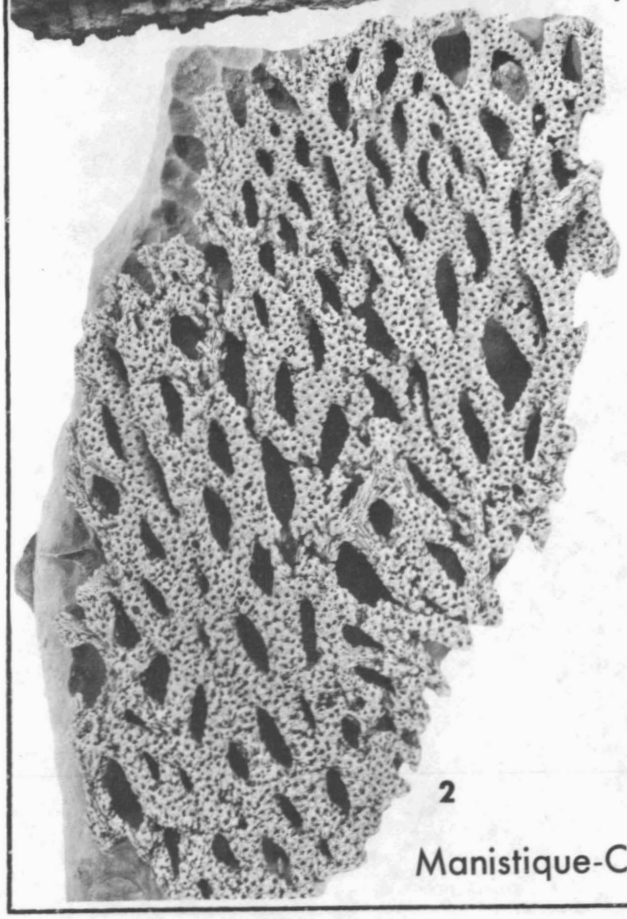

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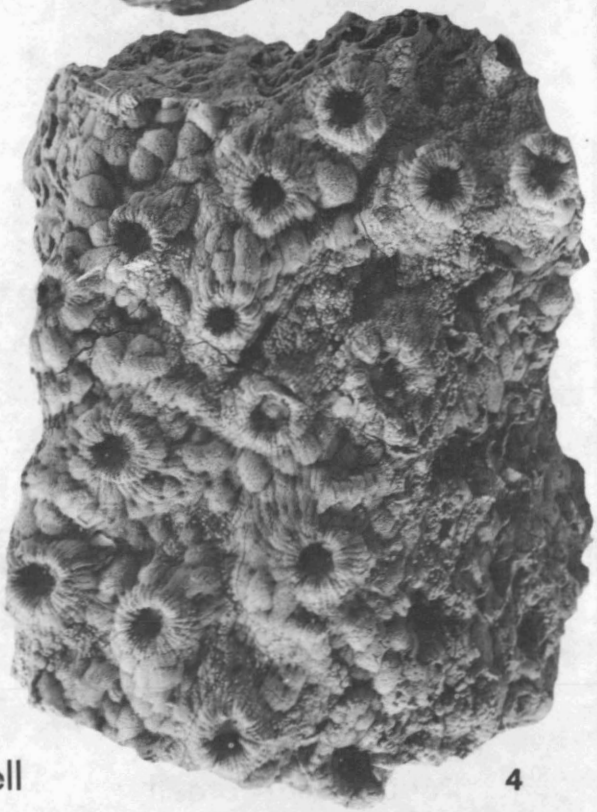

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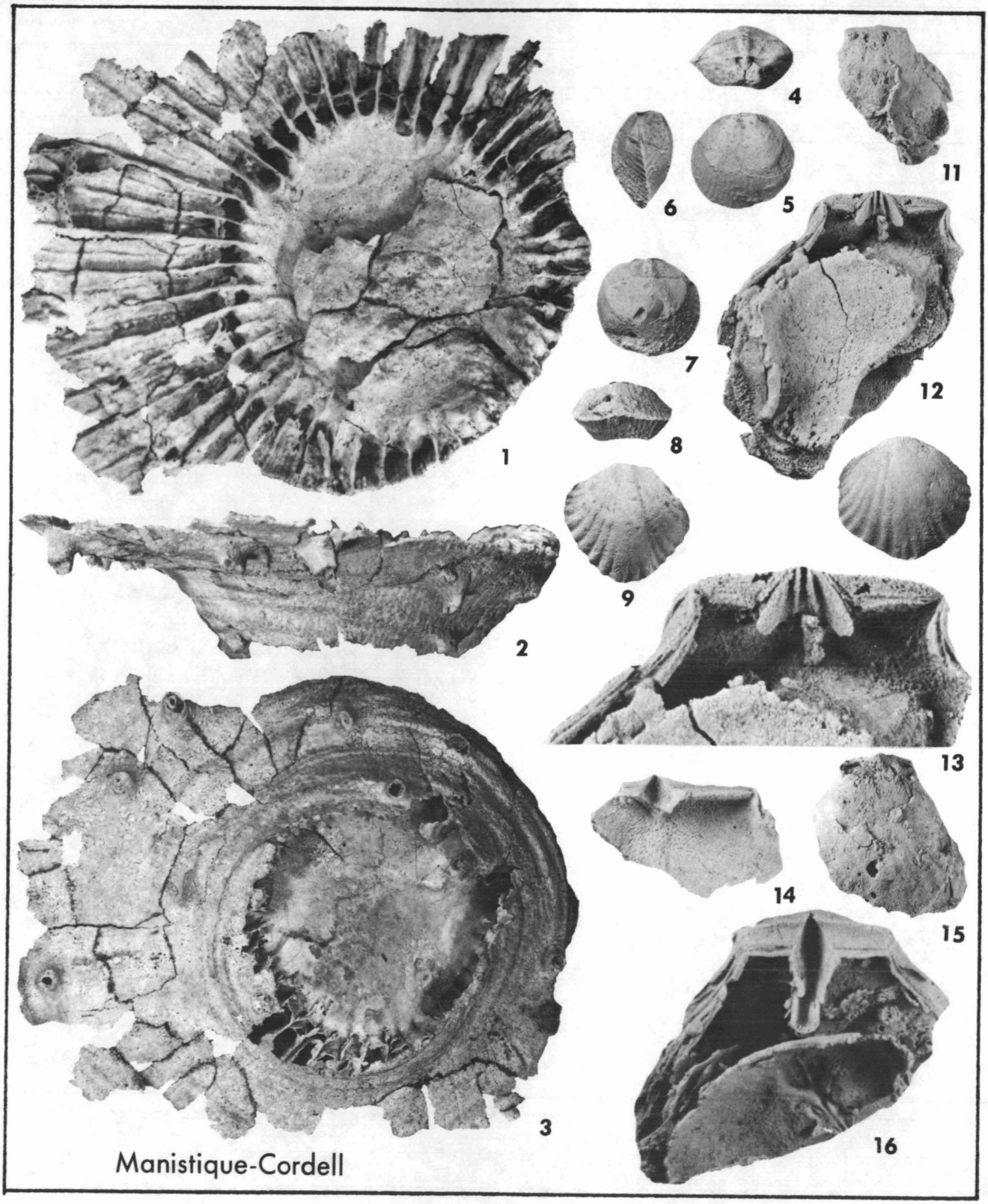
Manistique-Cordell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16
Manistique-Cordell

		Feet	Inches
12	Magnesian-limestone, light-gray and light buff-gray, very finely crystalline, occurring in layers 5 to 8 inches thick and containing a few thin lenses of laminated, darker brownish-gray limestone about 2 feet above the base. On weathering the limestone of the entire interval splits into layers $\frac{1}{4}$ to $\frac{1}{2}$ inch thick. The uppermost strata, which compose the floor of the quarry, contain many "sun-cracks" or dessication fissures.....	8	
	? Worm tracks Camarotoechia winiskensis Rhynchospira lowi Leperditia fabulina		
11	Limestone, very finely crystalline, darker and more buff-gray in color than the above, resembling very closely the limestone of interval 13. Chemical analysis (after R. A. Smith) -- CaO, 55.29 percent and MgO, 1.05 percent.....	1	
	Camarotoechia winiskensis Rhynchospira lowi Ilionia ? sp. Hormotoma attenuatum -- young individual Leperditia sp.		
10	Limestone, very finely crystalline to lithographic, very thin-bedded, light buff-gray, with conchoidal fracture and stylolites. Chemical analysis (after R. A. Smith) -- CaO 51.39 percent and MgO, 4.19 percent.....	2	
9	Dolomite, massive, hard, white to yellowish-white, containing a few cavities and grading into limestone above.....	2	6
8	Dolomite, massive, hard, light-buff, with many cavities formed by the solution of stromatoporoids and Favosites. The dolomite grades into the dolomite above. The basal 6 inches of the interval consists of a magnesian-limestone, very similar to that of interval 3. The limestone grades upward into the dolomite.....	6	
	Duncanella ? sp. -- one or more forms preserved as molds of the exterior and calices and probably the same as the species of Duncanella found in the Hendricks strata of the "11-mile bluff." Favosites n. sp. no. 1 -- characteristic Hendricks form		

PLATE 8 -- CORAL AND BRACHIOPODS

Figures x 1 except as noted

1-3 - Heterolasma foerstei Ehlers. UMMP 7290. About $\frac{1}{2}$ mile S of Gould City.

4-8 - Stricklandia (Microcardinalia) manitouensis Williams. UMMP 44498. Drummond Island, Chippewa Co.

9, 10 - Stricklandia (Microcardinalia) cf. castellana White. UMMP 44529. Drummond Island, Chippewa Co.

11-16 - Stricklandia (Microcardinalia) raberensis Boucot & Ehlers. All specimens from cliff about 2 miles S of Raber, Chippewa Co. 12, 14, 16, x 2; 13, x 4.

		Feet	Inches
	Favosites n. sp. no. 3 -- characteristic Hendricks form Favosites sp. Dinobolus ? sp. Trimerella aff. T. grandis -- several specimens Cf. Rhynchospira lowi Ilionia ? cf. I. ? parvula		
7	Limestone, yellowish-gray, finely crystalline with many, small irregularly shaped cavities. On top of the limestone there is a red, plastic clay, ¼ to 3/4 inch thick. This clay is a residuum resulting from the solution of the limestone of this interval and probably that at the base of interval 8. Chemical analysis (after R. A. Smith) -- CaO, 55.75 percent.....	1	
	Leperditia ? sp. Isochilina cf. I. latimarginata		
6	Limestone, slightly magnesian, finely crystalline, darker gray than limestone above and containing a few, angular and rounded fragments of somewhat darker gray limestone and a few, small cavities near the top. On top of the limestone there is a red, plastic, residual clay ¼ to 3/4 inch thick.....	3	6
5	Limestone, finely crystalline, lighter and more buff-gray than that above, distinct conchoidal fracture and a few cavities. A red plastic clay, ¼ to 3/4 inch thick, rests on top of this limestone.....		7
4	Limestone, finely crystalline, light buff-gray and not sharply marked off from limestone below. A red plastic clay, ¼ to 3/4 inch thick, rests on the top of the limestone.....	2	
3	Limestone, finely crystalline, darker buff-gray than that above, with numerous digitate and anastamosing areas of minute calcite and dolomite crystals of light-buff color. The limestone contains few cherts and when struck with a hammer, gives off an odor of petroleum.....	4	
	Duncanella sp. Leperditia ? sp. -- small form or young individual		
2	Limestone, slightly magnesian, and light-gray. At the base there is a band of buff-gray, very finely crystalline limestone with an average thickness of 1 inch		10
1	Limestone, finely crystalline and gray except in places where it contains irregular-shaped areas of minute, yellowish-gray dolomite crystals. Between this limestone and that above there is a red, plastic clay, ¼ to 3/4 inch thick.....	3	
	The fossils listed below were collected from the uppermost one-inch of the limestone -- just below the red clay. Trimerella aff. T. grandis -- 1 specimen Camarotoechia winiskensis Atrypa ? sp. Leperditia fabulina var. Undetermined ostracod -- possibly new genus Pelecypod -- too poorly preserved for identification		
		59	11

The strata of the intervals 13, 14, and 15 are exposed in the quarry wall. Strata, composing intervals 7 to 12 inclusive, are exposed in a test-pit in the southeastern part of the quarry. The beds of intervals 1 to 6 inclusive were at one time exposed in a deep pit excava-

ted for the site of the crushing-plant.

At the time of Savage and Crooks' visit to the quarry somewhat higher and lower strata of the Hendricks Member were exposed. The thickness and lithologic character of these strata can be recognized best by examining the following section of Savage & Crooks and comparing this section with that made by the present writer.

Section of strata exposed at Hendricks Quarry and test pit
(After Savage & Crooks with the addition of the names of the fossils noted by these writers)

		Thickness Feet	Thickness Inches
	Fiborn Limestone		
24	Dolomite, gray, thin-bedded; vesicular.....	6	
23	Dolomite, gray, fine-grained, badly disintegrated, in places cherty.....	4	
22	Limestone, brownish-gray to gray, compact, very fine-grained, earthy, with sharp conchoidal fracture; the basal part containing crystals of calcite.....	18	
	Actinostroma cf. tenuifilatum Favosites forbesi var. Zaphrentis cf. stokesi Atrypa putilla Camarotoechia ? winiskensis Orthis flabellites Plectambonites cf. transversalis var. Schuchertella cf. propinqua Spirifer sp. Isochilina latimarginata Leperditia fabulina		
	Hendricks Dolomite		
21	Limestone, white, fissile, fossiliferous, with some black streaks, weathering into laminae $\frac{1}{4}$ to 2 inches thick.....	8	
20	Limestone, lithographic; similar to the 18 foot stratum above.....	1	
	Atrypa putilla Camarotoechia ? winiskensis Spirifer sp. Leperditia fabulina Illaenus sp.		
19	Limestone, grayish-white, fissile, thin-bedded, stylolites structure prominent....	1	4
	Atrypa putilla Camarotoechia ? winiskensis Cyclonema cf. daytonensis Illaenus sp.		
18	Limestone, yellowish-white, hard, massive.....	2	8
17	Dolomite, yellowish-brown, fossiliferous, massive, crystalline.....	5	9
	Zaphrentis sp. Camarotoechia ? winiskensis		
16	Limestone, yellowish-brown, soft.....	1	
	Downward continuation of section in the test pit (= crusher pit of Ehlers)		
15	Limestone, white, with black streaks $\frac{1}{4}$ to 2 inches apart; in upper 1 foot there is a tendency to part along bedding planes.....	8	10
14	Limestone, lithographic, similar to no. 22.....	1	
13	Limestone, white, dense, with black streaks.....	2	8
12	Limestone, whitish, dense with no streaks.....	1	9
11	Limestone, yellowish-brown above, passing into gray at the base where it becomes more massive, and contains numerous small solution cavities.....	6	
10	Limestone in three layers, respectively 9, 13, and 15 inches thick, brownish-		

		Feet	Inches
	gray, fine-grained, separated from one another by thin clay bands.....	3	
9	Limestone, lithographic at base passing upward into a cherty shale.....	1	6
8	Shale band		3
7	Limestone, grayish-white...		7
6	Shale band.....		6
5	Limestone, magnesian, grayish-white, crystalline...	2	
4	Dolomite, white, highly crystalline.....		9
3	Limestone, grayish-white...	1	6
2	Limestone, white, crystalline.....	1	
1	Dolomite, gray to white, crystalline, massive, breaking angularly, and exhibiting no bedding. To floor of crusher pit.....	2	
		81	1

In Savage & Crooks' section the strata of intervals 24, 23, and 22 are included within the "Fiborn Limestone." As originally defined, the name Fiborn was applied by R. A. Smith only to the limestone of interval 22. Savage & Crooks doubtless found that the fauna of the typical Fiborn was also present in the beds of intervals 23 and 24 and consequently extended the upper limit of the Fiborn on the basis of this faunal similarity. In this connection it should be pointed out that some of the fossils, reported by Savage & Crooks as having been collected from the Fiborn Limestone, may have been obtained from the beds of intervals 23 and 24. In the writer's section the Fiborn Limestone is not recognized as a distinct stratigraphic unit; chiefly on account of its faunal similarity to strata above and below, it is included in the Hendricks Member of the Burnt Bluff Formation. In Savage & Crooks' section 10 feet of strata are noted as occurring above the Fiborn instead of $7\frac{1}{2}$ as described in the writer's section. The exposure of higher strata adjacent to the quarry through the removal of the soil by the quarrymen doubtless accounts for this greater thickness. Intervals 21, 20, 19, 18, 17, and 16 of Savage & Crooks' section respectively correspond to intervals 12, 11, 10, 9, 8, and 7 of the writer's section. Below interval 16 of the former section and interval 7 of the latter section, the intervals of the two sections when considered individually do not correspond very closely in thickness. However, it is very probable that the 13 feet and 11 inches of strata included in intervals 1 to 6 inclusive of the writer's section, are the same as the 14 feet and 3 inches of strata noted in intervals 12, 13, and 14 of Savage & Crooks' section. If the base of interval 12 of Savage & Crooks' section corresponds to the base of interval 1 of the writer's section, then intervals 1 to 12 of the former section include 19 feet and 1 inch of still lower Hendricks strata than described in the latter section. These lower beds of the Hendricks were exposed at the time of Savage & Crooks' visit as the result of a deepening of the crusher pit. By comparing the two sections it will be noted that Savage & Crooks saw 21 feet and 2 inches more Hendricks beds than did the writer.

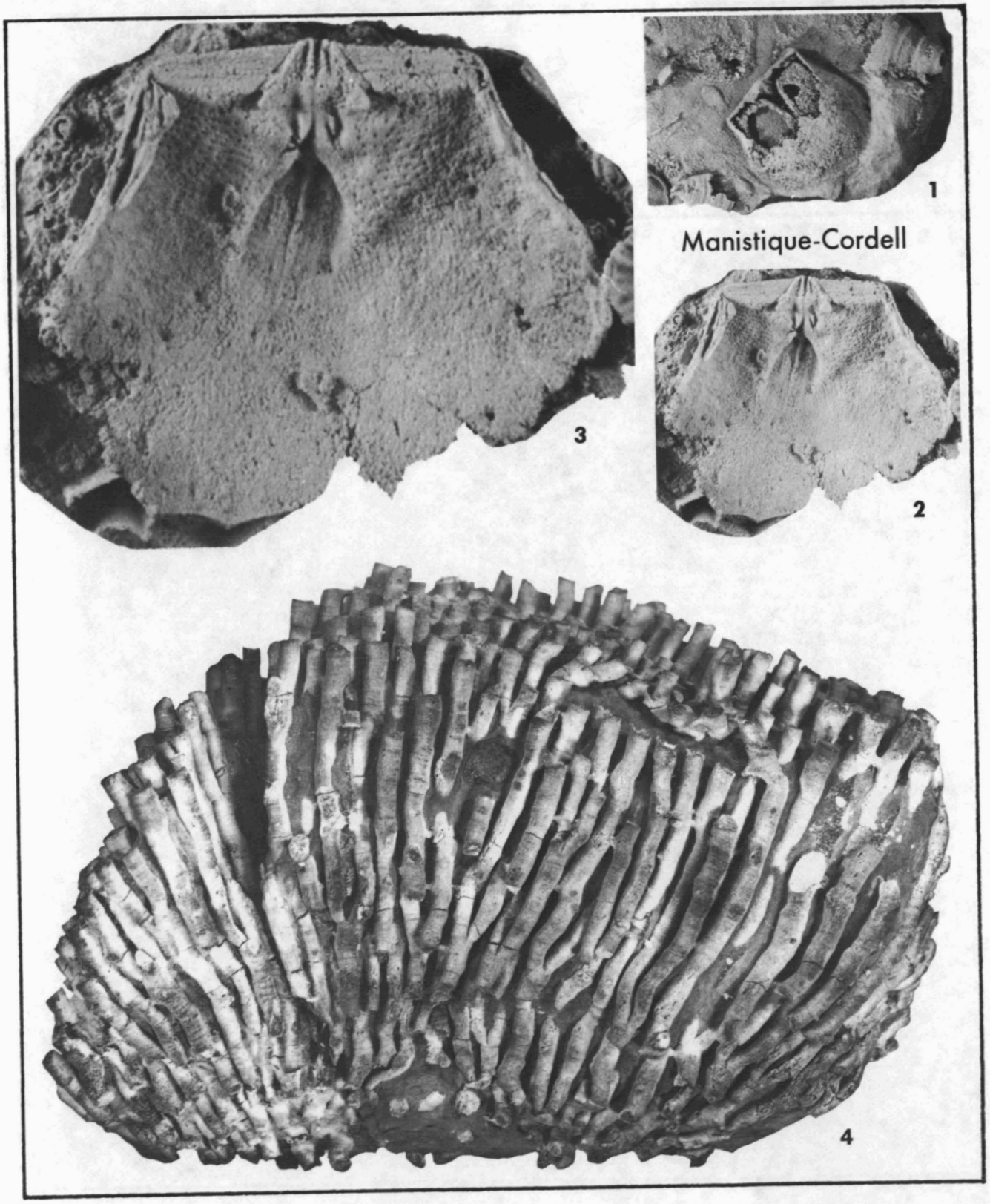
The predominance of limestones over dolomites in the Hendricks Member as indicated so clearly by the descriptions of the sections made by Savage & Crooks and by the writer, is very likely to lead one to believe that the Hendricks strata at Hendricks Quarry are not the same age as the dolomites exposed in the bluffs rising above the shore of Big Bay de Noc. The error

PLATE 9 -- CORAL AND BRACHIOPOD

Figures x 1 except as noted

1-3 - Stricklandia (Microcardinalia) raberensis Boucot & Ehlers. 1, UMMP 44497A. 2, x 2; 3, x 4.

4 - Syringopora verticillata Goldfuss. Locality unknown.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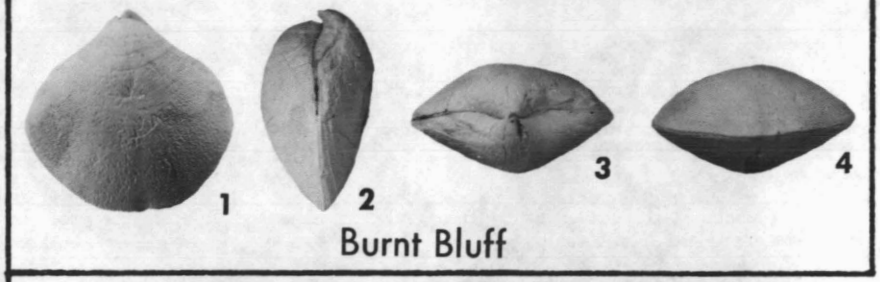
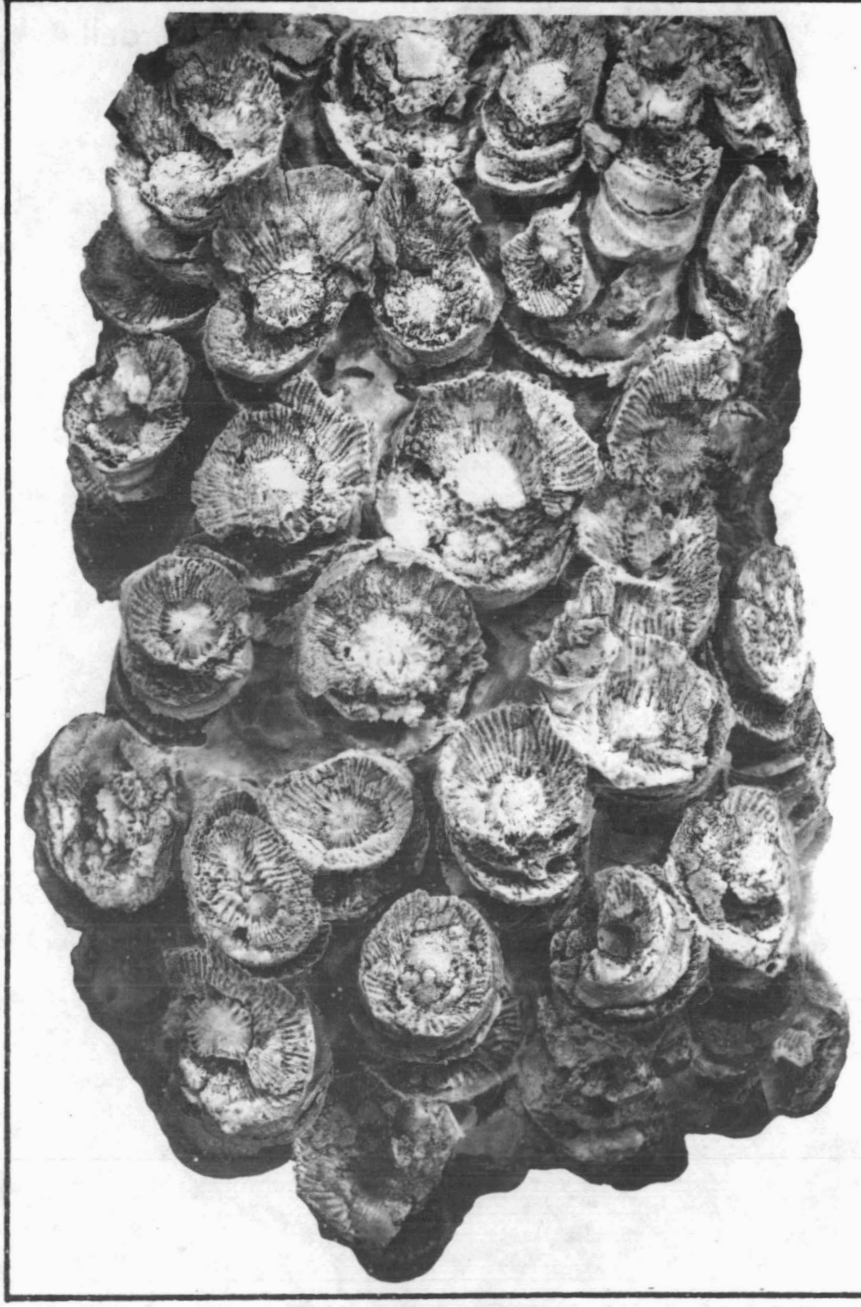


Burnt Bluff



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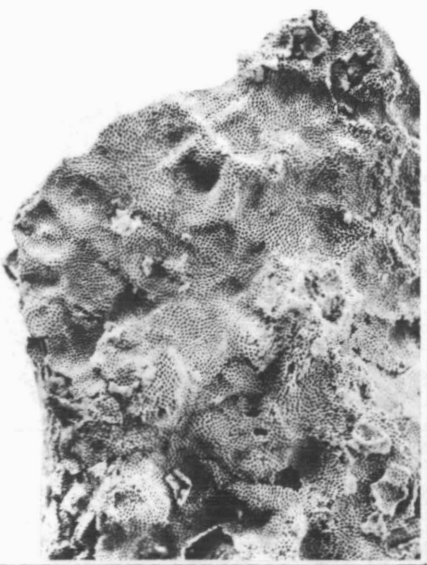


of this belief will quickly be apparent, however, as soon as one finds that many of the characteristic fossils of the limestones at Hendricks Quarry are also present in the dolomites of these bluffs (see lists of fossils given in descriptions of the sections of Burnt Bluff "11-mile bluff") and recognized that most of the Hendricks limestones change laterally into dolomites.

The lateral dolomitization of the "Fiborn Limestone" (interval 13 of Hendricks Quarry section) is very well shown in southeastern Schoolcraft County. In the so-called "Blaney Quarry" (Loc. 60) at Calspar (formerly Nicholsonville), the Fiborn Limestone is exposed in its typical highly calcareous state.

Section of strata exposed in the Nicholsonville Quarry or "Blaney Quarry" of the Inland Lime & Stone Company at Calspar (formerly Nicholsonville), Schoolcraft County, Locality 60

(sec. 3, T 42 N, R 13 W)

		Thickness Feet	Thickness Inches
	Burnt Bluff Limestone and Dolomite		
	Hendricks Member		
5	Limestone (typical Fiborn Limestone of R. A. Smith), thick-bedded, grayish-buff, very finely crystalline, with small disseminated crystals of calcite and small geodes of calcite and locally dolomitized beds 3 feet thick...	26	
4	Limestone, high magnesian, very light yellowish-gray to yellowish-white, coarser crystalline than limestones below and above, ranging in thickness from 1' to 24".....	1	9
3	Limestone, very similar lithologically and chemically to the "Fiborn Limestone" of interval 5. It differs from this limestone in having numerous irregular-shaped cavities, most of which are lined with calcite. Upper 8" of interval consist of thin, uneven bands of limestone alternating with very thin bands of white calcite.....	8	6
2	Dolomite, massive, buff-gray, weathering into layers 1" thick. This dolomite is shown at the top of the pit noted below..	2	
1	Dolomite -- present in a water-filled pit near the Company's lime kilns. According to Mr. George Nicholson of the Inland Lime & Stone Co., the dolomite of the lower part of this interval is thick-bedded and contains many cavities.....	6	
		44	3

PLATE 10 -- BRACHIOPOD AND CORALS

Figures x 1

1-4 - Whitfieldella sp. Specimen from coral-stromatoporoid bed at top of W wall of Inland Lime & Stone Company Quarry.

5 - Lyellia decipiens Rominger. Locality unknown.

6 - Syringopora fimbriata Rominger. UMMP 8547. Drummond Island, Chippewa Co.

7 - Coenites laminatus Hall. Point Detour, Chippewa Co.

8 - Blothrophyllum caespitosum Rominger. UMMP 8587. Point Detour.

According to R. A. Smith (1916, p. 264) the lower part of the Fiborn in this quarry is more dolomitic than at localities farther eastward. At several places between the quarry and a point about 1 3/4 miles west, the Fiborn is even more dolomitic. In a ditch along the side of a road 2 miles west of the Nicholsonville Quarry (Loc. 63), about 3 inches of partially dolomitized Fiborn Limestone are exposed beneath 8 inches of highly calcareous Fiborn Limestone. As the result of partial dolomitization, the lower 8 inches of magnesian-limestone has become more coarsely crystalline than the typical Fiborn. Numerous small cavities in the magnesian-limestone were formed by the solution of scattered crystals of calcite, the solution probably being contemporaneous with the process of dolomitization. The fact that this dolomitic limestone has nearly the same color as the undolomitized Fiborn, contains some undissolved, scattered crystals of calcite, and grades upward into typical calcareous Fiborn, shows beyond question that this dolomitic limestone was originally a highly calcareous limestone. A far more advanced stage in the dolomitization of the Fiborn Limestone is shown by the rock exposed in the upper part of a low ridge about $2\frac{1}{4}$ miles southwest of the outcrop in the ditch. This rock, which is well shown a short distance northeast of the SE corner of sec. 12, T 42 N, R 14 W (Loc. 66), approaches a true dolomite in lithologic composition. It is thick-bedded like the Fiborn Limestone but differs from it in being more coarsely crystalline and in having a lighter gray color. Numerous small cavities in the dolomite mark the former positions of crystals of calcite, which were probably dissolved at the time of dolomitization of the rock.

Without seeing less dolomitized examples of the Fiborn, a person in the field is unlikely to realize that this light-gray, decidedly crystalline dolomite is stratigraphically identical with the darker buff-gray, highly calcareous Fiborn Limestone of lithographic texture. Furthermore, it is also very doubtful whether one would suspect that the small cavities were formed by the solution of the calcite crystals of the Fiborn Limestone.

Fortunately, certain stratigraphic and paleontologic evidence shows very definitely that the dolomite occupies the stratigraphic position of the Fiborn and hence lends support to the contention that it represents an advanced state in the dolomitization of the Fiborn Limestone. As the result of a relatively high, southeasterly dip -- about 3°S 10°E as shown by the lowest exposed beds of the dolomite in a small, abandoned quarry at the southwest end of the ridge (Loc. 67) -- strata underlying the dolomite make their appearance along the road at Locality 68. These strata consist of about 10 feet of light-gray and light buff-gray dolomites, most of which are thick-bedded. The presence of numerous molds of the shells of Trimerella in some of the beds is most significant in view of the fact that similarly preserved remains of this brachiopod were found in strata below the Fiborn Limestone at Hendricks Quarry. In the Hendricks Quarry section described above, it will be noted that several specimens of Trimerella were collected from a massive buff dolomite (interval 8) about $13\frac{1}{2}$ feet below the base of the Fiborn Limestone (interval 13), and that a single specimen was found in a finely crystalline, gray limestone (interval 1) about $31\frac{1}{2}$ feet below the Fiborn Limestone. Certain field relationships indicate very definitely that the trimerellid dolomite along the road represents a southwestern continuation of the upper Trimerella-bearing bed of the Hendricks Quarry region. About 1 mile northwest of the roadside exposures of the trimerellid dolomite, 2 feet of limestone are exposed in an east-west road (Loc. 69), which with little doubt are the southwestern continuation of the limestone at Hendricks Quarry described as interval 3 of the quarry section. On account of the general southeastward dip of the strata higher and higher Hendricks beds are encountered in passing southeastward from the outcrop at Locality 69 to the roadside exposure of the Trimerella-bearing dolomite at Locality 68. Since the lower Trimerella-bearing bed (interval 1) of the Hendricks Quarry section occupies a position below the limestone at Locality 69, it is evident that the trimerellid dolomite along the road at Locality 68 must represent the southwestward continuation of the upper Trimerella-bearing bed of the Hendricks Quarry region. The trimerellid dolomite at Locality 68 is approximately 10 feet below the cavity-bearing dolomite of the ridge at Locality 66. In view of the fact that the upper Trimerella-bearing bed at Hendricks Quarry is $13\frac{1}{2}$ feet below the Fiborn Limestone, one is forced to believe that the dolomite of the ridge occupies the stratigraphic position of the Fiborn Limestone and represents a highly dolomitized phase of this limestone.

Additional evidence showing that the Fiborn Limestone and underlying limestones become dolomitized in passing southwestward from the Nicholsonville Quarry is indicated by other field observations and information kindly sent to the writer by the State Geologist, Mr. R. A. Smith. In a small roadside quarry (Loc. 65), located in the side of a low, westward-facing bluff about one-quarter mile west of Locality 63, about $11\frac{1}{2}$ feet of Hendricks strata are exposed. These strata with the exception of the lowest one, a buff-gray magnesian-limestone ranging in thickness from 2 feet 4 inches to 2 feet 10 inches, consist of thick-bedded dolomites of light-gray, light greenish- and bluish-gray, and buff-gray colors. They occupy a position a very short distance below the Fiborn Limestone, the covered interval between the uppermost stratum in the quarry and the nearby exposure of the Fiborn at locality 2 probably being not more than 10 feet. The finding of a fragment of the mold of a Trimerella in one of the strata close to the top of the quarry proves beyond doubt that this brachiopod occurs a short distance below the typical Fiborn Limestone exposed nearby at Locality 63, and supports the writer's contention that the dolomite at Locality 66 represents a dolomitized phase of this limestone. Mr. R. A. Smith in a communication to the writer states that grayish-white dolomitized beds are exposed about 30 paces south of the quarry at Locality 65 and that the typical calcareous Fiborn outcrops about 10 paces farther south at a slightly higher elevation of 4 feet. In the writer's opinion these two beds are very likely the same as those noted by him at Locality 63. According to Smith a crystalline dolomitized bed, possibly representing a part of the Fiborn, is exposed on the western side of a large swamp about 500 paces to the southwest of the Fiborn Limestone, noted as occurring about 40 paces south of the roadside quarry (Loc. 65). The location of this exposure with respect to other outcrops leads Smith to believe that this dolomitic bed probably is stratigraphically higher than the typical Fiborn just south of the quarry. However, Mr. Smith states that it will be impossible to definitely establish the position of this bed until the exact elevations and dips of the various exposed strata of the area are determined. During the course of his study of the Fiborn Limestone, Mr. Smith found that this limestone becomes more and more dolomitic when traced westward from a point near the southwestern shore of Pike Lake, about $4\frac{1}{2}$ miles east of the Nicholsonville Quarry, to section 8 just south of Locality 65. According to him, lenses of dolomite are shown within the Fiborn in some test pits near the quarry at Nicholsonville and in the northern part of section 10 located south of this quarry. Further evidence of the dolomitization of the Fiborn Limestone is indicated by exploratory drillings of the Inland Lime & Stone Company in the region just west and southwest of the quarry.

In view of the fact that the Fiborn Limestone in its typical highly calcareous state is of considerable commercial value, it is very important to know just how far this limestone extends to the southwest of the Nicholsonville Quarry. According to Mr. Smith, numerous exposures of the limestone are exposed along the road leading southward from the center of the north line of sec. 8, T 42 N, R 13 W (Loc. 64). Less than $\frac{1}{2}$ mile west of these exposures and about 40 paces south of the quarry at Locality 65, Smith found another outcrop of this limestone. On the ridge (Loc. 66) about 2 miles southwest of this outcrop the Fiborn is represented by the light-gray to buff-gray, cavity-bearing dolomite. The thickness of this dolomite, 20 to 24 feet, is almost as great as the thickness, 26 feet, of the Fiborn Limestone in the Nicholsonville Quarry. Evidently most of the Fiborn Limestone has become completely dolomitized somewhere in the region between the ridge and the outcrops of the limestone in sec. 8. In the writer's opinion no considerable thickness of the undolomitized Fiborn will be found south of the ridge or southwestward along the supposed strike of this limestone. Furthermore, the writer's field observations show that the position of the Fiborn Limestone in the Hendricks Member in south-central and southwestern Schoolcraft County and Delta County is without doubt occupied by light-gray to buff dolomites.

In spite of the fact that the Hendricks strata of the bluffs along the eastern shore of Big Bay de Noc and in the Nicholsonville-Hendricks Quarry region differ greatly in lithological character, certain beds can be recognized as being common to the two areas. One of the most continuous beds shown in the bluffs along Big Bay de Noc, is a thick-bedded, light-buff to grayish-buff dolomite with lighter buff, digitate areas of dolomite crystals, interval 26 of Burnt Bluff section and interval 9 of the "11-mile bluff." When traced northeastward into Schoolcraft and Mackinac Counties this dolomite

changes laterally into a magnesian-limestone, which resembles the Fiborn Limestone in color and texture but differs from it in having light-buff, digitate areas of dolomite crystals. About 2 feet are exposed beside the east-west road about 5 miles from the Nicholsonville Quarry (Loc. 69). The entire limestone, 6 feet in thickness, is well shown in a quarry excavated for road-metal about 2 miles north and $1\frac{1}{2}$ miles west of this quarry (Loc. 70) and at the side of the road about 1/8 mile northeast of the quarry (Loc. 71). At these two places it contains numerous remains of Clathrodictyon vesiculosum var. and other stromatoporoids, one or more species of Duncanella and Streptelasma, two new characteristic Hendricks species of Favosites, Aulopora ? sp., and Halysites catenularia, and less abundant remains of Rhynchospira lowi and Leperditia fabulina. Overlying the very fossiliferous limestone in the roadside quarry are 11 feet of even-bedded, light yellowish-gray, finely crystalline magnesian-limestone or dolomite, the weathered surface of which shows laminations. Immediately beneath the fossiliferous limestone are 4 feet of light yellowish-gray, finely crystalline, more dolomitic limestone. Below this dolomitic limestone are 2 feet of limestone resembling the Fiborn in color but differing from it in being laminated and more dolomitic. Underlying this limestone are 30 inches of yellowish-gray, finely crystalline magnesian-limestone. The abundantly fossiliferous limestone of this quarry is represented in the Hendricks Quarry section by the 4 feet of limestone of interval 3 and possibly the 2 feet of limestone of interval 4. About 7 inches above interval 4 of the Hendricks Quarry section is a gray, finely crystalline, slightly magnesian limestone (interval 6), containing a few angular and rounded fragments of somewhat darker gray limestone. This pebbly limestone occupies the stratigraphic position of the edgewise conglomerate of the sections at Burnt Bluff (interval 27) and the "11-mile bluff" (interval 10), and possibly represents a northeastward extension of this conglomerate. About 1 foot above the pebbly limestone of the Hendricks Quarry are 6 feet of light-buff dolomite (interval 8) containing remains of Trimerella and other

PLATE 11 -- BRACHIOPODS

Figures x 1 except as noted

1-12 - Camarotoechia winiskensis Whiteaves. All specimens from beds below the Fiborn Limestone in a ditch in Fiborn Quarry. 1-4, rather large specimen. 5-9, medium-size specimen; 9, x 2. 10-12, small but well-preserved specimen.

13-19 - Rhynchospira lowi Whiteaves. 15, Inland Lime & Stone Company Quarry, Mackinac Co. 14-16, Hendricks Quarry; 16, x 2. 17-19, Inland Lime & Stone Company Quarry; coarser ornamentation than most specimens.

20-22 - Glassia variabilis Whiteaves. Inland Lime & Stone Company Quarry, Mackinac Co.

23, 24 - Trimerella sp. Hendricks Quarry.

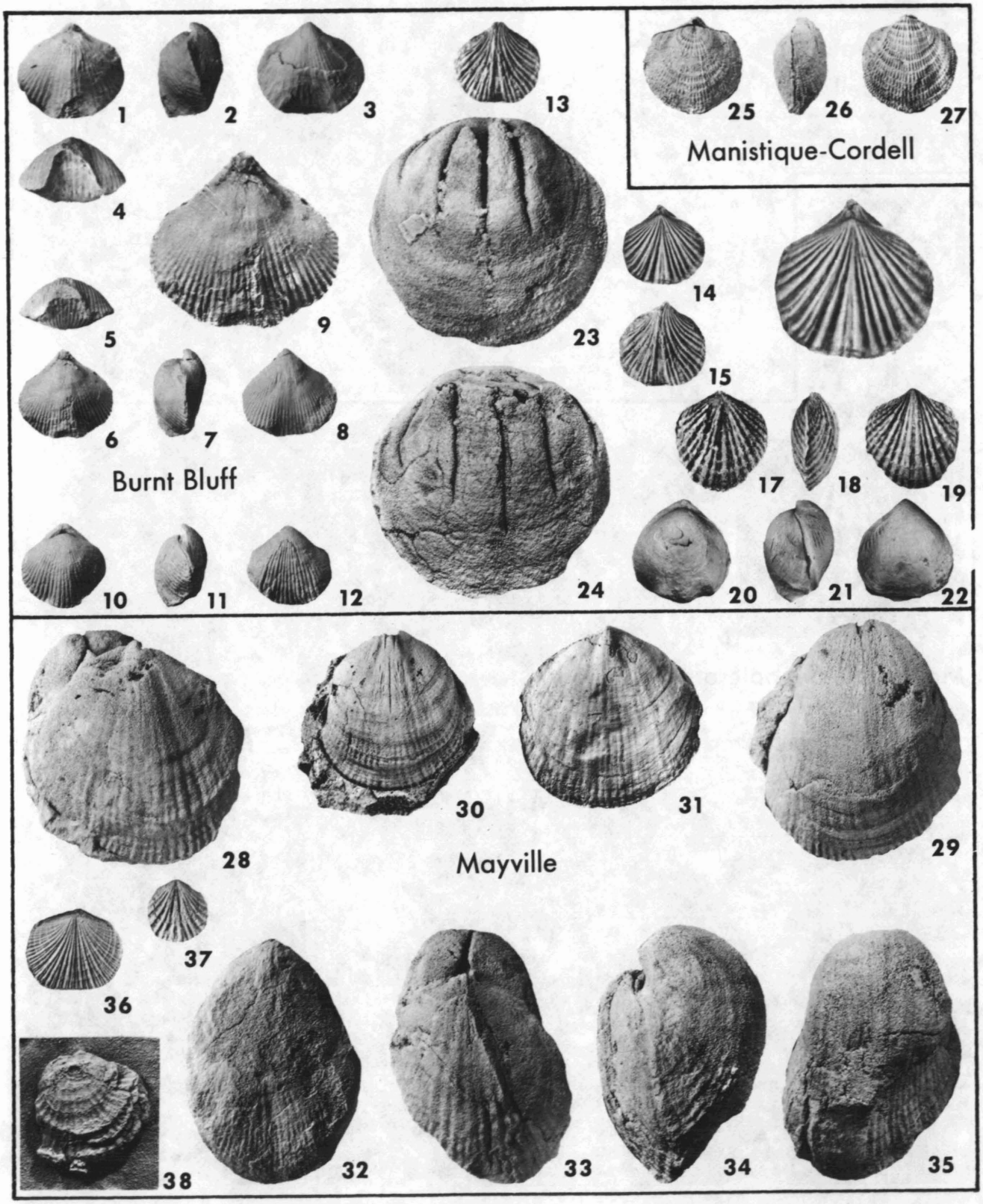
25-27 - Atrypa sp. Locality unknown.

28-35 - Virgiana decussata (Whiteaves). 28, 29, UMMP 31576; Mayville Dolomite, Mayville White Lime Company Quarry, about 3 miles S of Mayville, Wisconsin. 30, UMMP 31591; S side of Limestone Mountain, Mich. 31, UMMP 31586; Interlake Group, Fischer Branch Dolomite, NW of Fischer Branch, Manitoba, Canada. 32, UMMP 31574; drift blocks near SE corner sec. 1, T 41 N, R 18 W, Delta Co., about $3\frac{1}{2}$ miles N and 3/4 mile W of Cooks. 33-35, another specimen from Mayville White Lime Company Quarry in Wisconsin.

36 - Dalmanella eugeniensis var. cf. paleoelegantula Williams. Drummond Island. x 2.

37 - Coelospira planoconvexa (Hall). Shore of Scott Bay, Drummond Island.

38 - Atrypa laticorrugata Foerste. NW shore of Manistique Lake, $SE\frac{1}{4}$ $SW\frac{1}{4}$ sec. 29, T 45 N, R 12 W, Luce Co. x 2.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Manistique-Cordell
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Manistique-
Cordell


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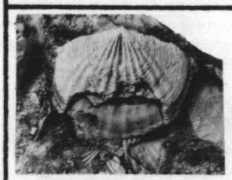


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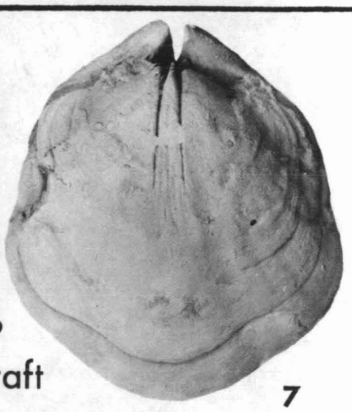
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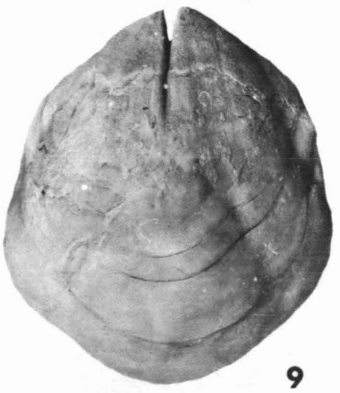
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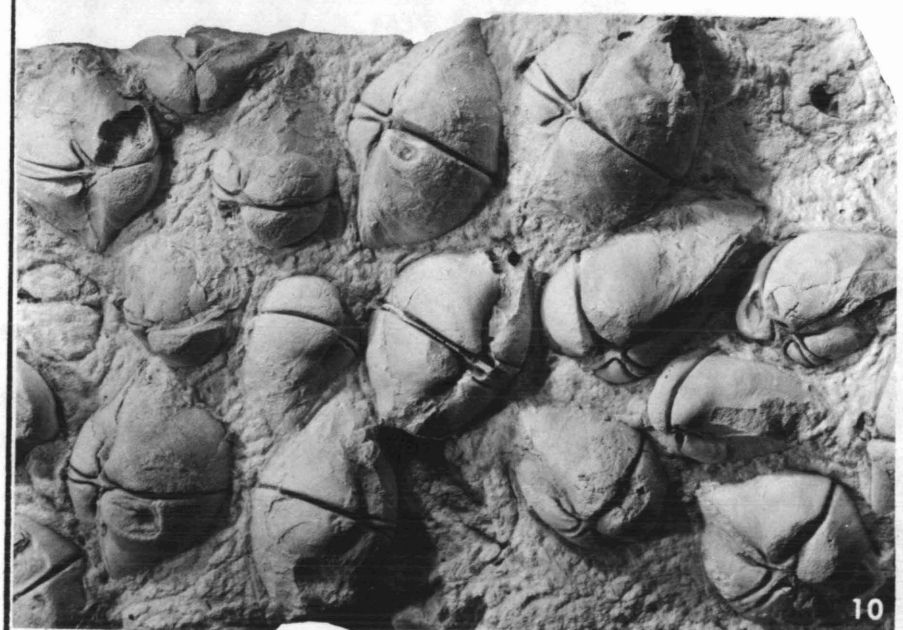
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11

fossils. In the "11-mile bluff," a fragment of a Trimerella was found in a somewhat similar dolomite (interval 11) of the same thickness, occupying a position about 5 feet above the edgewise conglomerate (interval 10). In the writer's opinion the Trimerella-bearing dolomites at the two localities without doubt are the same bed. At Hendricks Quarry the thick-bedded Fiborn Limestone (interval 13) is about 13 feet and 6 inches above the top of the Trimerella-bearing dolomite. In the bluffs along the eastern shore of Big Bay de Noc, thick-bedded, buff and buff-gray dolomites occupy a similar stratigraphic position above the trimerellid dolomite. Some of these dolomites with little doubt are a southwestern extension of the Fiborn. Owing to the fact that these dolomites are very similar lithologically to many underlying and overlying strata exposed in the bluffs, it is impossible to state which beds of dolomite exactly represent the Fiborn Limestone. It is the writer's belief that further field studies will probably demonstrate the continuity of many other dolomites of the Big Bay de Noc region with magnesian-limestones and limestones of the Hendricks Quarry area.

Detailed sections. -- These are grouped by counties.

Delta County

The largest exposures of Burnt Bluff strata in Delta County are present in the escarpment which rises above the eastern shore of Big Bay de Noc. Smaller exposures are present in St. Martin, Squaw, and Big Summer Islands at the entrance to Green Bay, beside the main highway leading from Fairport to Cooks, Schoolcraft County, and along several roads intersecting this highway.

St. Martins Island:

LOC. 31. A cliff of Burnt Bluff strata extends along the northern and western shores of St. Martins Island with few interruptions from the NW$\frac{1}{4}$ sec. 15 to the SW$\frac{1}{4}$ sec. 21, T 36 N, R 20 W. The cliff at most places consists of two parts, a lower one rising vertically from the shore to an average height of 15 feet and a higher inland one rising to an elevation of 50 to 60 feet above the level of Green Bay. The two parts of the cliff are usually separated by a bench -- probably a glacial-lake terrace, which is generally not more than 100 feet in width. At some places the lower cliff has been cut back by wave action, thus effecting a union with the higher cliff. The single cliff, produced in this manner, appears as a precipitous rock face rising abruptly from the Bay to a height of about 50 feet.

The lower 15 to 20 feet of strata exposed in the cliff consist chiefly of thin-bedded, light-gray to light brownish-gray, finely crystalline dolomites; the upper 35 to 40 feet are in large part thicker-bedded, buff, coarsely crystalline dolomites, some of which contain cavities apparently formed by the solution of Favosites and stromatoporoids.

The general dip of the strata is about 3° in a southeasterly direction. This dip is modified by slight undulations of the strata.

Although the writer was able to make only a hasty examination of these beds, he believes that all of the beds belong to the Hendricks Member of the Burnt Bluff Formation.

LOC. 32. The contact between the Burnt Bluff and Manistique formations is exposed on the eastern shore of St. Martins Island. It is best

PLATE 12 -- BRACHIOPODS

Figures x 1 except as noted

1-3 - Pentameroides bisinuatus McChesney, Scott Quarry, Chippewa Co.

4-6, 11 - Coelospira sp. All specimens from White Marble Lime Company Quarry in Manistique. 6, x 2.

7-10 - Pentamerus sp. Along N-S road about 1/8 mile S of NE corner sec. 11, T 43 N, R 2 W, 5 miles SE of Rudyard, Mackinac Co. Probably from lower Pentamerus dolomite. 10, block seen from lower surface showing brachiopods in presumed living position.

shown in a cliff a short distance south of the St. Martins Island light-house, situated near the shore in the NE¼ sec. 22, T 36 N, R 20 W.

The following section shows the lithological character of the beds above and below this contact.

Section of strata exposed in cliff near St. Martins Island Light-house, Locality 32

(NE¼ sec. 22, T 36 N, R 20 W)

		Thickness Feet
	Manistique Dolomite	
	Schoolcraft Member	
6	Dolomite, thin, uneven-bedded, buff in color, with cavities and numerous poorly preserved remains of Pentamerus.....	5
5	Dolomite, thin-bedded, light grayish-buff and finely crystalline.....	6
4	Upper Pentamerus dolomite. Massive, coarsely crystalline, grayish buff dolomite with molds of the shells of Pentamerus.....	10
3	Dolomite, thin, even-bedded, light gray to light brownish-gray and finely crystalline with molds of Pentamerus oblongus.....	15
2	Lower Pentamerus dolomite. Massive, coarsely crystalline, buff dolomite with numerous molds of the shells of Pentamerus oblongus.....	8
	Burnt Bluff Limestone and Dolomite	
	Hendricks Member	
1	Dolomite, thin, uneven-bedded, buff in color and containing considerable chert.....	9
		53

No diagnostic Hendricks fossils were found in the dolomite of interval 1. It is possible that a few will be found by giving more time to collecting than was available to the writer.

Hendricks types of stromatoporoids, however, are present in a 9-foot bed of massive, coarsely crystalline, buff dolomite, which occupies a position below the dolomite of interval 1 and crops out in the cliff a short distance north of the place where the section was obtained.

The section described above is of considerable interest in view of the fact that the Hendricks and most of the Schoolcraft strata extend northeastward to the eastern side of Drummond Island, with only minor local variations in lithologic and faunal composition. The remarkable continuity of these strata from St. Martins Island to Drummond Island indicates very strongly that these strata continue eastward into Ontario and southwestward into Wisconsin.

Little Summer Island: Most of Little Summer Island is composed of Hendricks strata, only the southeastern part of the island being occupied by Schoolcraft beds.

LOC. 33. The contact between the Hendricks strata and the lower Pentamerus dolomite is exposed in a low cliff on the southern shore just west of a small point of land in the SE¼ sec. 18, T 37 N, R 19 W.

As one proceeds a short distance northwestward along the shore, lower and lower beds of the Hendricks rise above the level of Green Bay. In a cliff, which extends along the shore for one-eighth of a mile, about 20 feet of Hendricks strata are exposed.

LOC. 34. A very light gray, finely crystalline limestone, containing minute, disseminated crystals of calcite, was seen by the writer on the shore at the southwestern point of the island (NW¼ sec. 18). At the time of the writer's visit only 8 inches were exposed over a small area at the water's edge.

The limestone is of considerable interest on account of its great purity, which probably approaches 100 percent calcium-carbonate.

Limestone of such purity is of rare occurrence in the Hendricks west of southeastern Schoolcraft County. The limestone at this locality is either a small lens or the undolomitized representative of some bed in the Hendricks, which elsewhere is a magnesian-limestone or dolomite.

Squaw Island:

LOC. 35. Shingle beaches, consisting almost entirely of finely crystalline, light-gray to buff dolomite, are present on the shore of Squaw Island, located a very short distance west of Little Summer Island. The ledges, from which this shingle was derived, could be seen on the bottom of the lake along the eastern side of the island at the time of the writer's visit.

The ledges on the lake bottom most likely belong to the Hendricks Member although it is possible that they may be some of the uppermost Byron strata.

Escarpment, western side of Garden Peninsula: The escarpment, which rises from the shore of Big Bay de Noc on the western side of the Garden Peninsula, contains many excellent exposures of Burnt Bluff strata. The detailed sections of two of these exposures, one at Burnt Bluff (Loc. 36) and the other about 11 miles northeast of Burnt Bluff (Loc. 43), have been described on previous pages.

LOC. 37. One of the finest and most instructive exposures of Burnt Bluff strata is at Middle Bluff, which is the most picturesque part of the escarpment bordering the western side of the Garden Peninsula. The section given below describes all of the strata exposed in the natural face of the bluff, in an abandoned quarry excavated in the southern end of the bluff near the village of Fayette, and in the higher, receding slopes above the top of the bluff.

Section of strata at Middle Bluff, near Fayette, Delta County, Locality 37

		Thickness Feet	Inches
	Manistique Dolomite		
	Schoolcraft Member		
21	Upper Pentamerus dolomite. Massive, coarsely crystalline, light grayish-buff in color with molds of the shells of Pentamerus. Exposures present only as cappings.....	1	
20	Dolomite, thin and even-bedded, finely crystalline, light bluish-gray to light grayish-buff in color with molds of the shells of Pentamerus.....	14	
19	Lower Pentamerus dolomite. Massive, coarsely crystalline, light grayish-brown with numerous poorly preserved molds of the shells of Pentamerus and silicified corals and stromatoporoids..	7	
	Stromatoporoids Favosites aff. F. favosus Favosites aff. F. hisingeri Cladopora aff. C. laqueata Halysites sp. Pentamerus cf. P. oblongus		
	Burnt Bluff Limestone and Dolomite		
	Hendricks Member		
18	Dolomite, massive, buff and cherty, weathering into uneven beds, 2 to 4 inches thick and containing a few silicified fossils. Dolomite is transitional with respect to its lithological character between rock of interval 17 below and Lower Pentamerus dolomite above.....	11	
	Stromatoporoids Favosites cf. F. favosus Halysites sp. Pentamerus ? sp. Atrypa sp.		
17	Dolomite, cherty, thin-uneven-bedded and finer crystalline than that above. Cherts most abundant in lower 2 feet of interval.....	12	
16	Dolomite, massive and light brown in color.....	2	
15	Dolomite, massive, light buff to grayish-buff and coarsely crystalline, with little chert and cavities, formed chiefly by the solution of Favosites and stromatoporoids. Numerous partially dissolved and poorly preserved remains of		

		Feet	Inches
	Hendricks types of Favosites and stromatoporoids present. Weathered surfaces of dolomite are white.....	18	
14	Dolomite, thick-bedded. Upper 5 feet is light grayish-buff in color. Lower 4 feet is light-gray and finer crystalline than upper 5 feet, has a conchoidal fracture and grades upwards lithologically into the upper 5 feet. Weathered surfaces of lower 5 feet bluish-gray.....	9	
13	Dolomite, thick-bedded, coarsely crystalline and light-brown in color, with many small, irregularly shaped cavities, and odor of petroleum when struck with hammer. Some of the cavities were apparently formed by the solution of Favosites and stromatoporoids. Weathered surfaces are gray in color and feel sandy. Darker gray, irregularly shaped areas, consisting of larger crystals of dolomite than those of the surrounding rock, stand in slight relief on the weathered surfaces.	6	
	Stropheodonta (Brachyprion) sp.— poorly preserved but similar to or identical with specimens found elsewhere in Hendricks strata.		
12	Dolomite, light-brown and coarsely crystalline, with streaks of carbonaceous matter. Weathered surfaces show distinct laminae and have a sandy feel. Lowest 2 feet most coarsely crystalline, uppermost 2 to 3 feet contain greatest abundance of carbonaceous matter.....	10	6
11	Dolomite, light-gray and finely crystalline, with a conchoidal fracture. Weathered surfaces are bluish-gray in color and show laminae, which at intervals are slightly undulatory. The basal 2 inches consist of an "edgewise conglomerate," whose angular pebbles are composed of dolomite closely resembling that of the surrounding matrix.....	2	8
10	Dolomite, massive, light-brown with a conchoidal fracture.....	1	
9	Dolomite, thick-bedded, coarsely crystalline, light-brown in color with lighter buff to yellow irregularly shaped areas of dolomite crystals and cavities formed by the solution of corals and stromatoporoids. Near the		

PLATE 13 -- BRACHIOPOD AND MOLLUSCS

Figures x 1

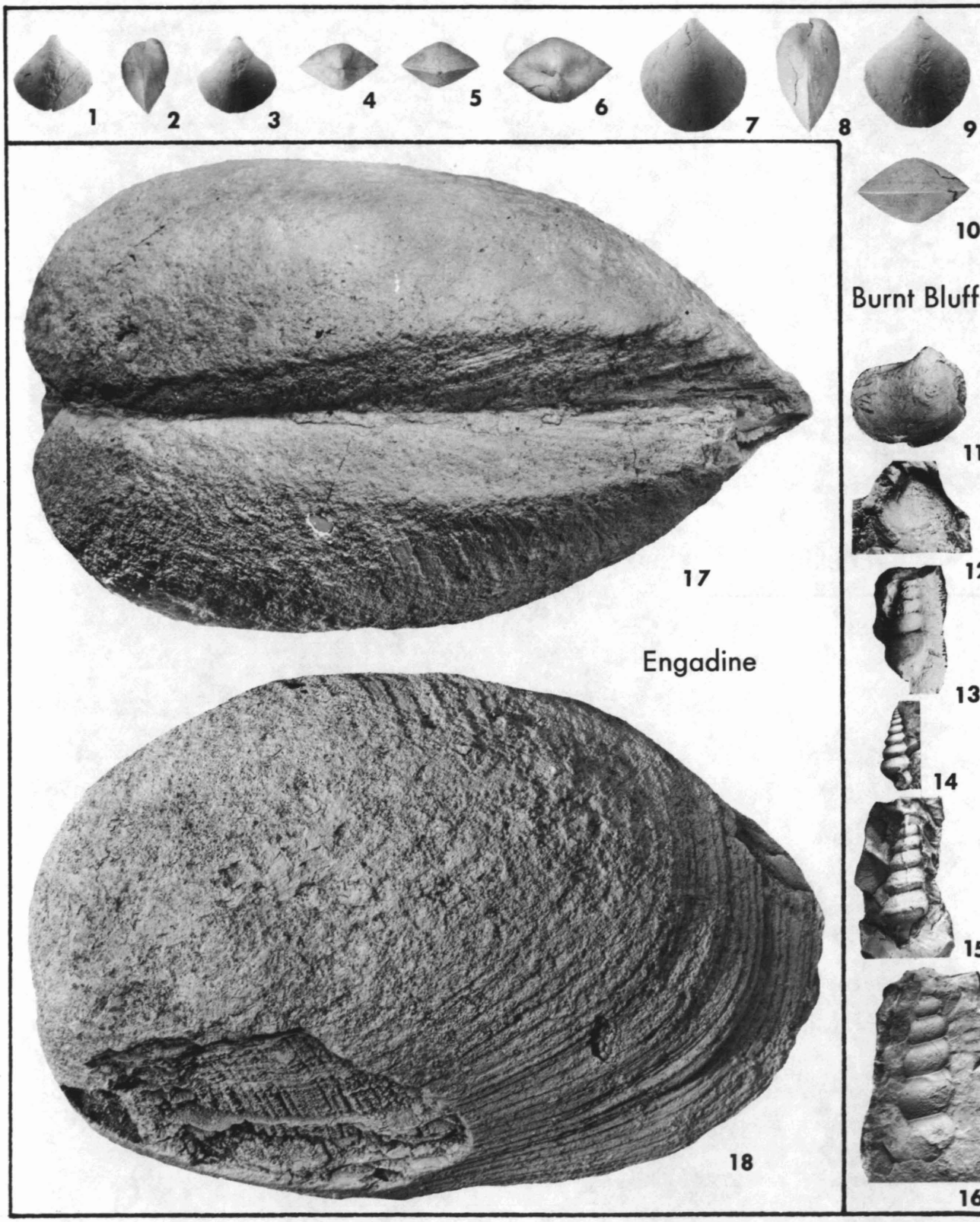
1-10 - Whitfieldella sp. Two specimens from coral-stromatoporoid bed overlying Fiborn Limestone, W wall of Inland Lime & Stone Company Quarry, 3/4 mile N of quarry office.

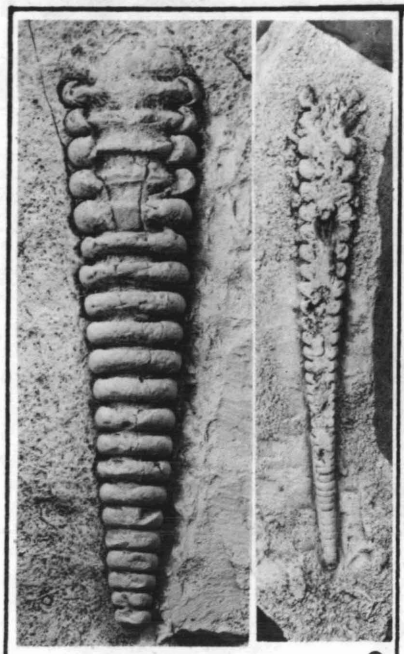
11, 12 - Ctenodonta sp. Two specimens from Fiborn Quarry, Mackinac Co.

13 - Hormotoma aff. whiteavesi Clarke & Ruedemann. Fiborn Quarry.

14-16 - Coelocaulus macrospira (Hall). (= Coelidium macrospira). Three specimens from Fiborn Quarry, Mackinac Co.

17, 18 - Megalomus canadensis Hall. Canadian specimen. Most Michigan specimens retain little shell material, being preserved as steinkerns. See other views in plate 17, figures 1-3.


1
2
3
4
5
6
7
8
9
10
Burnt Bluff
11
12
13
14
15
16
17
Engadine
18



1 2

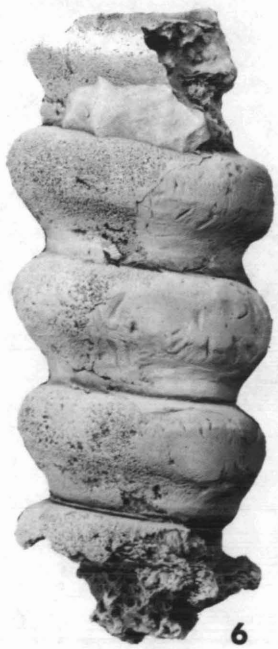
Burnt Bluff

3

4

5

Manistique-Cordell



6

7

8

9

		Feet	Inches
	top, the dolomite contains streaks of carbonaceous matter.....	5	
8	Dolomite, gray, finely crystalline and with conchoidal fracture. Weathered surfaces are bluish-gray in color.....	4	
7	Dolomite, dark-gray and more coarsely crystalline than that of the interval 6.....	1	6
6	Dolomite, light-gray to white and coarsely crystalline.....	1	6
5	Dolomite, thick-bedded, light-gray to light brownish-gray, finely crystalline with very thin laminations showing on weathered surfaces.....	16	
4	Dolomite, darker brown than that of interval 3.....	2	10
3	Dolomite, brown, with laminae showing on weathered surfaces.	2	
2	Dolomite, similar to that below but with thinner bedding and few cavities.....	3	
1	Dolomite, thick-bedded, buff, coarsely crystalline, with cavities formed by solution of Hendricks types of Favosites.....	5	
		135	

Most of the Hendricks strata, exposed at Burnt Bluff and in the "11-mile bluff," are also present at Middle Bluff. This fact may be ascertained by comparing the intervals of the three sections with one another after having placed in alignment the continuous and persistent "edgewise conglomerate" of these sections.

LOC. 38. Hendricks strata are exposed in a thickly wooded cliff, which extends in a north-south direction along the eastern side of South River Bay and reaches an elevation of about 125 feet above this bay. The best exposure, which contains the northward continuation of the strata of intervals 9 to 14 of the Middle Bluff section, is located in the SW$\frac{1}{4}$ sec. 23, T 39 N, R 19 W. The base of the exposure is about 40 feet above the level of South Bay.

LOC. 39. At Garden Bluff, located in secs. 10, 11, and 15, T 39 N, R 19 W, Hendricks strata are present in a cliff, which rises abruptly above Big Bay de Noc to an elevation of about 40 feet. The beds, exposed in this cliff, are the same as those of intervals 5 to 14 of the section at Middle Bluff.

LOC. 40. About 3/4 mile east of Garden Bluff is an abandoned quarry, situated near the shore of Goulley's Harbor. Beds in this quarry are a continuation of intervals 10 to 14 of the Middle Bluff section.

Near the top of a bluff southwest of the quarry the dolomite of interval 17 and part of the dolomite of interval 18 of the Middle Bluff section are exposed.

PLATE 14 -- CEPHALOPODS

Figures x 1

1, 2 - Stokesoceras romingeri Foerste. Both from Hendricks Member, Hendricks Quarry. 1, UMMP 7558. 2, UMMP 7557.

3 - Armenoceras gouldense Foerste. UMMP 7548. N of Hunts Spur, Mackinac Co.

4 - Armenoceras rotulatum (Billings). Top of bluff 1$\frac{1}{2}$ miles SE of Raber, Chippewa Co.

5 - Huronia annulata Hall. Drummond Island.

6 - Huronia obliqua Stokes. UMMP 7546. Drummond Island.

7 - Huronia bigsbyi Stokes. UMMP 2814. Drummond Island.

8 - Huronia vertebralis Stokes. Drummond Island.

9 - Stokesoceras engadinense Foerste. UMMP 7551. NE of Engadine, Mich.

Cappings of the lower Pentamerus dolomite of the Schoolcraft Member of the Manistique Formation are present at the surface of the flat land, located a short distance back from the top of the bluff at an elevation of about 80 feet above Big Bay de Noc.

LOC. 41. In a cliff a short distance northwest of Vans Harbor, which is located about 1 mile northwest of the village of Garden, the contact between the Hendricks and Schoolcraft strata is well shown.

LOC. 42. Lower Hendricks strata than exposed in this cliff are present along the shore between the cliff and a point about 1 mile to the northwest.

Exposures along highway between Fairport and Cooks: Numerous exposures of Hendricks strata are present beside the main highway leading northward from Fairport to Fayette, to Garden, and thence to Cooks and along roads intersecting this highway.

A detailed description of these exposures is not essential to an understanding of the stratigraphy of the region. By first making an examination of the excellent sections at Burnt Bluff, Middle Bluff, and the "11-mile bluff," one has no difficulty in determining the exact stratigraphic position of the strata of these roadside exposures.

Schoolcraft County

In Schoolcraft County Burnt Bluff strata are exposed in the region west of Indian Lake, in a cuesta between Indian Lake and the Manistique River, and at numerous places in the southeastern part of the County.

Region west of Indian Lake

Burnt Bluff and also some Manistique strata are near the surface of much of the County west of Indian Lake. All of the Burnt Bluff strata, which the writer found at the surface in this region, are exposed north of Cooks and belong to the Hendricks member.

LOC. 44. The lowest Hendricks strata observed are present in a very small quarry excavated for road-metal in the side of a low, east-west trending ridge about 6 miles north and $1\frac{1}{2}$ miles east of Cooks ($SW\frac{1}{4}$ sec. 28, T 42 N, R 17 W). From 5 to 6 feet of light yellowish-gray to cream-colored magnesian-limestones and dolomite of this quarry (see section by R. A. Smith, 1916, p. 263) specimens of Camarotoechia winiskensis, Rhynchospira lowi, Leperditia fabulina, and other characteristic Hendricks fossils were collected. These fossiliferous strata possibly represent the northeastward continuation of the beds of intervals 1, 2, and 3 shown in the "11-mile bluff."

LOC. 45. Hard, thick-bedded, bluish-gray dolomites, containing numerous molds of the shells of Trimerella are exposed about $3\frac{1}{4}$ miles south of this quarry. These dolomites are best shown along the road just east of the SW corner of sec. 9, T 41 N, R 17 W, and in the nearby fields on both sides of the road leading north from this section corner.

LOC. 46. The Trimerella-bearing beds are shown in a small quarry excavated for road-metal in a small hill about $\frac{1}{2}$ mile east of the SW corner of sec. 9, T 41 N, R 17 W, and about 100 yards north of the road along the south line of this section. The lithological character of these beds is given in the following section.

Section of strata exposed in quarry about $\frac{1}{2}$ mile E of SW cor. sec. 9, T 41 N, R 17 W, Locality 46

		Thickness Feet	Thickness Inches
	Burnt Bluff Limestone and Dolomite		
	Hendricks Member		
4	Dolomite, hard, massive, bluish-gray with conchoidal fracture and cavities resulting from the solution of the shells of Trimerella. On weathering, dolomite becomes pitted, buff in color and somewhat friable.....	3	6
3	Dolomite, hard, massive, light bluish-gray, with conchoidal fracture and some cavities.....	3	2
	Trimerella cf. T. acuminata Liospira ? sp.		
2	Dolomite similar to that of interval 4 above with few molds of shells of Trimerella.....	3	2

		Feet	Inches
1	Dolomite, hard, light bluish-gray to light yellowish-gray, with few cavities and conchoidal fracture and divided into layers 8 inches to 1 foot in thickness.....	6	
		15	10

The beds exposed in this quarry and along the roads and fields a short distance to the west belong to the Hendricks Member. With little doubt some or all of the beds containing Trimerella represent a westward continuation of the Trimerella-bearing dolomite, exposed along the road about 1/8 mile north of the SE corner sec. 12, T 42 N, R 14 W, and other places in southeastern Schoolcraft County.

LOC. 47. About 3 feet of hard, massive, light-gray dolomite with many small cavities are exposed in a low ridge, which crosses the east-west road about 3/4 mile west of the southwest corner sec. 9, T 41 N, R 17 W. As the result of solution, much of which may have taken place in pre-Pleistocene time, fissures eight inches in width have been formed along the joint-planes of the dolomite.

The dolomite contains a few poorly preserved remains of Favosites, which very much resemble forms characteristic of the Hendricks strata.

LOC. 48. About $\frac{1}{4}$ mile west of this ridge, approximately 100 feet east of the SW corner sec. 8, 4 to 6 feet of very similar dolomite are exposed in the road.

The lithologic character of the rock at these two places and the presence of Hendricks-like forms of Favosites at the former locality lead the writer to believe that the rock may be the dolomitized representative of the limestone of interval 13 (Fiborn Limestone of R. A. Smith) of the Hendricks Quarry section.

Cuesta between Indian Lake and Manistique River:

LOC. 49. The most conspicuous topographic feature of the region between the northeastern shore of Indian Lake and the Manistique River is a cuesta, which terminates in a northward-facing escarpment. This escarpment, which has an east-west trend in the southern part of sec. 14, T 42 N, R 16 W, extends westward into the southeast quarter of sec. 15, thence southwestward to the west-central part of sec. 22 and thence southeastward into the north-central part of sec. 27. From the southeastern part of sec. 14 the escarpment trends southeastward into the northwest quarter of sec. 23, thence southwestward to the south-central part of this section, thence northeastward to the southwest quarter of sec. 24, and thence southeastward as a very low discontinuous cliff to the northeastern part of sec. 25.

LOC. 50. Exposures of Hendricks strata are numerous along this escarpment and the roads traversing the gentle back slope of the cuesta. The best exposure is present in the face of the northward-facing part of the escarpment where a cut has been made for the highway leading from Manistique to Shingleton. The rocks exhibited at this place are described in the following section.

Section of strata in cut of State Highway 94 about 4 miles N of Manistique, Schoolcraft County, Locality 50
(about $\frac{1}{4}$ mile S of center of sec. 14, T 42 N, R 16 W)

		Thickness Feet	Inches
	Burnt Bluff Limestone and Dolomite		
	Hendricks Member		
11	Dolomite, thin-bedded, light-gray to brownish-gray and finely crystalline.....	2	
10	Covered.....	2	
9	Dolomite, thick-bedded, coarsely crystalline, brown, splitting into thinner beds on weathering.....	6	
	Favosites sp. - similar to or identical with Favosites sp. no. 1 found in Hendricks strata at other localities		
	Stropheodonta ? sp.		
	Camarotoechia winiskensis		
	Coelidium ? sp.		
	Leperditia cf. L. fabulina		
8	Covered interval.....	7	

		Feet	Inches
7	Dolomite, massive, finely crystalline and light-gray. Weathered surfaces are white and show distinct laminae. The basal 1 to 1½ feet is an "edgewise conglomerate," the angular pebbles of which are similar to the enclosing dolomite except for a slightly lighter gray color. The laminae on the weathered surface of the conglomerate and of the dolomite for a distance of about 6 inches to 1 foot above the conglomerate are decidedly crumpled and to some extent faulted. The laminae of the upper 1½ to 2 feet of dolomite are either horizontal or very slightly undulating.....	4	
6	Dolomite, thick-bedded, coarsely crystalline, buff with lighter buff, irregularly shaped areas of dolomite crystals and silicified fossils and cavities formed by solution of fossils. On weathering, exhibits a thinner, uneven bedding.....	6	9
	Stromatoporoids - poorly preserved and undetermined		
	Favosites sp. - closely related to common Hendricks forms		
	Aulopora ? sp.		
	Halysites cf. H. catenularia		
	Crinoid columnals		
	Rhynchospira lowi		
	Whitfieldella sp. - small form, probably new		
	Pycnomphalus ? sp. - a common Hendricks form		
5	Dolomite, massive, finely crystalline, light-gray to light bluish-gray, exhibiting a thinner bedding and a buff color on weathering.....	4	
4	Dolomite, massive, coarsely crystalline, bluish-gray and not sharply separated from underlying and overlying strata.....	1	
3	Dolomite, finely crystalline, light-gray and laminated.....	16	
2	Dolomite, massive, light-buff to light-gray and laminated.....	4	
1	Dolomite, thick-bedded, light brownish-gray with poorly preserved silicified fossils, on weathering becomes pitted and friable.....	6	
	Duncanella sp. - probably same as D. sp. no. 1 found in Hendricks strata at other localities		
	Duncanella sp.		
	Streptelasma ? sp.		

PLATE 15 -- CEPHALOPODS AND OSTRACODS

Figures x 1 except as noted

1, 2, 7, 8 - Leperditia sp. Specimens from Fiborn Limestone, Hendricks Quarry. 2, x 4; 7, 8, x 2.

3-6 - Leperditia fabulina Jones. 3, 4, Fiborn Limestone in Hendricks Quarry; 3, x 2; 4, x 4. 5, 6, beds below Fiborn Limestone, ditch in Hendricks Quarry; 5, x 2; 6, x 4.

9 - Dihogmochilina latimarginata (Jones). (= Isochilina latimarginata). Fiborn Limestone, Hendricks Quarry.

10 - Armenoceras gouldense Foerste. UMMP 7547. SW¼ sec. 7, T 42 N, R 12 W, ¼ mile N of Hunts Spur, Mackinac Co.

11 - Huroniella ehlersi Foerste. UMMP 7541. Scott Quarry, Chippewa Co.

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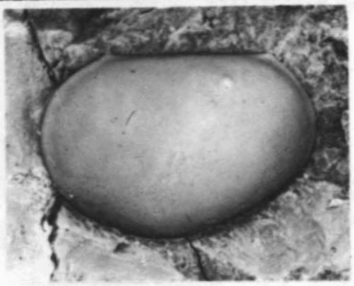

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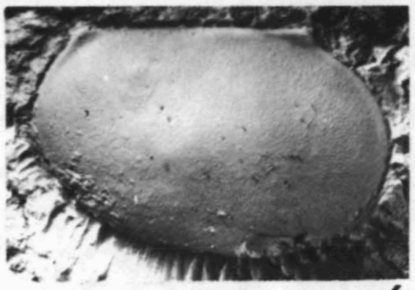

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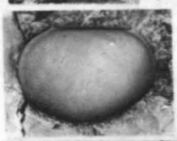

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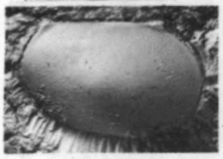
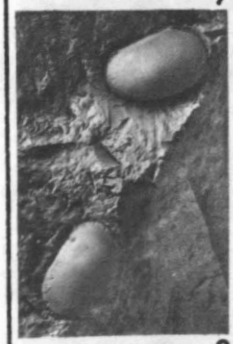


5

Burnt Bluff

7



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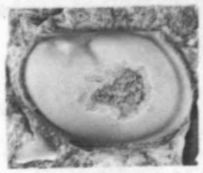
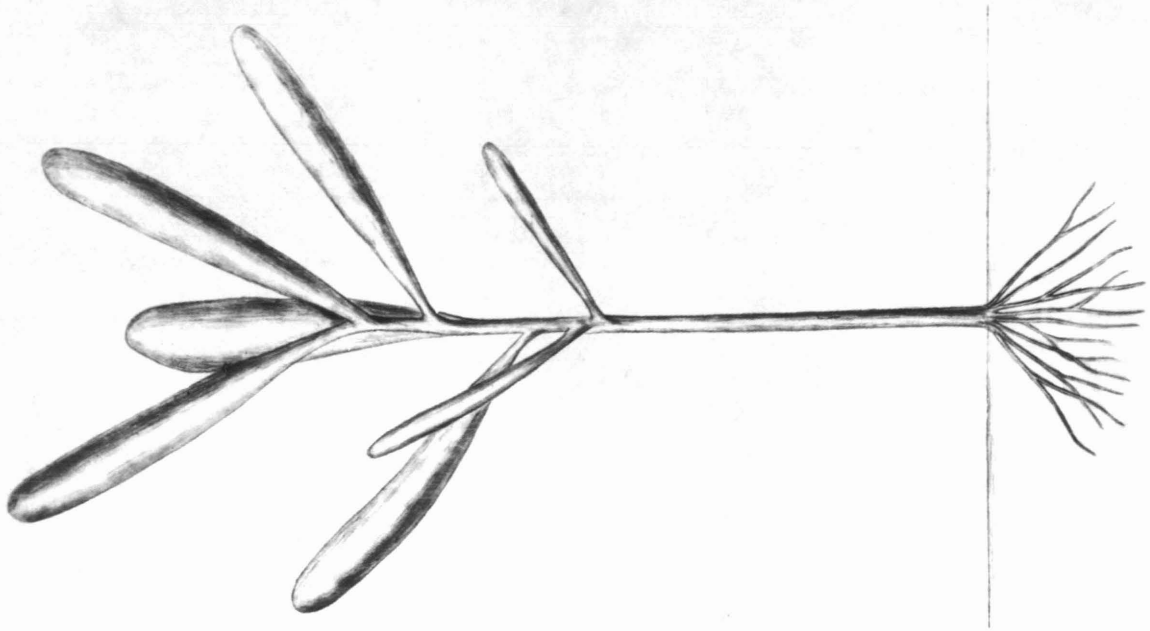


9

Manistique-
Cordell

10

11



1 Manistique-Schoolcraft

2

	Feet	Inches
Atrypa ? sp. Whitfieldella sp. - small form, probably same as one found in Hendricks strata at other localities.		
	58	9

This section is instructive in demonstrating the northeastward extension of some of the Hendricks strata exposed in the bluffs rising above the eastern shore of Big Bay de Noc. The edgewise conglomerate of interval 7 is the same as that of interval 27 of the Burnt Bluff section, interval 11 of the Middle Bluff section, and interval 10 of the "11-mile bluff." The dolomite of interval 6 is the northeastward continuation of interval 26 of the Burnt Bluff section, intervals 9 and 10 of the Middle Bluff section, and interval 9 of the "11-mile bluff." Further comparison of the sections will show the northeastward extension of other strata.

The edgewise conglomerate shown in the highway cut and in the bluffs along the eastern shore of Big Bay de Noc is of considerable interest as regards its manner of formation. Many edgewise conglomerates are composed of fragments formed on tidal flats by the breaking up of dried mud. The mud of the tidal flat, which by uplift is exposed to evaporation, soon develops dessication fissures or "sun cracks"; the mud then curls up from the edges of these fissures and is broken up and tossed about by the wind. Many of the dried fragments of mud produced in this manner are dropped by the wind in the nearby water or are incorporated in the deposit formed during an advance of the sea over the flat. The presence of dessication fissures at the top of the edgewise conglomerate exposed in the "11-mile bluff" suggests very strongly that the conglomerate at this place was formed in the manner just stated. On the other hand the crumpled and faulted condition of the laminae of the conglomerate exposed in the highway cut indicates a gliding of a partially indurated sediment, the angular fragments being formed by the breaking up of the harder layers. The undulating, less crumpled laminae of the conglomerate of the bluffs in the Big Bay de Noc region also suggest the same mode of formation. Probably both methods of formation were active in producing the conglomerate. The decided crumpled and faulted nature of the laminae of the conglomerate in the road-cut indicates very strongly, however, that gliding was the more important agent in this particular area.

Northeast shore of Indian Lake, Indian River and vicinity:

LOC. 51. Hendricks limestones and dolomites are exposed at intervals along the northeast shore of Indian Lake and in a low cliff a short distance east of this shore between the outlet of the lake into Indian River and a point about 1 mile to the northeast. The lowest stratum is present along the shore about 1 foot above the water at the northeast end of the series of exposures. It consists of a massive, light-gray, finely crystalline dolomite, with a brachiopod closely resembling Camarotoechia winiskensis Whiteaves, Ctenodonta ? sp. Pterinea occidentalis Whiteaves, Pterinopecten ? sp., and Trochonema n. sp. About 1/8 mile southeast of the northeast end of the series of outcrops the next higher stratum is exposed. This stratum is a very pure limestone, lithographic in texture and with numerous small slit-like cavities formed by the solution of the crystals of some unknown mineral. Freshly-broken surfaces of the limestone are light-gray with a buff tinge; weathered surfaces are almost white. The limestone resembles the "Fiborn Limestone" of R. A. Smith but may be distinguished by its slit-like cavities and by its lower stratigraphic position. A short distance to the southeast a higher bed, consisting of a light-gray to light-buff, partly laminated dolomite, makes its appearance on the lake shore. On the lake shore about $\frac{1}{2}$ mile northeast of the outlet of Indian Lake, the dolomite of interval 1 of the section

PLATE 16 -- GRAPTOLITES

Specimen x 1

1, 2 - Graptolites. 1, reconstruction of colony. 2, remains from highest unit of Schoolcraft Member, White Marble Lime Company Quarry in Manistique.

in the cut of the Manistique-Shingleton highway is exposed. Still higher strata, represented in the road cut, make their appearance along the shore as the outlet of Indian Lake is approached.

LOC. 52. Ledges of dolomite, occupying still higher positions in the Hendricks Member are present at several places on the bottom of Indian River between Indian Lake and the Manistique-Shingleton highway (State Highway 94).

LOC. 53. A massive light gray, coarsely crystalline dolomite is present at the surface in an area of 3 to 4 acres immediately north of the Indian River and east of the Manistique-Shingleton road (State Highway 94). About 7 feet of rock are exposed in a few small quarries which were excavated in this dolomite for the purpose of obtaining building stone. The fact that the contact between the Hendricks and overlying Schoolcraft strata crosses the Manistique-Shingleton highway less than $\frac{1}{4}$ mile to the south of the river indicates that this dolomite is high in the Hendricks Member.

Southeastern Schoolcraft County: Hendricks strata are exposed at numerous places in southeastern Schoolcraft County in the area between the Manistique River and the contact line between the Burnt Bluff and Manistique formations.

Only a few of the more important exposures are described. A knowledge of the super-position of the Hendricks strata gained from an examination of the strata shown in the cut along the Manistique-Shingleton highway, in the Big Bay de Noc area, and at Hendricks quarry, will usually enable one to recognize the exact or approximate stratigraphic positions of the beds of the smallest outcrops.

LOC. 54. Several exposures of Hendricks strata are present in a northward and northwestward-facing escarpment, located one quarter to three-quarters of a mile south and southeast of the Manistique River and extending between points 6 and 12 miles northeast of Manistique (sec. 22, T 42 N, R 15 W, to sec. 34, T 43 N, R 14 W).

LOC. 55. One of the largest exposures in the face of this escarpment is located about 9 miles northeast of Manistique in the southwest quarter of sec. 8, T 42 N, R 14 W. About 48 feet of Hendricks dolomites are shown in the upper part of the escarpment, which at this place rises to an elevation of 75 to 80 feet above a large swamp bordering the Manistique River. The edgewise conglomerate, exhibited in the cut of the Manistique-Shingleton highway and in Big Bay de Noc region, outcrops about 42 feet above the swamp. Below the conglomerate 14 feet of dolomite are shown; above it a little less than 34 feet of dolomite are present. The highest bed of the Manistique-Shingleton road cut also seems to be present in the escarpment. It is succeeded by 13 to 14 feet of higher Hendricks dolomites.

LOC. 56. About 45 feet of strata, consisting chiefly of light-gray to buff, thick-bedded dolomites, are exposed in a northeastward-facing cliff about 3/4 of a mile east of the exposure discussed above. These strata are stratigraphically higher than the highest beds exposed at the top of the escarpment overlooking the swamp. Some of the thick beds in the upper part of the cliff apparently occupy the position of the Fiborn Limestone of R. A. Smith, and may be its dolomitic equivalent.

The cliff, in whose face the thick-bedded dolomites are shown, is a prominent topographic feature. It is over a mile in length and extends from the northeast quarter of sec. 17 to the southwest quarter of sec. 4, T 42 N, R 14 W.

LOC. 57. Between the base of this cliff and the top of the escarpment rising above the swamp along the Manistique River, the land surface is quite flat. This bench-like surface is probably a wave-cut terrace of Lake Nipissing or a terrace of a pre-Pleistocene river, which at one time carved out much of the present valley of the Manistique River.

Numerous exposures of Hendricks strata occur on the flat land. A thick-bedded, brownish-gray to buff, coarsely crystalline dolomite appears as a natural rock pavement over most of the surface in the southern half of sec. 8, T 42 N, R 14 W. Some ledges near the so-called "river road," which traverses the flat land between the two escarpments and continues southwestward to Manistique, contain numerous remains of stromatoporoids and Favosites.

Some of the beds at the surface of the terrace or in the lower part of the escarpment to the east, probably occupy the stratigraphic position of the Trimerella-bearing dolomites along the north-south road $3\frac{1}{2}$ miles to the east (1/8 mile N of SE corner sec. 12, T 42 N, R 14

W) and at several places north of Cooks. The writer's failure to find remains of Trimerella in the beds of the terrace or lower part of the escarpment does not definitely indicate the absence of this brachiopod in these strata. In the field the writer frequently found it difficult to obtain a specimen of Trimerella from the Trimerella-bearing strata because of the nature of their preservation and manner of occurrence in the rocks. The specimens are preserved only as indistinct external and internal molds of the shells, which usually are much compressed. The external and internal molds of the shells sometimes occur in abundance in thin bands; more often, however, they are distributed through the rock at considerable distances from one another. When widely distributed in the rock, a specimen is likely to be found only as the result of the fortunate blow of a hammer.

LOC. 58. Molds of the shells of Trimerella are very abundant in the dolomite of a small, low ridge, located about 5 miles northeast of Manistique in the NE$\frac{1}{4}$ SE$\frac{1}{4}$ sec. 27, T 42 N, R 15 W. It is best shown at the sides of the "river road" which crosses this ridge, and in a small, abandoned quarry located on the east side of the ridge just south of the road. It is very thick-bedded, light-gray, and 9 feet thick, with many cavities formed by the solution of stromatoporoids and Favosites.

There seem to be three species of Trimerella. One is related to T. acuminata Billings and T. ekwanensis Whiteaves. Another is somewhat similar to T. grandis Billings, and the third is probably new.

In addition to Trimerella the dolomite contains remains of poorly preserved stromatoporoids, a zaphrentid, a common Hendricks type of Favosites, Rhynchospira lowi Whiteaves, a new species of Trochonema, and a few other indeterminable gastropods.

A massive, brownish-gray dolomite 2 feet in thickness underlies the Trimerella-bearing rock. It contains numerous small, irregularly shaped cavities, lines with minute crystals of dolomite, and weathers to a brown color.

A massive, light brownish-gray dolomite, 4 feet in thickness, overlies the Trimerella-bearing rock. It contains many irregularly shaped cavities and looks very much like the dolomite, exposed 8 miles to the northeast (SE$\frac{1}{4}$ sec. 12, T 42 N, R 14 W), and thought to be the dolomitized Fiborn limestone.

The dip of the strata of this ridge is about 9° S 50° W, which is almost at a right angle to the general southeastward dip of the Niagaran strata of this part of the Northern Peninsula.

Largely on account of the relatively high, southwesterly dip of the beds, lower and lower Hendricks strata appear along the river road for a mile and a half northeast of the ridge. The presence of cherty, buff, fossiliferous Manistique dolomites - probably basal Cordell beds - along the sides of a southerly trending road only $\frac{1}{2}$ mile southwest of the ridge is in large part also due to this high dip.

An extensive area around Nicholsonville has limestones and dolomites very near the surface, cropping out as rock pavement or low ridges. Although no great thickness of strata is exhibited in any particular one, these localities add to our understanding of the stratigraphy of the upper Burnt Bluff, particularly the Fiborn Limestone which grades westward into dolomites in this region.

LOC. 59. The thick-bedded "Fiborn Limestone," which commercially is the most valuable bed in the Niagaran series of the Northern Peninsula, and the overlying magnesian-limestone, representing the westward extension of intervals 14 and 15 of the Hendricks Quarry section, occur at the surface in a belt of varying width for a distance of about 4 miles east of the Nicholsonville Quarry. Field exposures of these strata are abundant in nearly all of sec. 3 and the northern parts of secs. 1 and 2, T 42 N, R 13 W, and the southern parts of secs. 34, 35 and 36, T 43 N, R 13 W, of Schoolcraft County and in a large part of section 6 and the southeastern part of sec. 5, T 42 N, R 12 W, and the southern part of sec. 31 and southwestern part of sec. 32, T 43 N, R 12 W, of Mackinac County.

The "Fiborn Limestone" is exposed at several places southwest of the Nicholsonville Quarry. Outcrops are numerous in the eastern and southern parts of sec. 4, the southeastern part of sec. 5 and the northern part of sec. 9, T 42 N, R 13 W. According to information, kindly sent to the writer by Mr. R. A. Smith, numerous exposures of the limestone are also present in the northern half of sec. 8 of this township.

LOC. 60. More than 44 feet of limestone and dolomite are exposed in the Nicholsonville or "Blaney" Quarry in sec. 3, T 42 N, R 13 W, including the uppermost bed of 26 feet of thick-bedded, finely crystalline, very pure, grayish-buff Fiborn Limestone. A complete section has been given above.

A few feet of strata were exposed in a small pit in the floor of the quarry beneath this limestone at the time of the writer's visit. These strata consist of a white to yellowish-white, coarsely crystalline dolomite, ranging from 12 to 18 inches thick, and an underlying pure limestone, 10 inches thick and resembling the "Fiborn Limestone" but differing from it in having a lighter color and in possessing an unevenly banded structure. Between the thin, uneven bands are thin seams of calcite crystals.

LOC. 61. The two beds shown in the pit are exposed at the base of a very low bluff about 3/4 of a mile north of the quarry and about $\frac{1}{2}$ mile east of the Blaney & Southeastern Railroad. At this place the banded limestone has a thickness of 2 feet.

LOC. 62. Test pits dug in connection with exploration for limestone in the northern part of sec. 10, T 42 N, R 13 W, came upon fine-grained limestone a few inches below the surface.

LOC. 63. A ditch beside the road about 2 miles west of Nicholsonville Quarry exposes 3 inches of partially dolomitized Fiborn below 8 inches of highly calcareous limestone. This marks the onset of dolomitization that reaches completion a few miles farther west.

LOC. 64. Many exposures of limestone can be seen in ditches along the road in sec. 8, T 42 N, R 13 W, extending southward from the center of the north line of the section.

LOC. 65. A small roadside quarry in the side of a low westward-facing bluff near the SW corner sec. 5, less than half a mile west of Locality 64, shows $11\frac{1}{2}$ feet of dolomitic strata which are considered to lie below the Fiborn.

LOC. 66. Rock outcrops in a low ridge a short distance northeast of the southeast corner of sec. 12 approach a true dolomite. They are thick-bedded like the Fiborn, but are coarsely crystalline.

LOC. 67. Dolomite is exposed in a small quarry at the southwest end of the above ridge. Their position indicates that beds here are at about the same stratigraphic level as the Fiborn.

LOC. 68. Roadside exposures between secs. 11 and 12 are dolomite with Trimerella molds. The 10 feet of strata at this locality are presumed to lie below the stratigraphic level of the Fiborn, as do the Trimerella-bearing strata in Hendricks Quarry.

PLATE 17 -- VARIOUS FOSSILS

Figures x 1

1-3 - Megalomus canadensis Hall. 1, 2, specimen shown in plate 13, figures 17, 18. 3, another Canadian specimen.

4 - Hormotoma sp. Fiborn Quarry, Mackinac Co.

5, 6 - Dinobolus sp. Two specimens from Fiborn Quarry.

7, 8 - Camarotoechia winiskensis Whiteaves. Two specimens from Fiborn Quarry.

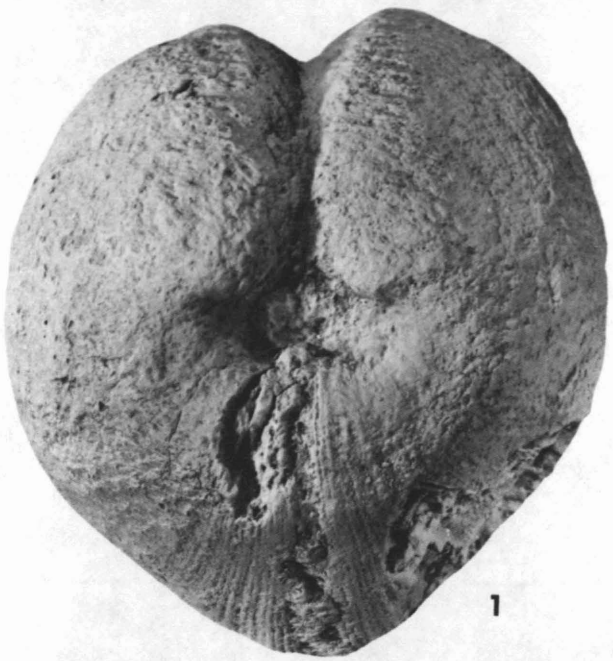
9 - Spirifer (Delthyris) crispus Hisinger var. Hendricks Quarry.

10 - Colpomya sp. Fiborn Quarry.

11 - Pterinea occidentalis Whiteaves. Lake shore at Marblehead, Drummond Island.

12 - Trochonema sp. Fiborn Quarry.

13, 14 - Dihogmochilina latimarginata (Jones). (= Isochilina latimarginata). Both specimens from Fiborn Quarry.



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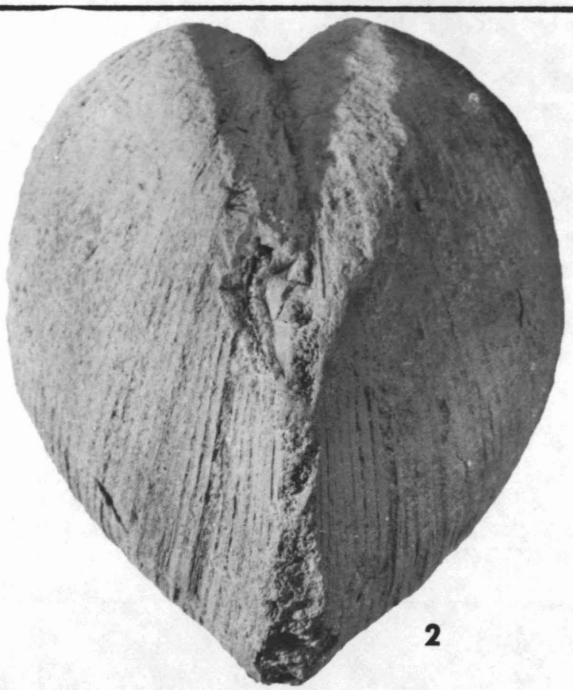

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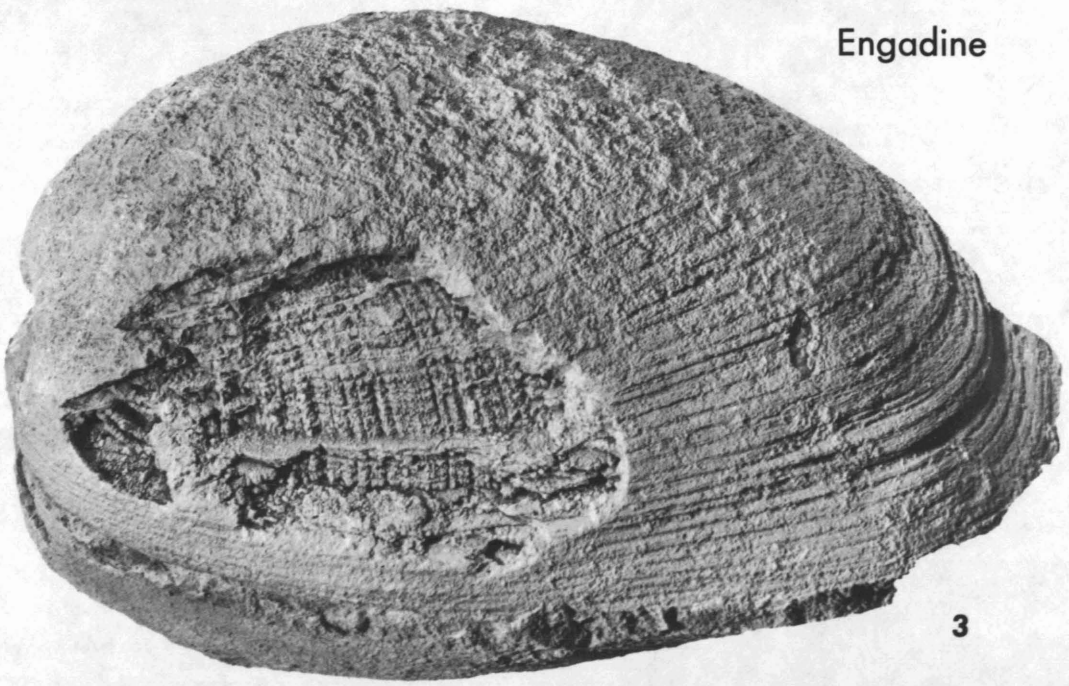
Engadine



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Burnt Bluff

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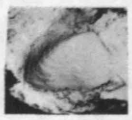

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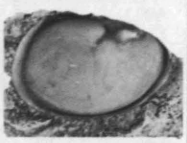

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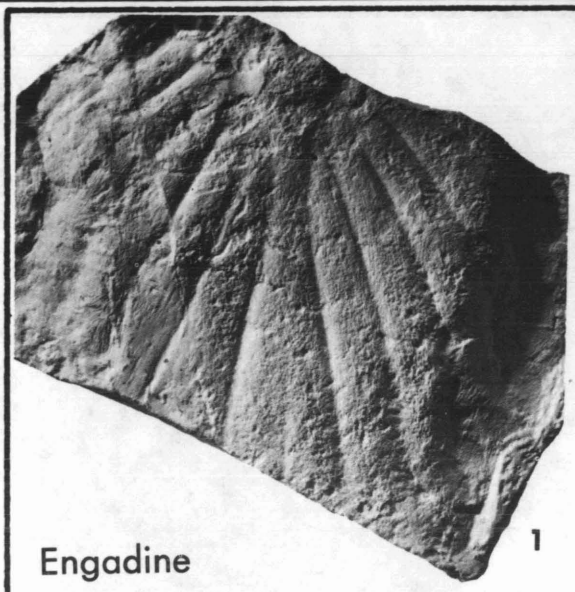

Engadine

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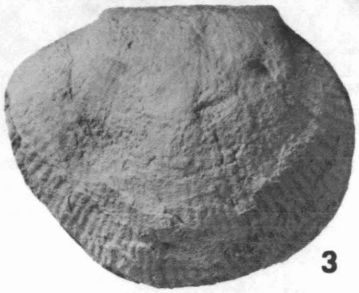

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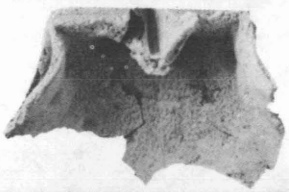

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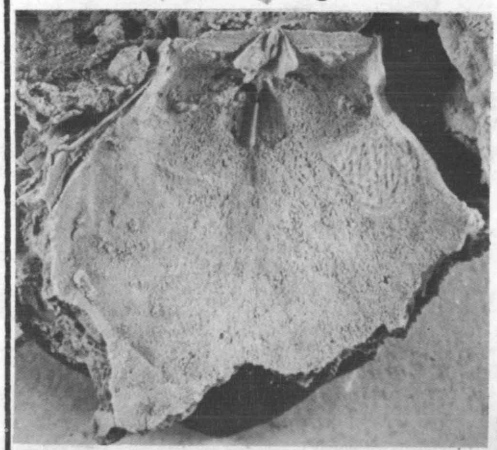

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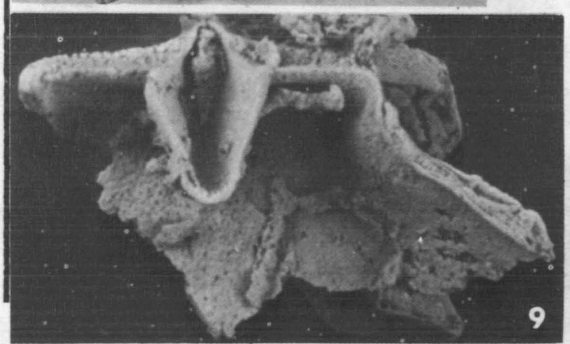

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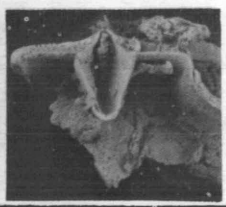
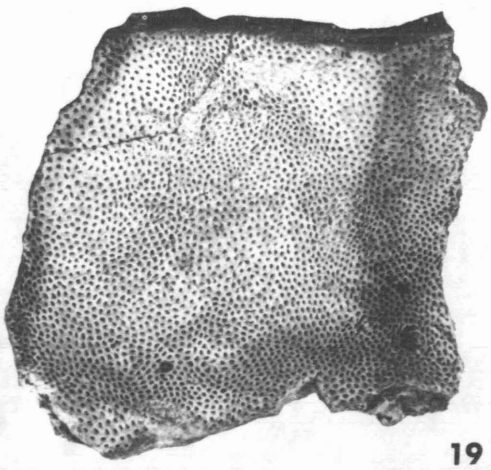
Manistique-
Cordell





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LOC. 69. About one mile northwest of the previous locality, near the corner of sec. 2, T 42 N, R 14 W, 2 feet of limestone is exposed in the road. These beds are below the Trimerella beds, and equivalent to interval 3 at Hendricks Quarry.

LOC. 70. About 2 miles north and 1½ miles west of Nicholsonville Quarry, in the NE¼ sec. 29, T 43 N, R 13 W, a small quarry for road metal uncovered 6 feet of limestone like that exposed at the previous locality.

LOC. 71. The same strata crop out beside the short northeast-southwest section of highway, about 1/8 mile northeast of the quarry at Locality 70.

Because the soil cover is so thin in this area, rock can be uncovered with a shovel at many other places in southeastern Schoolcraft County.

Mackinac County

Exposures of Burnt Bluff strata are less numerous in Mackinac County than in Delta and Schoolcraft Counties. Locally, however, the strata are at the surface of areas of considerable size. The "Fiborn Limestone" and overlying magnesian-limestones of the Hendricks Member are the beds most frequently found in outcrop.

Region north of Hunt's Spur:

LOC. 72. The "Fiborn Limestone" and the overlying magnesian-limestones of intervals 14 and 15 of the Hendricks Quarry section are at the surface of a large area (nearly all of sec. 6 and the NE part of sec. 5, T 42 N, R 12 W, and the southern part of sec. 31 and the SW part of sec. 32, T 43 N, R 12 W) about 1½ miles north of Hunt's Spur, situated on the Minneapolis, St. Paul, & Sault Ste. Marie Railroad. The exposures are a part of the series of outcrops, which are present in the belt of land extending eastward from the Nicholsonville Quarry region.

LOC. 73. The new quarry of the Inland Lime & Stone Company, first situated in the SW¼ and center sec. 6, T 42 N, R 12 W, and later expanded into sec. 5, exposes the thickest known section of the Fiborn Limestone, about 50 feet. At the top of the west wall, a low bioherm yields excellently preserved fossils, including some species which have not been discovered elsewhere. The strata have the same general character as those exposed three miles to the west in the old Nicholsonville Quarry.

Northwest of Gould City:

LOC. 74. The "Fiborn Limestone" and some beds of overlying magnesian-limestone are at the surface of much of the southern parts of

PLATE 18 -- VARIOUS FOSSILS

Figures x 1 except as noted

1, 2 - Scutellum laphami (Whitfield). Both specimens from quarry of Drummond Dolomite, Inc., sec. 1, T 41 N, R 4 E, SW corner Drummond Island.

3 - Stricklandia (Microcardinalia) multilirata Whitfield. UMMP 44492. Bed 20 to 40 feet above base of Engadine Dolomite. Quarry of Drummond Dolomite, Inc., S part sec. 36, T 42 N, R 4 E, SW part Drummond Island.

4, 5 - Stricklandia (Microcardinalia) cf. multilirata Whitfield. Mold of inner surface of pedicle valve and steinkern. Same locality as given for figure 3.

6-9 - Stricklandia (Microcardinalia) raberensis Boucot & Ehlers. All three specimens from cliff about 2 miles S of Raber, Chippewa Co. 6-8, x 2; 9, x 4.

10-13 - Camarotoechia sp. Field in SE¼ sec. 36, T 42 N, R 15 W, ½ mile E of Marblehead Quarry, Schoolcraft Co.

14-18 - Stricklandia sp. UMMP 31582. Probably middle part of Cordell Dolomite, Drummond Island.

19 - Coenites crassus Rominger. Locality unknown.

secs. 19 and 20 and the northern parts of secs. 29 and 30, T 43 N, R 11 W, located a short distance northwest of Gould City.

Roadside, 4 miles north of Gould City:

LOC. 75. At the side of the road leading northward from Gould City and about 4 miles north of this community a small outcrop of limestone is present which is either the "Fiborn" or a lower bed in the Hendricks exactly like this limestone. The strike of the strata in this region and certain topographic relationships are such as to lead the writer to believe that this limestone is the "Fiborn" and not a lower bed.

North of Engadine:

LOC. 76. Numerous blocks of a magnesian-limestone, containing many remains of Hendricks types of stromatoporoids and Favosites, are present in the drift beside the road, located on the west line of sec. 27, T 44 N, R 10 W, about $4\frac{1}{2}$ miles north and 1 mile east of Engadine. The limestone, from which these blocks were dislodged by the Pleistocene glaciers, probably rests upon the "Fiborn Limestone" and is represented in the Hendricks Quarry section by interval 14. The occurrence of blocks of this limestone on the road indicate that the higher strata of the Hendricks are close to the surface either at this locality or in the region a very short distance farther north.

LOC. 77. According to R. A. Smith (Smith, 1916, p. 239) the "Fiborn limestone" is near the surface in sec. 29, T 44 N, R 10 W, about $4\frac{1}{2}$ miles north of Engadine and about $1\frac{1}{2}$ miles south of Donald. The limestone was found by this writer at a depth of 5 feet in a shallow open well on the farm of August Wandtland, near the center of the section and at a depth of 28 inches in holes dug for telephone poles beside the road along the east side of the section. According to Smith, an analysis of a sample blasted from the well on the Wandtland farm contains 47.72 percent of calcium oxide and 5.93 percent of magnesium oxide. The fact that this limestone contains a higher percentage of magnesia than is usual for the "Fiborn" indicates either that it is dolomitized at this locality or that it is not the Fiborn but a lower or higher bed in the Hendricks. The apparent nearness to the surface of the basal Manistique strata in the region a short distance south of the Wandtland farm leads the writer to believe that the limestone in the well is either the "Fiborn" or a higher bed, and not a lower bed.

Hendricks Quarry and vicinity:

LOC. 78. The strata exposed in the Hendricks Quarry, which is partly within the $NW\frac{1}{4}$ sec. 6, T 44 N, R 8 W, and partly within the $NE\frac{1}{4}$ sec. 1, T 44 N, R 9 W, have been described above. They have also been discussed in detail by R. A. Smith (1916, p. 234-239), who furthermore has reported their chemical composition.

LOC. 79. The surface of the land about the quarry constitutes the gentle back slope of a small cuesta, which terminates in a northward-facing escarpment 80 to 100 feet in height, about $\frac{1}{2}$ mile north of the quarry. The escarpment is of considerable length. From the point one-half mile north of the quarry, it extends southeastward for about three-quarters of a mile through the southern part of sec. 31, T 45 N, R 8 W, Luce County, and thence southward into the eastern part of sec. 6, T 44 N, R 8 W, Mackinac County; west of this point, it extends southwestward through sec. 36, T 45 N, R 9 W, Luce County, the $NW\frac{1}{4}$ sec. 1 and $NE\frac{1}{4}$ sec. 2, T 44 N, R 9 W, Mackinac County, and then trends southward to southeastward in the $SE\frac{1}{4}$ sec. 2.

The "Fiborn Limestone" caps the escarpment at most places and appears at the surface of much of the gentle back slope of the cuesta. Beds above the "Fiborn," intervals 14 and 15 of the quarry section, cap the escarpment at few places and outcrop at higher points on the back slope of the cuesta.

LOC. 80. The Fiborn Quarry, operated by the Fiborn Limestone Company, is located about 4 miles northeast of Rexton. The strata exposed in the quarry and the names of the fossils collected from them are noted in the following section.

Section of strata exposed in Fiborn Quarry
4 miles northeast of Rexton, Locality 80

Burnt Bluff Limestone and Dolomite

Hendricks Member

		Thickness Feet	Thickness Inches
4	Limestone (Fiborn of R. A.		

		Feet	Inches
	Smith), lithographic in texture, light buff-gray with scattered crystals of calcite. The basal 9 feet is somewhat coarser crystalline than the rock above and contains numerous remains of stromatoporoids and Favosites. Above this basal part are 19 feet of limestone similar to the typical "Fiborn." Locally, as shown in the southeastern part of the quarry, the uppermost 3 feet of this 19 foot part of the limestone is somewhat coarser crystalline and contains small cavities formed by the solution of scattered crystals of calcite. This 3-foot portion also contains internal molds of two rather large gastropods, which are very doubtfully referred to Pycnomphalus and Hormotoma. It is slightly dolomitized and weathered and represents a lithologic phase of the "Fiborn" shown at many other places in the Northern Peninsula.....	28	
	Actinodictyon sp. (dumose form) - probably new Clathrodictyon vesiculosum var. Favosites - 2 new species, characteristic of Hendricks strata Orthis flabellites Rhynchospira lowi ? Hormotoma sp. ? Pycnomphalus sp. Leperditia fabulina - several varieties Isochilina latimarginata		
3	Limestone, magnesian, yellowish-white and laminated. Bed not sharply separated from limestone of interval 4.....	1	6
	Camarotoechia winiskensis Leperditia fabulina Isochilina latimarginata		
2	Limestone, lithographic in texture, light buff-gray and somewhat fractured. It contains many small cavities and irregularly shaped, light yellowish-gray, more crystalline, dolomitized areas.....	1	
	Stromatoporoid Favosites n. sp. - a typical Hendricks form Dinobolus n. sp. Dinobolus sp. Trimerella ? sp. - apparently young individual Orthis ? sp. Camarotoechia winiskensis and varieties Spirifer (Delthyris) crispus n. var. Rhynchospira lowi Ctenodonta n. sp. Cf. Pterinea occidentalis Ilionia ? parvula Coelocaulus cf. C. macrospira Hormotoma ? sp. Liospira ? sp. Pleurotomaria ? sp. Trochonema n. sp. Fusispira ? sp. Orthoceras sp. Phragmoceras sp. Phragmoceras ? sp. Leperditia fabulina and varieties Isochilina n. sp. - closely related to I. armata Isochilina latimarginata		
1	Limestone, very finely crystalline to lithographic and light buff-gray, resembling very closely the overlying limestone and containing numerous remains of brachiopods, pelecypods, and gastropods.....	1	6
	Stromatoporoids Favosites n. sp. - typical Hendricks form Lingula sp.		

	Feet	Inches
Camarotoechia sp.		
Camarotoechia winiskensis and varieties		
Rhynchospira lowi		
Ctenodonta n. sp. no. 1		
Ctenodonta n. sp. no. 2		
Ctenodonta n. sp. no. 3		
Whitella n. sp.		
Cf. Pterinea occidentalis		
Colpomya n. sp.		
Ilionia ? parvula		
Ilionia ? n. sp. no. 1 or n. var. no. 1 of I. ? parvula		
Ilionia ? n. sp. no. 2 or n. var. no. 2 of I ? parvula		
Coelocaulus sp. cf. C. macrospira		
Hormotoma aff. H. whiteavesi		
Liospira aff. L. stevensoni		
Euomphalopterus ? sp.		
Trochonema n. sp.		
Orthoceras sp.		
Phragmoceras cf. P. whitneyi		
Leperditia fabulina		
Leperditia fabulina varieties		
Leperditia whiteavesi		
Isochilina latimarginata		
	32	

At the time of the writer's visit to the quarry, the strata of intervals 1, 2, and 3 were exposed only at the top of a water-filled pit, part of a natural sink located a short distance south of the crusher plant.

The walls of the quarry consist of the "Fiborn Limestone" -- interval 4 of the section; the floor of the quarry at most places is the top of the magnesian-limestone of interval 3.

The lithologic character of the "Fiborn" varies from place to place in the quarry wall. The description of its lithologic character as given in the section is based on the examination of the quarry wall south of the crusher. At some places in the quarry the limestone is banded and lacks the scattered crystals of calcite; at other places the uniform character of the rock is interrupted by small reefs, composed of stromatoporoids and Favosites.

Roadside exposures about 7 miles southeast of Rudyard, Chippewa County:

LOC. 81. The most easterly located exposures of Burnt Bluff strata which the writer found in Mackinac County are present beside a north-south trending road about 7 miles southeast of Rudyard, Chippewa County.

Along the side of this road, about 1/8 mile S of the NE corner sec. 11, T 43 N, R 2 W, are many blocks of light-gray and steel-gray, finely crystalline dolomite, which contain very few, poorly preserved fossils seemingly related to Hendricks forms.

LOC. 82. A very short distance south of this

PLATE 19 -- VARIOUS FOSSILS

Figures x 1 except as noted

1-5 - Dihogmochilina latimarginata (Jones). (= Isochilina latimarginata). All specimens from Fiborn Limestone in Hendricks Quarry. 3, x 4; 5, x 3.

6 - Scutellum (Scutellum) sp. Fiborn Limestone, Hendricks Quarry.

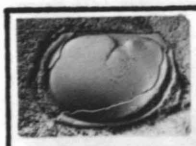
7, 8 - Scutellum sp. Schoolcraft Member, White Marble Lime Company Quarry in Manistique. 7, x 2; 8, x 6.

9, 10 - Porpites michiganensis (Bassler). UMMP 31593. Scotts Quarry.

11 - Asthenophyllum patula (Rominger). (= Streptelasma patulum). UMMP 11206. About $\frac{1}{2}$ mile S of Gould City, $SE\frac{1}{4}$ sec. 29, T 43 N, R 11 W, Mackinac Co.

12, 13 - Romingerella major (Rominger). Point aux Barques, Schoolcraft Co. 13, x 5.

14 - Bryozoa from core rock of bioherm. Shore of Scott Bay, Drummond Island, Chippewa Co.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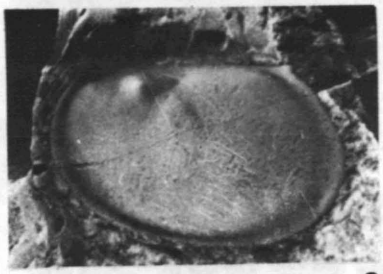
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Burnt Bluff


4


8

Manistique-Schoolcraft


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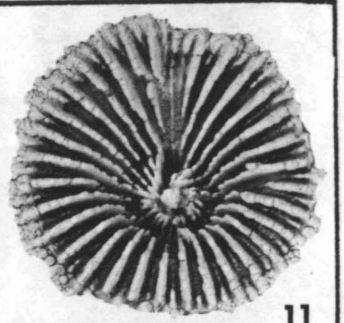
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Manistique-Cordell


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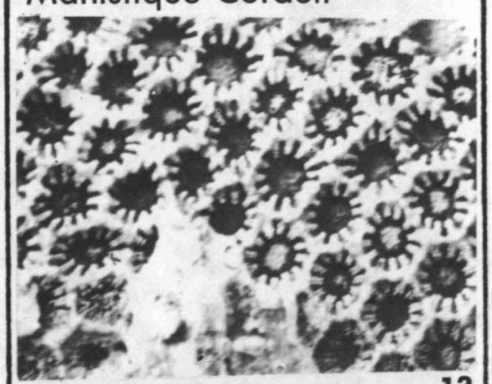
Mayville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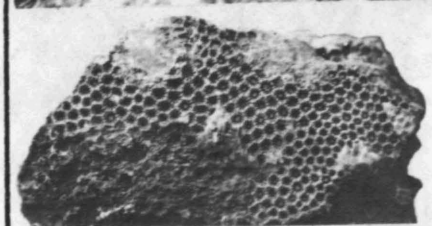
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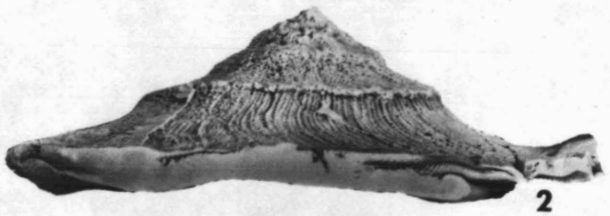

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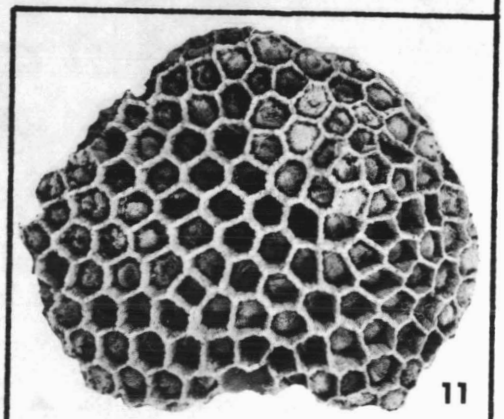

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4

Burnt Bluff

Manistique-Cordell

5

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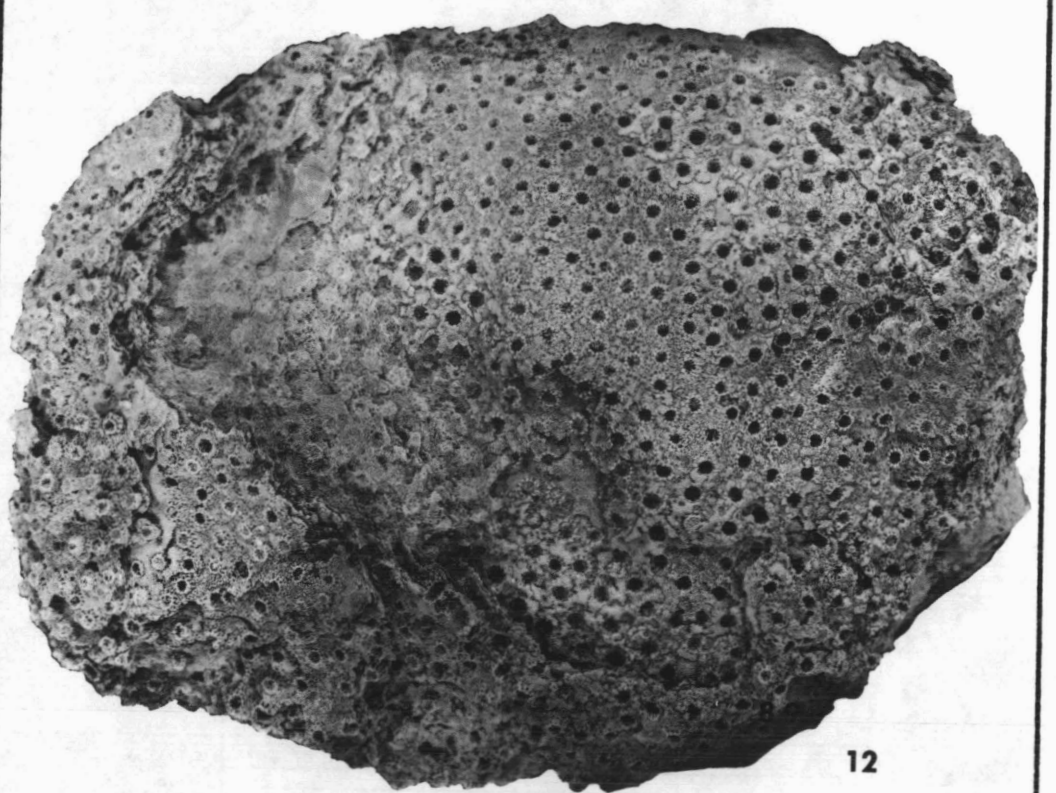

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Schoolcraft

point 6 feet of grayish-buff, finely crystalline limestone are exposed in the road. It resembles the "Fiborn" very closely but differs from it in having irregularly shaped, lighter colored, more coarsely crystalline areas, which probably represent places of partial dolomitization. The rock contains remains of Clathrodictyon vesiculosum Nicholson & Murie n. var. Labechia n. sp., Favosites n. sp., and Isochilina latimarginata (Jones), all of which are very common and characteristic fossils of the Hendricks strata.

A very short distance south of this outcrop the lower Pentamerus dolomite of the Schoolcraft Member of the Manistique is exposed on the north side of a low ridge crossing the road.

This definite stratigraphic marker at most localities in the Northern Peninsula approaches a true dolomite in lithologic and chemical composition. At this locality, however, it contains a very large amount of calcium-carbonate and without question is a magnesian-limestone. The high calcium-carbonate content is in large part due to the replacement of the shells of Pentamerus with gray to greenish-gray calcite.

Between the base of the lower Pentamerus dolomite and the top of the limestone containing the characteristic Hendricks fossils, there is a covered interval of only 5 feet. The fact that this covered interval is so small clearly shows that the contact between the Hendricks member and the Schoolcraft member of the Manistique, is at or a short distance below the base of the lower Pentamerus dolomite.

It is of interest to note that higher beds of the Schoolcraft member are shown along the road at short distances south of the exposure of the lower Pentamerus dolomite. On the top of the low ridge crossing the road is an outcrop of the thin, even-bedded, light gray, finely crystalline dolomite, which is remarkable for its continuity from Delta County to the eastern side of Drummond Island. On the south side of the ridge the lower Pentamerus dolomite is again shown. A short distance south about 7 feet of the overlying thin, even-bedded dolomite are exposed in a small quarry excavated for road-metal. At a higher elevation just south of this quarry, which is located on the west side of the road a little less than $\frac{1}{4}$ mile S of the NE corner sec. 11, the upper Pentamerus dolomite makes its appearance. This bed, which is exceedingly helpful as a stratigraphic marker on account of its remarkable continuity, is exactly similar to the lower Pentamerus dolomite in lithologic composition and in the type of preservation of the shells of Pentamerus. A short distance south of this exposure, overlying, thin, even-bedded, light-gray, finely crystalline dolomites are present in the road, the basal beds being about 25 to 30 feet above the lower Pentamerus dolomite. At the top of a hill (NE$\frac{1}{4}$ SE$\frac{1}{4}$ NE$\frac{1}{4}$ sec. 11), a little less than 1/8 mile southeast of the exposure last mentioned, are small outcrops of thin-bedded, buff, cherty dolomites, containing silicified stromatoporoids, corals, and brachiopods and apparently belonging to the Cordell Member of the Manistique Formation.

Luce County

As far as the writer knows, Burnt Bluff strata are exposed only at two places in Luce County, one of these being about $\frac{1}{2}$ mile north of Hendricks Quarry and the other about 5 miles east and $\frac{1}{2}$ mile north of the quarry.

LOC. 83 At the first locality there is a high es-

PLATE 20 -- VARIOUS FOSSILS

Figures x 1

1, 2 - Raphistomina sp. Natural mold and cast. Fiborn Quarry, Mackinac Co.

3-7, 9 - Whitfieldella sp. Two specimens from coral-stromatoporoid bed at top of W wall of Inland Lime & Stone Company Quarry, Mackinac Co.

8 - Whitella sp. Fiborn Quarry, Mackinac Co.

10 - Cheirurus sp. White Marble Lime Company Quarry, Manistique.

11 - Favosites favosus (Goldfuss). Drummond Island.

12 - Lyellia americana Edwards & Haime. UMMP 8425. Point Detour, Chippewa Co.

carpment which is capped by Hendricks strata. A further description of the exposures in this escarpment and tabulations of the chemical composition of Hendricks strata are given by R. A. Smith (1916, p. 231-234).

LOC. 84. The second occurs in a bluff, which extends northwestward from the SW$\frac{1}{4}$ sec. 36 to the NE$\frac{1}{4}$ sec. 35, T 45 N, R 8 W. Outcrops in this bluff are very few in number owing to a covering of glacial soil and vegetation. At the top of the bluff, near a lumber camp established by Mr. L. O. Paquin, the writer found 3 feet of a magnesian-limestone, containing numerous remains of stromatoporoids and Favosites and apparently representing a continuation of the limestone of interval 14 of the Hendricks Quarry section. By removing some soil and talus, 6 feet of underlying limestone were found, which resembles the Fiborn but differs from it in being more dolomitic and showing very few scattered crystals of calcite.

In the talus near the top of the bluff the writer found pieces of limestone resembling the limestones occupying a position below the Fiborn at Hendricks Quarry (intervals 11 and 12 of the Hendricks Quarry section).

The writer's observations lead him to believe that the Fiborn Limestone and some underlying and overlying strata are present in the upper part of the bluff. However, it is quite possible that all are below the Fiborn Limestone.

Chippewa County

In Chippewa County Bluff strata are exposed about four miles west of Trout Lake, about three-quarters of a mile south of Cordell, in an escarpment about three-quarters of a mile south of Raber, and on Lime and Drummond Islands. The most complete sections of these strata are shown on Drummond Island.

Four miles west of Trout Lake:

LOC. 85. At a lumber camp, established by the Cheesbrough Lumber Company in the southern part of sec. 18, T 44 N, R 6 W, about 4 miles west of Trout Lake, an excellent section of the Fiborn Limestone is shown in a test-pit. The lower 10 feet exhibit the typical, very finely crystalline, buff-gray, highly calcareous phase of the Fiborn. Above this are 4$\frac{1}{2}$ feet of somewhat coarser crystalline, much lighter buff-gray magnesian-limestone, which is either a lens in the Fiborn or a locally dolomitized part of it. Resting on this magnesian-limestone are 8 feet of typical calcareous Fiborn Limestone like that in the lower part of the pit.

LOC. 86. On the top of a small knoll about 100 feet south of the pit a highly calcareous limestone is exposed which is very similar to the Fiborn, except for being coarser crystalline.

Between the top of the knoll and top of the pit there is an interval of 7 feet. A few small outcrops within this interval contain a limestone like the Fiborn in the upper 8 feet of the test-pit, leading one to believe that all of the strata of this interval probably belong to the Fiborn.

LOC. 87. Near the edge of a swamp about 500 feet north of the pit is an exposure of highly calcareous limestone exactly like the Fiborn. The base of this exposure is 4$\frac{1}{2}$ feet lower than the base of the test-pit.

If the strata in this area are nearly horizontal or dip slightly to the south, as is very likely the case, then 4$\frac{1}{2}$ feet should be added to the thickness of the Fiborn at this locality, giving a total of about 34 feet.

Three-quarters of a mile south of Cordell:

LOC. 88. About three-quarters of a mile south of Cordell, a station on the Minneapolis, St. Paul, & Sault Ste. Marie Railroad, 9 miles east of Trout Lake, is a small cuesta with the escarpment on its north side. Surrounding the cuesta is a flat land, the former bottom of glacial-lake Algonquin.

Several exposures of Hendricks strata are present in some glacial-lake terraces situated between the eastern part of the escarpment (NW$\frac{1}{4}$ SE$\frac{1}{4}$ sec. 29, T 44 N, R 4 W) and a point about 1/3 mile to the northeast. All of the exposed strata seem to occupy a position above the Fiborn Limestone of R. A. Smith. A gray magnesian-limestone, containing numerous remains of stromatoporoids and Favosites and probably representing an eastern continuation of the limestone of interval 14 of the writer's Hendricks Quarry section, apparently is the lowest exposed bed. The Fiborn Limestone is certainly near the surface in this area and is very likely to be found in outcrop as the result of further

search. Above this limestone, containing numerous remains of stromatoporoids and Favosites, are at least 9 feet of thin-bedded, light-gray magnesian-limestone. The highest bed observed by the writer consists of 2 feet of very porous dolomite, which is bluish to buff-gray when unweathered but buff to brown when weathered. This dolomite, which is separated from the underlying thin-bedded limestones by a small covered interval, probably is not far below the Hendricks-Manistique contact.

About one-quarter of a mile southeast of the eastern end of the cuesta are other exposures of the strata, described in the preceding paragraph.

Escarpment south of Raber:

LOC. 89. About three-quarters of a mile south of Raber is a high, northeastward-facing escarpment, which extends southeastward across the southern part of sec. 33, T 43 N, R 3 E, the northeastern part of sec. 4, T 42 N, R 3 E, and the western side of sec. 3, T 42 N, R 3 E. From sec. 3 it continues southeastward for several miles along the shore of Potagannissing Bay, decreasing in height in this direction.

About 97 feet of Manistique strata, which will be described more fully on subsequent pages, compose the upper part of the escarpment in the NE$\frac{1}{4}$ sec. 4. Almost the entire thickness of the lower Pentamerus dolomite marking the base of the Manistique is shown about 1/8 mile south of the northeast corner sec. 4 on the west side of an old road, leading southeastward into sec. 3 from Raber. The base of this dolomite, which is not exposed, is approximately 140 feet above the level of Potagannissing Bay.

Between the base of this dolomite and a point about 45 feet lower are some poor exposures of thin and thick-bedded dolomites of the Hendricks Member. Most of these outcrops are hidden from view in a thick stand of second-growth poplar and birch trees. They may be readily found, however, by locating an east-west trending road, which intersects the road from Raber near the NW corner sec. 4. One of the exposures will be found on the north side of the road about 200 feet east of the corner. At very short distances north and south of this exposure other outcrops will be found. Thin- and thick-bedded buff dolomites of the Hendricks are also present in the road, leading from Raber at its intersection with the east-west road and at a point about 600 feet northwest of this intersection. The lowest exposed Hendricks strata in this vicinity are approximately 95 feet above the level of Potagannissing Bay.

Lime Island in Potagannissing Bay:

LOC. 90. As far as the writer knows, the only exposures of Burnt Bluff strata on Lime Island are present in an abandoned quarry on its northwestern shore and near the top of an escarpment at its northern end. Fortunately, the exposures are so situated as to definitely show that the Burnt Bluff strata overlie the Mayville Dolomite.

In the discussion of the Mayville Dolomite on previous pages it was shown that 7 feet of the Virgiana-bearing dolomite are exposed on the northwestern shore of Lime Island, about one-quarter of a mile north of the coaling dock of the Pittsburg Coal Company.

The Virgiana bed at this locality is overlain by 17 feet of massive, buff, finely crystalline dolomite, which the writer provisionally includes in the Burnt Bluff formation. The contact between the two beds is not shown; it seems to be about 1 foot below the floor of an abandoned quarry, excavated in the Burnt Bluff Dolomite.

About 1/3 mile northeast of the quarry, 6 feet of light to dark buff-gray, very finely crystalline dolomitic limestone are exposed near the top of an escarpment. This limestone, the base of which is approximately 57 feet above the top of the dolomite in the quarry, resembles the typical calcareous Fiborn Limestone of R. A. Smith in color and texture. It differs from it, however, in being somewhat dolomitic, in lacking scattered crystals of calcite and in possessing numerous cavities, many of which were formed by the solution of flat, tabular-shaped crystals of some unknown mineral. The presence of Leperditia fabulina var. and an apparent variety of Camarotoechia winiskensis definitely shows its faunal relationship to the strata of the Hendricks Member.

On a bench or terrace about 25 feet below the base of the limestone and in the talus on the steep slope above the terrace are numerous blocks of limestone of different lithological composition from the limestone near the top of the escarpment. At some places the blocks are

very numerous, closely spaced and of the same lithologic character, suggesting that they are nearly in place. From a block of very light gray earthy appearing dolomite with a conchoidal fracture, the writer collected the remains of a Cyrtodonta ? sp., Pterinea sp., Pterina cf. P. occidentalis Whiteaves, Leperditia caeca Jones ?, and an unidentified Leperditia. From a block of a much darker gray, slightly more crystalline dolomite he obtained a few poorly preserved specimens of Leperditia, and, from a block of a finely crystalline, light buff-gray dolomite, a single specimen each of an Orthis flabellites Foerste and a Platystrophia. All of these blocks were probably derived from strata occupying a position between the top of the 17-foot dolomite of the quarry and the 6-foot bed of limestone near the top of the escarpment. However, it is possible that some of these blocks as well as other pieces of dolomite on the terrace and in the talus may have come from a point above the 6-foot bed of limestone.

At the top of the escarpment, about 18 feet above the top of the 6-foot limestone, are numerous blocks of a thick-bedded, very light gray magnesian-limestone having a conchoidal fracture and a slight earthy feel. Blocks of this limestone are also present on a surface, which slopes from the top of the escarpment to a small, narrow terrace, just above the exposure of the 6 feet of limestone. On account of a thin covering of soil it could not be determined whether these blocks represented talus material from the limestone at the top of the escarpment or dislodged material from ledges which may be present between it and the top of the 6 feet of limestone. In the writer's opinion they more likely came from the uppermost limestone.

The presence of Leperditia fabulina var. and an apparent variety of Camarotoechia winiskensis in the 6-foot bed of limestone seems to indicate that this limestone should be included in the Hendricks Member of the Burnt Bluff Formation. If it occupies a position in the Hendricks above the plane of division between the Hendricks and Byron members - tentatively placed at the base of interval 15 of the type section at Burnt Bluff, Big Bay de Noc, then the thickness of the Byron strata on Lime Island is not greater than 57 feet. If some of the strata below the 6 feet of limestone occupy a position above the Hendricks-Byron contact, then the thickness of the Byron Member would be even less. As there are 117 feet of Byron strata exposed at Burnt Bluff -- undoubtedly more are present below the shore at this place -- it is apparent that the Byron Member is very much thinner on Lime Island. If the 6-foot bed of limestone occupies a position below the provisionally set Hendricks-Byron contact, the thinning of the Byron Member on Lime Island may be more apparent than real.

Along the west shore of Lime Island for a distance of nearly 2 miles southeast of the Pittsburg Coal Company dock, are ice-ramparts containing numerous blocks of gray to buff dolomite and limestones, and some igneous and metamorphic rocks. All of these blocks have been transported and deposited by the Pleistocene

PLATE 21 -- VARIOUS FOSSILS

Figures x 1 except as noted

1-3 - Pentameroides sp. Scott Quarry, Chippewa Co.

4, 5 - Atrypa sp. Locality unknown.

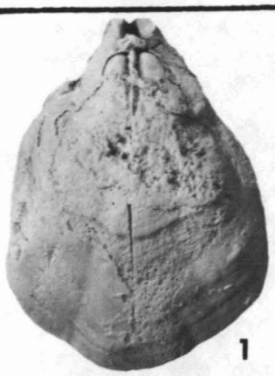
6-11 - Dihogmochilina latimarginata (Jones). (= Isochilina latimarginata). All specimens from the Fiborn Limestone in Hendricks Quarry. 6, 8, 10, 11, x 3.

12 - Rhynchospira lowi Whiteaves. Inland Lime & Stone Company Quarry, Mackinac Co. x 2.

13 - Pentamerus sp. Along N-S road 5 miles SE of Rudyard, about 1/8 mile S of NE corner sec. 11, T 43 N, R 2 W, Mackinac Co. Probably lower Pentamerus dolomite.

14 - Dalmanella eugeniensis var. cf. paleoelegantula Williams. Drummond Island.

15 - Virgiana decussata (Whiteaves). UMMP 31573. Interlake Group, Fischer Branch Dolomite, NW of Fischer Branch, Manitoba, Canada. Illustrated for comparison with Michigan specimens.



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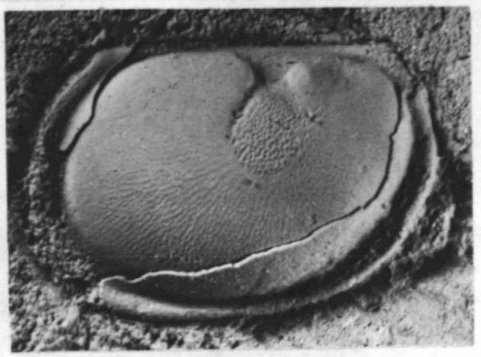
Manistique-Cordell



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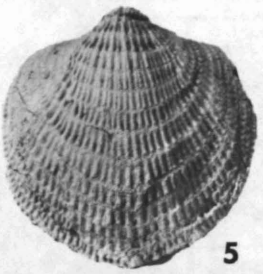

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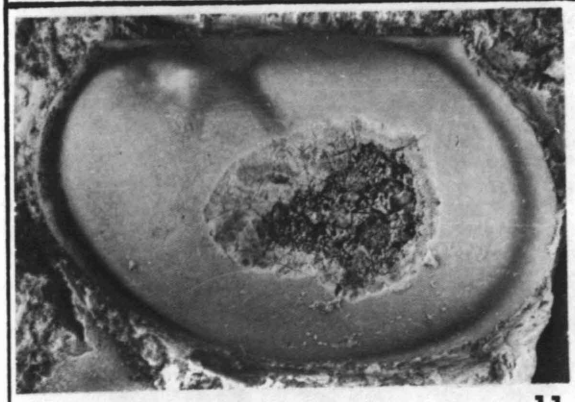

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Schoolcraft

Burnt Bluff

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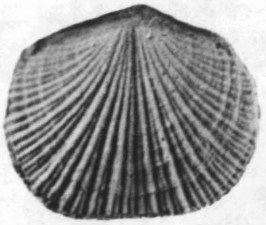

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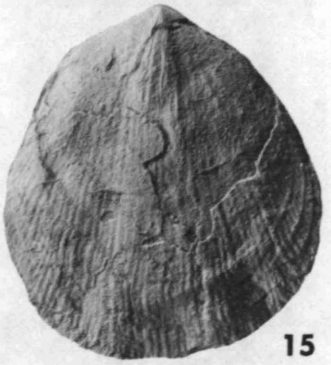

Mayville

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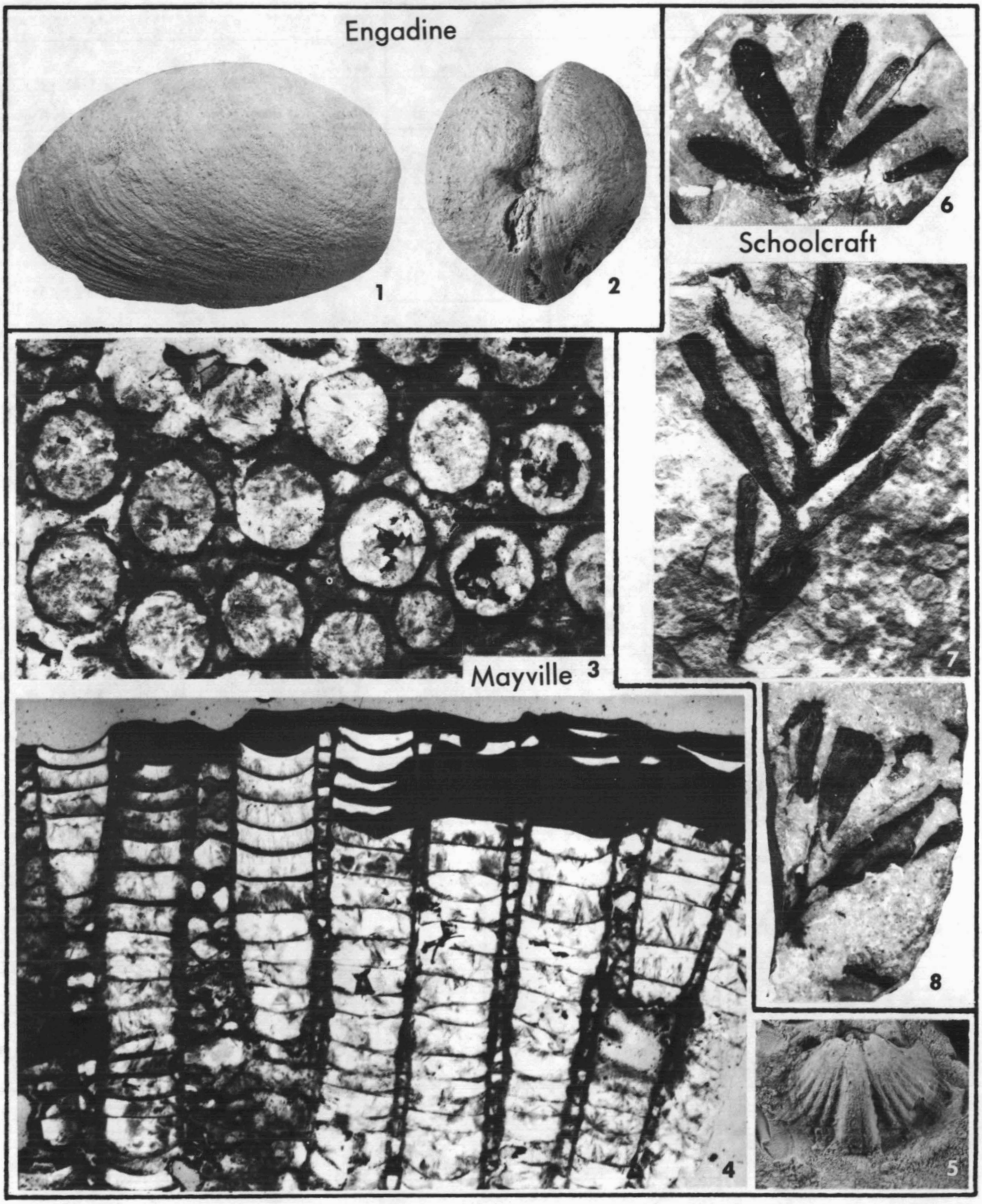

Engadine
1
2
6
Schoolcraft
7
Mayville 3
4
8
5

glacier and subsequently pushed up into ramparts by the ice-jams of Potagannissing Bay. Most of the limestones and dolomites were dislodged from the ledges of Burnt Bluff strata, which are at or near the surface of Lime Island. The blocks consist of light-gray to buff-gray magnesian-limestones and dolomites, similar to those at the top of the escarpment at the north end of the island and in the talus below the 6-foot bed of limestone. Between points along the shore 1 and 2 miles southeast of the coal dock are many blocks of a dark buff-gray, very finely, somewhat cherty, crystalline limestone, containing some scattered crystals of calcite and irregularly digitate, lighter buff-gray, partially dolomitized areas. These blocks of limestone contain remains of Clathrodictyon vesiculosum Nicholson & Murie var., Stromatopora sp., Streptelasma ? sp., Favosites n. sp. -- a characteristic Hendricks form, Dinobolus sp., Stropheodonta (Brachyprion) sp., Camarotoechia winiskensis Whiteaves var., Rhynchospira lowi Whiteaves, Whitfieldella sp., Orthoceras sp., and Leperditia cf. L. whiteavesi Jones. This assemblage of fossils shows that the blocks of limestone belong to the Hendricks Member. It is the writer's belief that the blocks were derived from a stratigraphically higher bed than the highest bed exposed in the escarpment at the north end of Lime Island. The limestone closely resembles in lithological character a limestone at Marblehead, Drummond Island, described below in interval 10 of the Marblehead section.

The limestone of these blocks may readily be confused with the typical Fiborn Limestone, small selected pieces being indistinguishable. As previously stated, however, the Fiborn Limestone is not present in southeastern Chippewa County, its place in the Hendricks Member being occupied by thick-bedded buff to buff-gray dolomites. Moreover, certain field relationships indicate that it is very doubtful whether these dolomites, representing the dolomitic phase of the Fiborn, are present on Lime Island. In the escarpment about $\frac{1}{4}$ mile south of Raber and only 2 miles west of the southern part of Lime Island, these dolomites are over 100 feet above the level of Potagannissing Bay. In order for the dolomites to be present on Lime Island at a much lower topographic position, either a decided increase in dip or a change in direction of dip must be postulated. The absence of a departure from the general dip of the strata indicates that the dolomites are not present on Lime Island.

According to Smith (1916, p. 209), pieces of limestone, identical in physical characteristics with the Fiborn Limestone, were observed in the drift of a trench dug for steam mains from the engine house to the quarters of the Pittsburg Coal Company. These pieces of limestone may have been derived from the same bed as the blocks of Fiborn-like limestone, found along the shore about 1 mile southeast of the coal dock. It is also possible that they were transported from ledges of Black River Limestone which are known to be present on the northeast shore of St. Joseph Island, only 14 miles northeast of Lime Island. Blocks of Black River limestone closely simulating the Fiborn Limestone are present in considerable abundance in the ice-ramparts along the southwestern shore of Lime Island and are present in the drift of the Island. Unless Black River fossils are found in the drift specimens of this limestone, it is quite possible for one to mistake the latter for detached pieces of the Fiborn Limestone.

Drummond Island:

LOC. 91. One of the best places to observe the

PLATE 22 -- VARIOUS FOSSILS

Figures x 1 except as noted

1, 2 - Megalomus canadensis Hall. Canadian specimen shown for characteristics of the species; most Michigan specimens preserved as steinkerns. Both x $\frac{1}{2}$.

3, 4 - Propora sp. Thin sections. Bioherm about 3/4 mile S of Stevenson's, NW shore Drummond Island. x 8.

5 - Platystrophia aff. daytonensis (Foerste). Probably from Drummond Island. x 2.

6-8 - Graptolites. Highest unit of Schoolcraft Member, White Marble Lime Company Quarry in Manistique.

Burnt Bluff strata in Chippewa County is in the vicinity of the village of Drummond on the western side of Drummond Island. Along the shore in the vicinity of Drummond village are two prominent sets of high terraces and bluffs; at some places on the hill southeast of the village a third, less conspicuous set is present above the upper of the two prominent ones.

On the western side of the village, massive, buff to gray dolomites are artificially exposed in the abandoned L. Seaman Quarry, excavated in the lowest terrace. As pointed out by R. A. Smith (1916, p. 207-208) and I. C. Russell (1905, p. 47, pl. 4), these dolomites are cut by vertical fractures or joints, which cross one another nearly at right angles. The intersection of these joints with the bedding-planes causes the dolomite to readily separate into rectangular blocks of considerable size. When the quarry was being worked many years ago, blocks were taken out for use in constructing the earlier ship canals at Sault Ste. Marie and in building breakwaters and piers on the Great Lakes. The following section is exposed in the quarry and in the bluffs above the quarry.

Section of strata exposed in L. Seaman Quarry and higher bluffs at Drummond, Chippewa County, Locality 91

		Thickness Feet	Inches
	Manistique Dolomite		
	Schoolcraft Member		
11	Lower Pentamerus dolomite. Massive, coarsely crystalline, buff-gray dolomite, containing poorly preserved molds of the shells of Pentamerus. Weathers into layers 3" to 6" thick.....	8	
	Stromatoporoid Syringopora ? cf. S. (?) tenella Pentamerus oblongus		
	Burnt Bluff Limestone and Dolomite		
	Hendricks Member		
10	Dolomite, thick-bedded, coarsely crystalline, buff. This dolomite is very similar to that above. Further paleontologic and stratigraphic studies may show that this dolomite should be included in the Schoolcraft Member of the Manistique.....	6	
9	Dolomite, massive, buff and somewhat cherty, containing few silicified corals and stromatoporoids and showing a thinner, very irregular bedding on weathering.....	5	
8	Covered.....	28	
7	Dolomite, massive, buff to brown, coarsely crystalline with cavities formed by solution of simple and compound corals.....	4	
6	Dolomite, gray to buff-gray, finely crystalline and laminated.....	4	
5	Covered.....	25	
4	Dolomite, thick-bedded, buff to buff-gray and cherty. Weathered surface nodular. Dolomite exposed at the top of quarry.....	3	6
	Clathrodictyon vesiculosum minutum Clathrodictyon sp. - dumose form Streptelasma ? sp. Simple coral - small form Favosites - 2 new species, characteristic of Hendricks strata Camarotoechia winiskensis Camarotoechia cf. C. winiskensis var. Colpomya ? sp. Diaphorostoma ? sp.		
3	Dolomite, finely crystalline, laminated, with few cavities apparently formed by solution of corals and stromatoporoids and with few geodes of calcite. Most beds buff or buff-gray. Some beds have filled "sun cracks" or dessication fissures.....	26	6

		Feet	Inches
2	Dolomite, darker buff than beds above and finely to coarsely crystalline. Near the center of the bed are numerous cavities formed by solution of stromatoporoids and corals.....	3	6
	Fucoids Stromatoporoids - indeterminable Favosites n. sp. - a characteristic Hendricks form Orthoceras ? sp.		
1	Dolomite, finely crystalline and laminated. Most beds gray to bluish-gray, a few beds buff-gray.....	8	6
		122	

The base interval 1 of this section is the quarry floor, which is about 6½ feet above the nearby shore of Potagannissing Bay. The few exposures, which are present between the shore and the quarry, consist of dolomites exactly similar to those of interval 1, thus indicating that this interval has a thickness of at least 15 feet.

Interval 4 of the above section is without doubt the same as interval 5 of Smith's section, described by him on page 208 of Publication 21, Michigan Geological and Biological Survey (1916) and the "middle nodular layer" (interval 9) of Ver Wiebe's section, described on page 326 of volume 3 of the "Papers of the Michigan Academy of Science, Arts and Letters" (1928).

The presence of Pentamerus-bearing beds in the basal part of the Manistique is noted in the sections of Smith and Ver Wiebe. According to Ver Wiebe's section, "lower and upper Pentamerus layers," corresponding to the present writer's lower and upper Pentamerus dolomites, are present in the bluffs above the top of the quarry. The section given by Smith, also notes the occurrence of two Pentamerus-bearing beds. Whether these beds correspond to my lower and upper Pentamerus dolomites, however, cannot be ascertained from Smith's description of this section.

The section given above by the writer notes the presence of the lower Pentamerus dolomite but not the upper Pentamerus dolomite. The upper Pentamerus dolomite may be present in the bluff, as stated by Ver Wiebe. The writer, however, did not find an unquestioned exposure of this dolomite in the bluffs above the top of the quarry. Blocks of a massive, buff Pentamerus-bearing dolomite were found by him at the base of a bluff containing ledges of similar dolomite. In the field the writer believed that these blocks had fallen from the ledges of the bluff. It is quite possible that the writer was mistaken in this belief, the apparently fallen blocks therefore representing the lower Pentamerus dolomite and the ledge above, the upper Pentamerus dolomite.

LOC. 92. About three-quarters of a mile southwest of the L. Seaman Quarry is another abandoned quarry, which is excavated in Hendricks strata.

The lithological character and thicknesses of the strata in this quarry are noted in the following section.

Section of strata exposed in quarry, three-quarters of a mile southwest of the L. Seaman Quarry, Locality 92

		Thickness Feet	Inches
	Burnt Bluff Limestone and Dolomite		
	Hendricks Member		
8	Dolomite, massive, buff and somewhat cherty, containing few silicified corals and stromatoporoids and showing a thinner, very irregular bedding on weathering.....	6	
	Stromatoporoid - indeterminable Simple corals - 2 inch in length and ¼ inch in width at calyx Favosites n. sp. - a typical Hendricks form Halysites sp. Crinoid columnals		
7	Dolomite, thick-bedded, buff, finer crystalline than dolomite above and showing laminations on weathered		

		Feet	Inches
	surface	4	
6	Covered	6	
5	Dolomite, similar to that of interval 8. Base not sharply separated from top of underlying dolomite	6	
	Simple corals - similar to those of interval 8. Favosites n. sp. - a typical Hendricks form Syringopora ? sp.		
4	Dolomite, massive buff and laminated	9	
3	Dolomite, massive, buff to brown, coarsely crystalline with cavities formed by solution of simple and compound corals, most of the cavities are present in upper 1½ feet	7	
	Simple coral - similar to those of intervals 5 and 8 Streptelasma ? sp. Halysites sp. Orthoceras ? sp. Leperditia aff. L. whiteavesi		
2	Dolomite, gray, finely crystalline and laminated with filled "sun-cracks" or dessication fissures	6	
1	Dolomite, buff to brown, finely to coarsely crystalline	15	
		59	

The relationship of the strata of this quarry to those in the L. Seaman Quarry may be recognized by comparing the sections. The dolomite of interval 8 is the same as that of interval 9 of the Seaman Quarry. The lower 4 feet of dolomite of interval 3 are represented in the Seaman Quarry by interval 7. The upper 4 feet of dolomite of interval 2 are also exposed in the Seaman Quarry as interval 6. The lower 2 feet of dolomite of interval 2 and all of the dolomite of interval 1, totalling 17 feet, are not exposed in the Seaman Quarry, but with little doubt are represented in covered interval 5 of this quarry. From these comparisons it is obvious that the strata of the quarry section described above, occupy a position in the Seaman Quarry section between the top of interval 9 and a point approximately 17 feet below the top of interval 5.

In his paper on the stratigraphy of Chippewa County, Van Wiebe (1928, p. 322-324, 326) describes a conspicuous bed in the Burnt Bluff Formation as the "middle nodular layer" and indicates that this bed is present in the two quarries discussed above. The "middle nodular layer" of the Seaman Quarry, which is the dolomite noted as interval 4 of the present writer's section of this quarry, is not the "middle nodular layer" of the quarry located three-quarters of a mile southwest of the Seaman Quarry. As the result of a southwesterly dip, the "middle nodular layer" of the Seaman Quarry occupies a lower and lower topographic position in passing southwestward from this quarry and fails to appear in the quarry three-quarters of a mile to the southwest. It is probably present less than 10 feet below the lowest bed exposed in the floor of this quarry.

In his section of the quarry three-quarters of a mile southwest of the L. Seaman Quarry, Ver Wiebe (1928, p. 323) noted the occurrence of the "upper Pentamerus layer" of the Manistique. This layer, which is the same as the present writer's upper Pentamerus dolomite, was also observed by the writer in the woods at the top of the hill, a considerable distance east of the top of the quarry. At several places on the hill and at lower elevations the writer also found exposures of the lower Pentamerus dolomite of the Schoolcraft member of the Manistique.

LOC. 93. Hendricks strata are exposed in an abandoned lime kiln quarry, located on the shore of Potagannissing Bay a little less than 1 mile northeast of Drummond village. In the following section beds are described which are present in the quarry and in bluffs above the quarry, the highest beds being exposed about ½ mile southeast of the quarry.

Section of strata exposed in abandoned lime kiln quarry and vicinity, about 1 mile northeast of Drummond, Locality 93

		Thickness Feet	Inches
	Manistique Dolomite		
	Schoolcraft Member		
9	Upper Pentamerus dolomite	2	

8	Dolomite, thin even-bedded, gray to buff-gray and finely crystalline.....	6	
7	Lower Pentamerus dolomite..	8	

Burnt Bluff Limestone and Dolomite

Hendricks Member

6	Dolomite, buff and coarsely crystalline	2	
5	Covered.....	55	
4	Dolomite, buff to buff-gray, finely crystalline and laminated. Top of quarry is at top of interval.....	14	
3	Dolomite, similar to that above except for the presence of cavities, which are particularly abundant in bands 9 inches to 1 foot thick near the top and bottom of the bed. Dolomite contains few, poorly preserved simple corals and stromatoporoids.....	4	9
2	Dolomite, similar to that of interval 4.....	4	6
1	Covered - from quarry floor to shore of Potagannissing Bay.....	20	
		116	3

A smaller thickness of Hendricks strata is noted in this section than in the section of this quarry, described by Ver Wiebe (1928, p. 321). Many beds occupying positions within covered intervals 1 and 5 of the writer's section are exposed along the shore and in bluffs between the lime kiln and L. Seaman Quarries. These beds are probably included in Ver Wiebe's section and as a result his section shows a greater thickness of exposed Hendricks strata than mine.

LOC. 94. In his paper on the stratigraphy of Chippewa County, Ver Wiebe (1928, p. 325) notes the occurrence of 56 feet of Burnt Bluff strata on the Victor Hilden Ranch, located in the NW$\frac{1}{4}$ sec. 26, T 42 N, R 6 E, about 4$\frac{1}{2}$ miles east of Drummond village. According to his description of the section, the Burnt Bluff strata at this place are overlain by 22 feet of Manistique beds, the uppermost bed being the Upper Pentamerus dolomite.

LOC. 95. A very fine exposure of Hendricks strata is shown along the lake shore and in the bluff at Marblehead on the eastern side of Drummond Island. The following section includes all of the strata outcropping in the bluff itself, in a small, abandoned quarry at the base of this bluff and along the shore from this quarry to a point about 1$\frac{1}{2}$ miles to the northwest.

The general dip of the strata at Marblehead is in a southerly to southwesterly direction. A few small and very local reversals in dip may be seen along the shore in walking northwestward from the old quarry; one of these reversals in dip is the result of deposition of dolomites on the sides of a small stromatoporoid reef. As the result of the general southerly to southwesterly dip of the beds, lower and lower strata appear along the shore in passing northwestward from the abandoned quarry.

Section of strata exposed at Marblehead, Drummond Island, Locality 95

		Thickness Feet	Inches
	Manistique Dolomite		
	Schoolcraft Member		
30	Covered, loose slabs of thin-bedded, buff dolomite on surface, probably derived from thin soil-covered ledge..	20	
29	Upper Pentamerus dolomite, massive, coarsely crystalline, light-brown dolomite, containing numerous molds of Pentamerus and few Favosites and stromatoporoids. On weathering dolomite shows thinner, uneven-bedding.....	8	
28	Dolomite, thin-bedded, light-gray and finely crystalline.....	3	
27	Covered, most of this interval probably consists of thin-bedded light gray, finely crystalline dolomite.....	15	
26	Lower Pentamerus dolomite similar to upper Pentamerus dolomite described above....	9	

		Feet	Inches
	Burnt Bluff Limestone and Dolomite		
	Hendricks Member		
25	Dolomite, thick-bedded, brownish-gray, interbedded with several chert layers 1 to 3 inches thick and containing poorly preserved remains of Favosites and stromatoporoids.	10	8
24	Dolomite, very light gray, in beds 2 to 4 inches thick.....	2	2
	Camarotoechia sp.		
23	Dolomite, massive, brownish-gray with cavities possibly formed from solution of fossils.	2	
22	Dolomite, brownish-gray, in layers 3 to 4 inches thick.....	2	6
21	Covered.....	5+	
20	Dolomite, very coarsely crystalline, brownish-gray with sandy feel. Highest bed in abandoned quarry.....	2	3
19	Dolomite, massive, cream-colored to very light brownish-gray. Upper $1\frac{1}{4}$ feet more crystalline, somewhat darker gray in color with irregularly shaped, yellowish-gray areas. Few silicified specimens of a small simple coral and Favosites.....	7	6
18	Dolomite, massive, finely-crystalline, varying in color from very light gray to very light brownish-gray.....	4	10
17	Dolomite, massive, predominately light-gray with some bands more brownish-gray. In a 2 foot band about 10 inches above base, limestone weathers into layers $\frac{1}{4}$ to $1\frac{1}{2}$ inches thick.....	6	4
16	Dolomite, massive, coarsely crystalline, brownish-gray to brown. Weathered surfaces appear sandy and show indistinct laminations.....	1	9
15	Dolomite, massive, cream-colored, with earthy feel. Lowest bed of abandoned quarry.....	1	3
14	Covered.....	10+	
13	Magnesian-limestone, much lighter gray than that below, more coarsely crystalline and without areas of yellowish, crystalline dolomite.....		10
12	Magnesian-limestone, dark-gray, very finely crystalline, almost lithographic, with areas of yellowish crystalline dolomite.....	1	10
11	Magnesian-limestone, massive, crystalline, and very light gray. On weathering, rock splits into layers $\frac{1}{4}$ to $1\frac{1}{2}$ inches thick.....	2	6
10	Magnesian-limestone, dark-gray, lithographic in texture, with irregular masses of chert and numerous irregularly digitate areas of yellowish crystalline dolomite.....	6	4
	Actinostroma ? sp. Clathrodictyon vesiculosum var. Streptelasma ? sp. Lyellia sp. Favosites n. sp. - hemispheric, closely tabulated, characteristic Hendricks form Halysites sp. Rhynchospira lowi		
9	Dolomite, very light gray to cream-colored, finely crystalline and laminated. On weathering, dolomite splits into thin slabs 1/8 to $\frac{1}{4}$ inch thick.....	5	6
8	Dolomite, finely crystalline, light-gray to buff, with a distinct conchoidal fracture, and metallic sound when struck with hammer.....	4	
7	Limestone, dark-gray, lithographic, high in $CaCO_3$ and containing gashes. Lowest 10 inches has very few gashes,		

		Feet	Inches
	and numerous shells of Stropheodonta (Brachyprion) and Leperditia. Overlying 6 to 8 inches of limestone has many small, irregularly shaped cavities, more numerous gashes and some specimens of Stropheodonta (Brachyprion) sp. Above this is a layer 1 foot thick containing the same brachiopod and exhibiting a very white surface. The succeeding limestone is conspicuous on account of its large gashes, $\frac{1}{2}$ to 1 inch in length, and white surface. It contains dumose stromatoporoids which produce low dome-like reefs in the rock from 1 to 3 feet in diameter.....	3	6
	Clathrodictyon sp. - dumose form, probably new Stropheodonta (Brachyprion) sp. - probably new Camarotoechia sp. no. 1 Camarotoechia cf. C. winiskensis var. Rhynchospira lowi Leperditia aff. L. caeca and L. whiteavesi Leperditia aff. L. hisingeri egena		
6	Dolomite, argillaceous very light gray to very light brownish-gray, with conchoidal fracture and earthy feel. Some of the light-gray beds contain numerous remains of Camarotoechia and Pterinea sp.....	5	6
	Simple coral - indeterminable Camarotoechia sp. Glassia sp. cf. G. variabilis Rhynchospira lowi Ctenodonta ? sp. Cyrtodonta ? sp. Pterinea occidentalis Pterinea sp. Trilobite - part of free cheek Leperditia aff. L. hisingeri egena		

		Feet	Inches
	Leperditia aff. L. caeca and L. whiteavesi		
5	Dolomite, poorly exposed at intervals along shore and in hillside. Some beds are argillaceous and others non-argillaceous and finely crystalline. The color of the beds varies from light-gray to light buff-gray. Most of the beds are laminated or split into thin slabs on weathering; a few are massive and have a conchoidal fracture.....	20+	
4	Limestone, consisting of dark-gray, highly calcareous areas and yellowish, irregularly shaped areas of crystalline dolomite. Gashed layers, 6 to 8 inches thick, are present near middle and at the top. Upper 2 feet have few irregularly shaped areas of crystalline dolomite but as a whole seem more dolomitic and are more distinctly bedded. Few remains of poorly preserved pelecypods.....	5	
3	Magnesian-limestone, earth and light-gray. Lower third contains numerous dessication fissures or "sun cracks," and weathers into thin slabs $\frac{1}{4}$ to 1 inch thick. Upper two-thirds is thicker-bedded, has a conchoidal fracture and is cut by numerous closely spaced joints. This part has remains of Leperditia cf. L. fabulina and Hormotoma sp.....		8
2	Magnesian-limestone, light brownish-gray containing numerous irregularly shaped cavities. Resembles weathered mortar and crumbles readily.....		1
1	Dolomite, very light gray, earthy, having numerous "sun cracks" and some ripple marks. On weathering, the dolomite splits into thin slabs $\frac{1}{4}$ to 1		

	Feet	Inches
inch thick. Base not seen....	5	
	172	11

This section is of considerable interest in showing the existence of several beds of limestone and magnesian-limestone. The purest limestone is that of interval 7. It was described by Rominger (1873, p. 33, 48) as an ash-colored, fine-grained, acicular limestone and subsequently noted by Smith (1916, p. 207) as interval 10 of his Marblehead section, which he constructed from Rominger's description of the strata at this place. Another very pure limestone is that of interval 4. It probably is a part of the limestones described by Rominger (1873, p. 35, 36, 48) as "light-colored absorbent limestones, separating in thin slabs, with uneven conchoidal surface" and noted by Smith (1916, p. 207) as interval 13 of his section. The magnesian-limestones of intervals 10, 11, 12, and 13 of the section described above are fairly high in calcium-carbonate. The limestone of interval 10 would undoubtedly show a very high percentage of calcium-carbonate, if the included chert and irregularly digitate masses of dolomite were removed.

Smith (1916, p. 154) pointed out that the ash-colored, fine-grained, acicular limestone of Rominger's section (= interval 7 of the writer's section and 10 of Smith's section) may possibly be the diminished representative of the Fiborn Limestone. From his observations at Marblehead, however, the present writer is convinced that the ash-colored limestone does not resemble the Fiborn except in chemical composition, and, furthermore, is not the much thinned Fiborn, but a limestone occupying a lower position in the Hendricks Member than the Fiborn.

In his paper on the stratigraphy of Chippewa County, Ver Wiebe (1928, p. 324) indicates that the Fiborn Limestone is probably represented at Marblehead by the ash-colored limestone and the next two underlying beds of Rominger's section (intervals 11 and 12 of Smith's section).

In the writer's opinion, the Fiborn is not present at Marblehead nor at other places on Drummond Island. This limestone occupies a position in the upper part of the Hendricks Member and is not very far below the lower Pentamerus dolomite of the Schoolcraft member of the Manistique. On Drummond Island its position is taken by buff to buff-gray dolomites. These dolomites may be the dolomitic equivalents of the Fiborn, but on account of their lithologic similarity to many other strata of the Hendricks, it is impossible to tell which beds of dolomite represent the Fiborn.

Ver Wiebe (1928, p. 322, 323, 326) erroneously identified certain beds in the quarries near Drummond village as limestones and doubtfully assigned them to the Fiborn. Samples taken from these beds by Ver Wiebe have been examined by the writer. Their failure to effervesce with cold dilute hydrochloric acid indicates that they are dolomites instead of limestone. These finely crystalline dolomites do not represent the Fiborn Limestone; in the writer's opinion they occupy a lower position in the Hendricks than this limestone.

LOC. 96. Burnt Bluff strata are exposed along much of the shore of Drummond Island between Pilot Harbor (also known as Pirate Harbor), located $3\frac{1}{2}$ to 4 miles northwest of the abandoned quarry at Marblehead, and Glen Point, situated about $1\frac{1}{2}$ miles in a straight line to the northwest of Pilot Harbor. They consist of light-gray to light buff-gray, thin-bedded and laminated dolomites. Some are finely-crystalline and non-argillaceous; others have an earthy feel and are argillaceous. Many of the beds have dessication fissures or "suncracks." All of the dolomites occupy a position below the lower bed of the Marblehead section and in the writer's opinion belong to the Byron Member of the Burnt Bluff Formation.

Correlation and faunal relationships of the Burnt Bluff Limestone and Dolomite. -- The Byron beds of the Burnt Bluff Limestone and Dolomite of the Northern Peninsula are a northward continuation of the Byron beds of Wisconsin.

The exceeding rarity of organic remains in the Byron beds indicates that the Byron sea was inhospitable to most forms of marine life. This inhospitable character of the sea may be attributed in large part to its shallowness and to the frequent exposure of its bottom to the air, as indicated by the presence of "sun cracks" in numerous beds of the Byron Member.

Ostracods are nearly the only evidence of former life in the Byron sea. Leperditia fonticola Hall, the only species described from the

FIG. 1 - Lower Mayville, small quarry N of Manistique Lake. Near Locs. 18 and 19. (Later, Manitoulin Dolomite.)

FIG. 2 - Bioherm in lower Mayville, 3/4 mile SW of Scott's, NW side of Drummond Island. Near Loc. 22. (Later, Manitoulin Dolomite.)

FIGS. 3, 4 - Bioherm in lower Mayville, 3/4 mile SW of Scott's. NW side of Drummond Island. Loc. 22. (Later, Manitoulin Dolomite.)

Byron strata of Wisconsin, seems to be more closely related to the Baltic type of Leperdita hisingeri Schmidt than to the Canadian form referred to this species by Jones. In a communication to the writer, Dr. E. O. Ulrich states that he has found another ostracod in the Byron beds of Wisconsin which is indistinguishable from the form identified by Jones (1891, p. 82, 83) as Leperdita hisingeri var. gibbera.

The occurrence of Leperdita hisingeri var. gibbera in the Byron beds is of considerable stratigraphic significance. The type of this ostracod was collected from the Silurian strata of Long Point, Lake Winnepegosis, Canada, where it was found in association with Leperdita hisingeri Jones (not Schmidt), Leperdita fabulina Jones, and Isochilina latimarginata Jones. The three last-mentioned ostracods are also found in the Hendricks strata of the Northern Peninsula, thus showing that the Hendricks and Byron beds are faunally related.

The writer believes that the Hendricks strata are very likely represented in northeastern Wisconsin by some or all of the "Transition beds" and the lower strata of the "Lower coral beds" of Chamberlin. This belief is based in large part on the similarity in stratigraphic position of the Hendricks and the Wisconsin strata.

The presence of Trimerella in the Lower Coral beds of Wisconsin suggests very strongly that the trimerellid beds of the Hendricks continue into Wisconsin. A form, which Chamberlin noted as Trimerella res. T. grandis, was reported by him (1878, p. 350) as occurring in the Lower Coral beds in the "railroad cut, section 2, Ashford," a locality about 2 miles northwest of Campbellsport, Fond de Lac County, Wisconsin. Specimens, which either served as the basis for this identification or were obtained by other workers from the Lower Coral beds at this locality, are preserved in the Greene Museum of the Milwaukee-Downer College at Milwaukee, Wisconsin. These specimens resemble Trimerella grandis but more probably belong to an undescribed, closely related species. In the writer's opinion they are indistinguishable from some of the forms of Trimerella found a short distance below the limestone of the Hendricks Member, designated as the Fiborn by R. A. Smith.

In a communication to the writer Doctor Foerste states that the cephalopod noted by Chamberlin (1878, p. 350) as occurring in the Lower Coral beds of the Ashford railroad-cut and designated as Discosorus conoideus, is not a Discosorus but a Stokesoceras. This specimen of Stokesoceras, which apparently was described and figured by Whitfield (1882, p. 299, pl. 20, fig. 6), may prove to be more closely related to Hendricks species of this genus than to Manistique ones. In this event, further evidence would be available in support of the continuation of the Hendricks Trimerella-bearing beds into Wisconsin.

A dolomite containing numerous remains of Pentamerus is shown in a railroad cut of section 11, Ashford Township, about one-half mile southeast of the Trimerella-bearing dolomite, exposed in the cut of the same railroad in section 2, Ashford Township, Fond du Lac County, Wisconsin, and occupies a stratigraphic position probably less than 40 feet above the Trimerella-bearing dolomite. The fact that the lower Pentamerus dolomite of the Schoolcraft Member of the Manistique is about the same distance above the highest trimerellid bed of the Hendricks Member leads the writer to believe that the Pentamerus-filled dolomite in the railroad cut at the Wisconsin locality may represent a continuation of the lower Pentamerus dolomite of the Schoolcraft Member. If this belief is substantiated by further study, it is very logical to suppose that the trimerellid beds of the Ashford railroad cut are also a continuation of the Trimerella-bearing strata of the Hendricks.

On account of the fact that the Hendricks fauna has been traced almost to Wisconsin, the writer feels confident that the existence of this fauna in the Niagaran rocks of northeastern Wisconsin will eventually be demonstrated. A restudy of the fauna of the trimerellid beds in the railroad cut at section 2, Ashford, and further collecting from the Lower Coral beds below the Pentamerus-filled dolomite and from the Transition beds, should result in the discovery of many characteristic species of the Hendricks strata.

The writer is opposed to the application of the name Waukesha to the Upper and Lower Coral beds of northeastern Wisconsin as suggested by Ulrich (1924, p. 82) and by Ulrich & Bassler (1923, p. 267). This opposition is based on the strong probability that some of the

Lower Coral beds contain the Hendricks fauna, which is quite different from the fauna of the typical Waukesha. Until it can be demonstrated that the typical Waukesha fauna is present in all of the strata of the Lower Coral beds in northeastern Wisconsin, the writer would not apply the name Waukesha to them.

The Burnt Bluff strata have not been recognized on Cockburn and Manitoulin Islands, Lake Huron, or on the Ontario mainland to the southeast of Manitoulin Island.

There is good reason, however, for believing that some of the Burnt Bluff strata must be present on Cockburn and Manitoulin Islands. On the eastern side of Drummond Island there are 150 to 200 feet of Burnt Bluff strata, and at Marblehead, which is only 3 to 4 miles west of Cockburn Island, characteristic Hendricks fossils are present in several beds of a section consisting of about 118 feet of Hendricks dolomites and limestones. In view of the fact that many of the Burnt Bluff strata are remarkable for their continuity across the eastern half of the Northern Peninsula, the writer feels certain that some of the 150 to 200 feet of Burnt Bluff strata underlying the eastern part of Drummond Island must continue eastward to Cockburn and Manitoulin Islands. In the writer's opinion some of the Burnt Bluff strata must be represented on these islands by some of the "undivided Lockport" dolomites of M. Y. Williams (1919, p. 60), occupying a position below the Fossil Hill coral horizon of the "undivided Lockport."

The Hendricks fauna is unquestionably related to the fauna of the Severn River Limestone of the Hudson Bay region. From the Hendricks strata the writer has collected remains of Camarotoechia ? winiskensis Whiteaves, Glassia variabilis Whiteaves, Pterinea occidentalis Whiteaves, Rhynchospira lowi Whiteaves, Isochilina latimarginata (Jones), and Leperditia fabulina Jones, representatives of which have been reported as occurring in the Severn Limestone by Savage & Van Tuyl (see table 2). Some of the specimens of Trimerella in the Hendricks strata are closely related to or are identical with Trimerella ekwanensis Whiteaves, which Savage & Van Tuyl list from both the Severn River and Ekwan River limestones and from the still higher Attawapiskat coral reef. It is the writer's belief that the similarity in the faunas of the Hendricks and Severn River Limestone will be even more evident when all of the fossils from these deposits are identified and compared.

The writer can see no reason for placing the Severn River Limestone in the Alexandrian Series, as has been done by Savage & Van Tuyl in 1919 (1919, p. 341, 342, 359-362, 367, 368) and by Savage in 1926 (1926, p. 533). After looking over the lists of fossils reported as occurring in the Severn Limestone by Savage & Van Tuyl (see table 2), the writer can find the name of only one species which occurs in the typical Alexandrian rocks of southern Illinois and Missouri. This species is identified provisionally with the brachiopod Schuchertella curvistriata Savage. This seems insufficient evidence.

The occurrence in the Severn River Limestone of two brachiopods identified by Savage & Van Tuyl (1919, p. 359-362) as Stropheodonta cf. philomela and cf. Whitfieldella julia, may have caused these writers to include the Severn River Limestone in the Alexandrian. According to Twenhofel (Twenhofel, 1928, p. 87, 189), Stropheodonta philomela (Billings) (= Brachyprion philomena Twenhofel) occurs in zones 3 and 4 of the Gun River Formation of the Anticostian Series and in zones 1 to 10 of the Jupiter Formation of the Niagaran Series of Anticosti Island. Whitfieldella julia (Billings), according to this writer (Twenhofel, 1928, p. 90, 221), is present in zone 4 of the Gun River Formation and zones 2 and 5 to 10 of the Jupiter Formation of this island. The fact that Schuchert & Twenhofel (1910, p. 684) thought that the Edgewood Formation of the Alexandrian Series should be correlated provisionally with the Gun River Formation, which contains remains of Strophodonta philomela and Whitfieldella julia, may have influenced Savage & Van Tuyl to assign the Severn River Limestone to the Alexandrian Series. Furthermore, Savage & Van Tuyl's position would seem to be supported by Twenhofel's recent statement (1928, p. 73) that the "lower two-thirds of the Gun River Formation contains the Anticosti equivalent of the Alexandrian series of Illinois, the Brassfield of Ohio and the Cataract formation of Ontario." There is stronger evidence, however, for believing that Stropheodonta philomela and Whitfieldella julia have no value as indicators of the Alexandrian age of the Severn Limestone. The lowest occurrence of Whitfieldella julia on Anticosti Island is in zone 4 of

FIG. 5 - Core rock of bioherm in lower Mayville, Stevenson's, Drummond Island. Loc. 25. (Later, Manitoulin Dolomite.)

FIG. 6 - Virgiana beds of Mayville, near old lime kiln, Lime Island. Loc. 27. (Later, type locality of Lime Island Dolomite.)

FIG. 7 - Mayville strata, roadside ditch E of Moss Lake. Loc. 5. (Later, type locality of Moss Lake Formation.)

FIG. 8 - Virgiana beds of Mayville, near old lime kiln, Lime Island. Loc. 27. (Later, type locality of Lime Island Dolomite.)

the Gun River. According to Twenhofel (1928, p. 73), this zone contains lower Clinton fossils and may represent the Sodus Shale, Furnaceville ore bed, and Walcott Limestone of the New York Clinton. Although present in a lower zone -- zone 3 of the Gun River -- Stropheodonta philomela may occur sufficiently high in the Gun River to be associated with Clinton fossils. Furthermore, if the entire Gun River Formation is of Clinton age, as believed by Ulrich & Bassler (1923, p. 369), then no part of the Gun River can be correlated with the Alexandrian, and, consequently Stropheodonta philomela and Whitfieldella julia must be considered as being of Clinton age. The Clinton age of these brachiopods is greatly supported by their occurrence in most of the zones of the Jupiter, which contains an undoubted Clinton fauna.

The assignment of the Hendricks strata and its included Fiborn Limestone to the Alexandrian Series by Savage & Crooks (1918, p. 61-64) may also have led Savage & Van Tuyl to incorrectly place the Severn limestones in the Alexandrian Series. According to Savage & Crooks the Hendricks and Fiborn beds contain the Alexandrian species Schuchertella cf. propinqua (Meek & Worthen), Atrypa putilla (Hall & Clarke), Homeospira subcircularis ? Savage, and Cyclonema cf. daytonensis Foerste, in addition to Camarotoechia ? winiskensis Whiteaves, Isochilina latimarginata (Jones), and Leperditia fabulina Jones, which as shown above are characteristic of the Severn River Limestone. In the writer's opinion the Alexandrian age of the Hendricks and Fiborn is not demonstrated by Savage & Crooks' identification of the four supposed Alexandrian fossils. Two of these fossils, Schuchertella cf. propinqua (Meek & Worthen) and Cyclonema cf. C. daytonensis Foerste are provisionally identified with Alexandrian species, and a third, Homeospira subcircularis ? Savage is doubtfully thought to be this Alexandrian form. Atrypa putilla (Hall & Clarke), the only form definitely identified with an Alexandrian species is most probably not this species but Rhynchospira lowi Whiteaves. A general similarity in structure between Rhynchospira lowi Whiteaves, which is abundant in the Hendricks strata, and Atrypa putilla (Hall & Clarke), at first led the writer to believe that the Hendricks specimens belonged to Atrypa putilla (Hall & Clarke). On closer examination, however, he was convinced that the Hendricks specimens belong to Rhynchospira lowi Whiteaves. In the course of his study of the Hendricks fossils the writer has not found a single form which can be unquestionably identified with known Alexandrian forms. The lack of any paleontological evidence in support of the Alexandrian age of the Hendricks consequently proves that the faunally related Severn River Limestone is not of Alexandrian age.

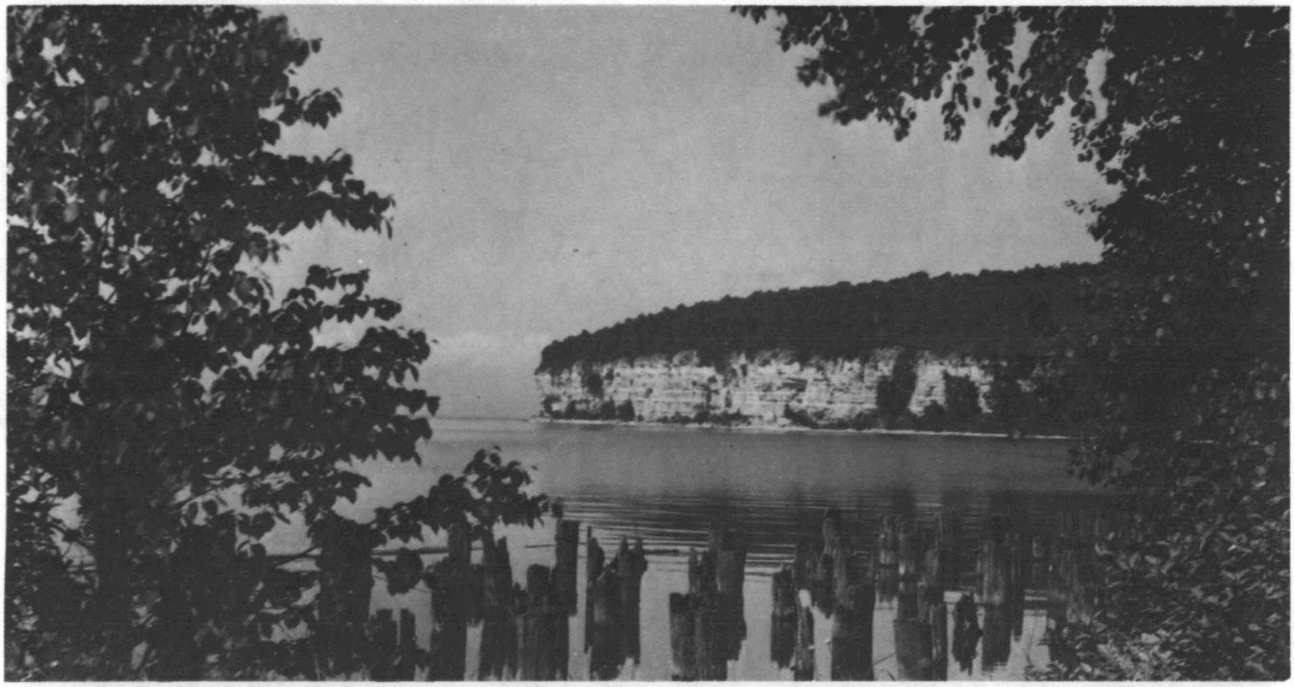
Certain stratigraphic relationships also show that the Burnt Bluff and Severn River formations are younger than the youngest known Alexandrian strata. Both undoubtedly occupy a position above the Virginia mayvillensis bed of the Mayville Dolomite. This bed has been traced from Wisconsin to Manitoulin Island, where it occupies a position above the Cataract strata. Savage's correlation (1926, p. 533) of the Cataract with the Byron beds of Wisconsin, the Burnt Bluff Formation (including Byron beds) of Michigan, and the Severn Limestone of the Hudson Bay region, is obviously incorrect. These Wisconsin, Michigan, and Hudson Bay deposits unquestionably occupy a position above the Cataract, which Savage (1926, p. 533) correctly correlates with the Brassfield Limestone, the youngest known deposit of the Alexandrian series of the Mississippi Valley.

In the writer's opinion all stratigraphic and paleontologic evidence shows that the Burnt Bluff should be assigned to the Clinton Group of the Niagaran Series and should not be considered as a younger formation of the Alexandrian Series. In the writer's discussion of the correlation of the Mayville Dolomite, it was pointed out that Ulrich & Bassler undoubtedly identified Clinton types of ostracods in the Dyer Bay Dolomite, which contains Virgiana mayvillensis. The Clinton age of the Dyer Bay Dolomite, which represents the northeastward continuation of the upper part of the Mayville Dolomite, clearly shows that the Burnt Bluff Formation and its correlates cannot be of Alexandrian age. Doctor Foerste's exceedingly important studies of Silurian cephalopods also show that the Burnt Bluff and Severn River strata are of Clinton age. According to this paleontologist (Foerste, 1929, p. 61) "typical Discosorus is known so far only from the Clinton." Discosorus ehlersi Foerste (see Foerste, 1924, p. 69-71) is present in both Burnt Bluff and Manistique strata. Its occurrence in the Manistique strata, which are of Clinton age, suggests a Clinton age for the Burnt Bluff beds.

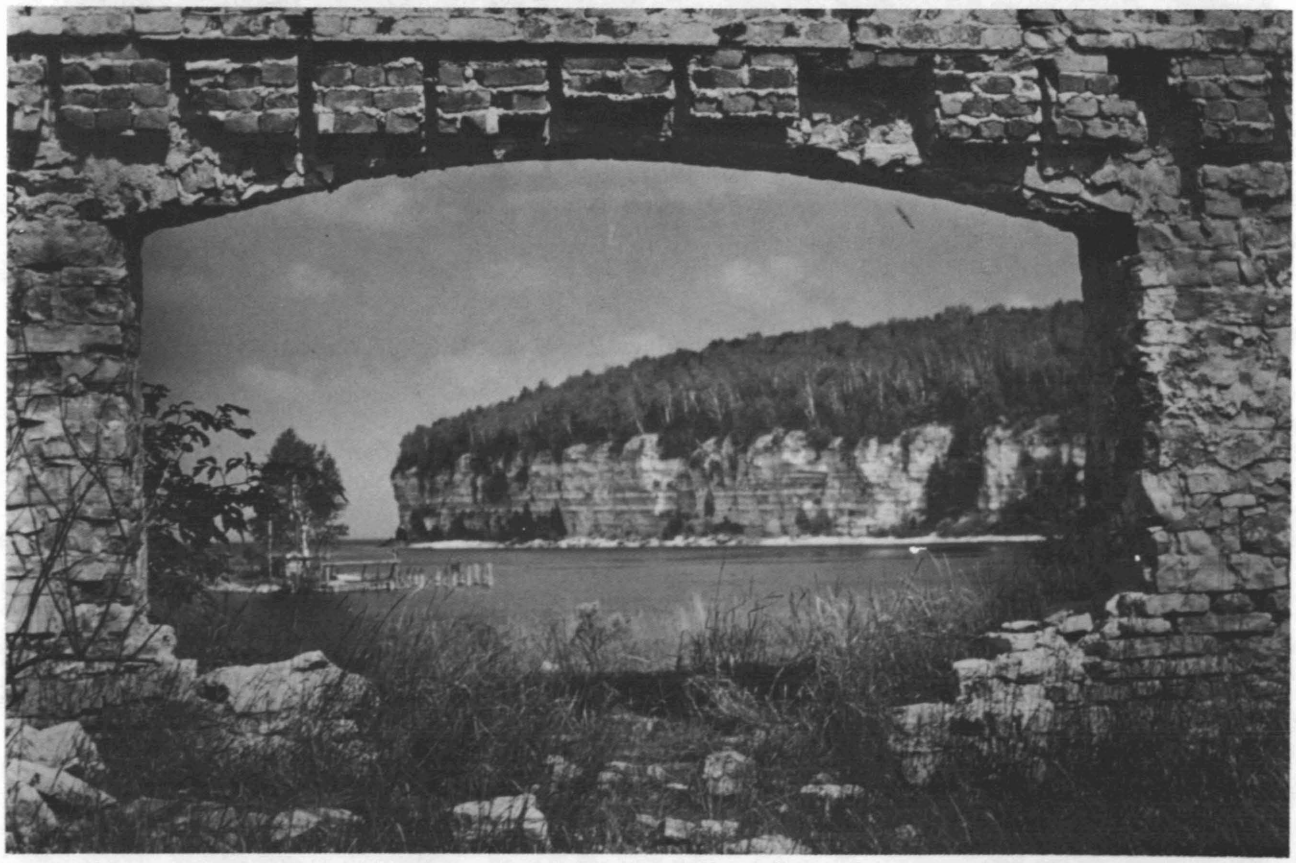
The Clinton age of the Burnt Bluff is also indicated by the occurrence of both Stokesoceras romingeri Foerste and S. engadinense Foerste in the Manistique as well as the Burnt Bluff strata (see Foerste, 1924, p. 77-80, 82-85). Evidence in support of the Niagaran and hence possible Clinton age of the Burnt Bluff Formation is given by the presence in this formation of fossils which are closely related to the Guelph species, Trimerella grandis Billings, Trimerella acuminata Billings, Hormotoma whiteavesi Clarke & Ruedemann, and Coelocaulus macrospira (Hall). If these fossils were not found in association with other Burnt Bluff fossils, one would very probably consider them as variations of the Guelph species and correlate the Burnt Bluff Formation with the Guelph. The fact that they are known to occur below the Guelph and are not exactly like the Guelph species indicates that they are undescribed forms, which were probably ancestral to the Guelph species. The Manistique Formation, overlying the Burnt Bluff strata, contains a Palaeocyclus which is strikingly like the Clinton species P. retuloides (Hall), a Coelospira which closely resembles C. hemispherica (Sowerby), and other fossils of decided Clinton relationships. The occurrence of the Burnt Bluff strata between the Manistique beds with a Clinton fauna, and the Mayville Dolomite with another Clinton fauna, clearly establishes the position of the Burnt Bluff Strata within the Clinton Group.

The fact that the Severn River and Ekwan River Limestones have very similar faunas leads the writer to believe that both limestones should probably be correlated with the Burnt Bluff strata. The similarity between the Severn River and Ekwan River faunas will be recognized by examining table 2, showing the geologic range of the specifically identified fossils listed by Savage & Van Tuyl from the Severn River and Ekwan River limestones. In this table 30 species are listed as occurring in the Severn River Limestone. All of these species are present in the Ekwan River Limestone with the exception of Zaphrentis stokesi ?, cf. Alveolites niagarensis, Schuchertella aff. curvistriata, Clorinda mesoplicata, cf. Whitfieldella julia, Ctenodonta subovata, Pterinea occidentalis, Leperditia hisingeri fabulina, and Leperdita hisingeri variety. Zaphrentis stokesi ?, cf. Alveolites niagarensis, Ctenodonta subovata, and Leperdita hisingeri var., may be represented in the Ekwan River Limestone by forms identified as Zaphrentis stokesi, Alveolites niagarensis, cf. Ctenodonta subovata, and Leperdita hisingeri variety. Of the 30 species listed from the Severn River, only four are therefore definitely restricted to this formation. One of these, Clorinda mesoplicata, may ultimately be found in the Ekwan River Limestone since it is listed as occurring above this limestone in the Attawapiskat coral reef. Fifty-nine (59) fossils are listed from the Ekwan River Limestone. Ten (10) of these, Tyrrellia severensis, cf. Camarotoechia coalescens, Trimerella borealis, Euomphalus minor, Euomphalopterus tyrrelli, Euomphalopteris cf. tyrrelli, Gyronema cf. dowlingi, Actinoceras hearsti, Phragmoceras whitneyi, and Phragmoceras cf. whitneyi are restricted to the Ekwan River Limestone and four (4) Aphyllostylus gracilis, Meristina expansa, Diaphorostoma perforata and Megalomphala robusta, are found only in the Ekwan River Limestone and Attawapiskat coral reef. Twenty-six (26) are common to the Ekwan River and Severn River Limestones. The remaining nineteen (19) fossils are not represented in the Severn River Limestone. Two of the nineteen (19) fossils have been reported as occurring as low as the Richmond (English Head) and two as high as the Helderbergian. Considered as a group, the nineteen (19) fossils represent a Niagaran assemblage. In the writer's opinion, most of the nineteen (19) fossils might readily be included in the fauna of the Severn River Limestone without affecting its geologic age. A further study of the 10 species (4 provisionally identified) restricted to the Ekwan River Limestone, the 4 species restricted to the Ekwan River Limestone and Attawapiskat coral reef, and the specifically unidentified fossils of the Ekwan River Limestone, may show that the faunas of the Ekwan River and Severn River Limestones are not so closely related as would appear from an examination of Savage & Van Tuyl's faunal lists. Until this is done, however, the writer is compelled to believe that the Ekwan River and Severn River Limestones have essentially the same fauna and that both of these limestones should be correlated with the Burnt Bluff strata. This view is supported by the common occurrence in the Ekwan River and Burnt Bluff strata of Amplexus severnensis, Camarotoechia ? winiskensis, Glassia variabilis, Rhynchospira lowi, Hormotoma whiteavesi, Liospira stevensoni, Phragmoceras cf. whitneyi, and Isochilina latimarginata.

In the writer's opinion, Savage (1926, p.



FIGS. 9, 10 - Burnt Bluff strata, cliff at Fayette facing Big Bay de Noc. Loc. 37. Figure 10 seen through ruins of old iron-furnace buildings.



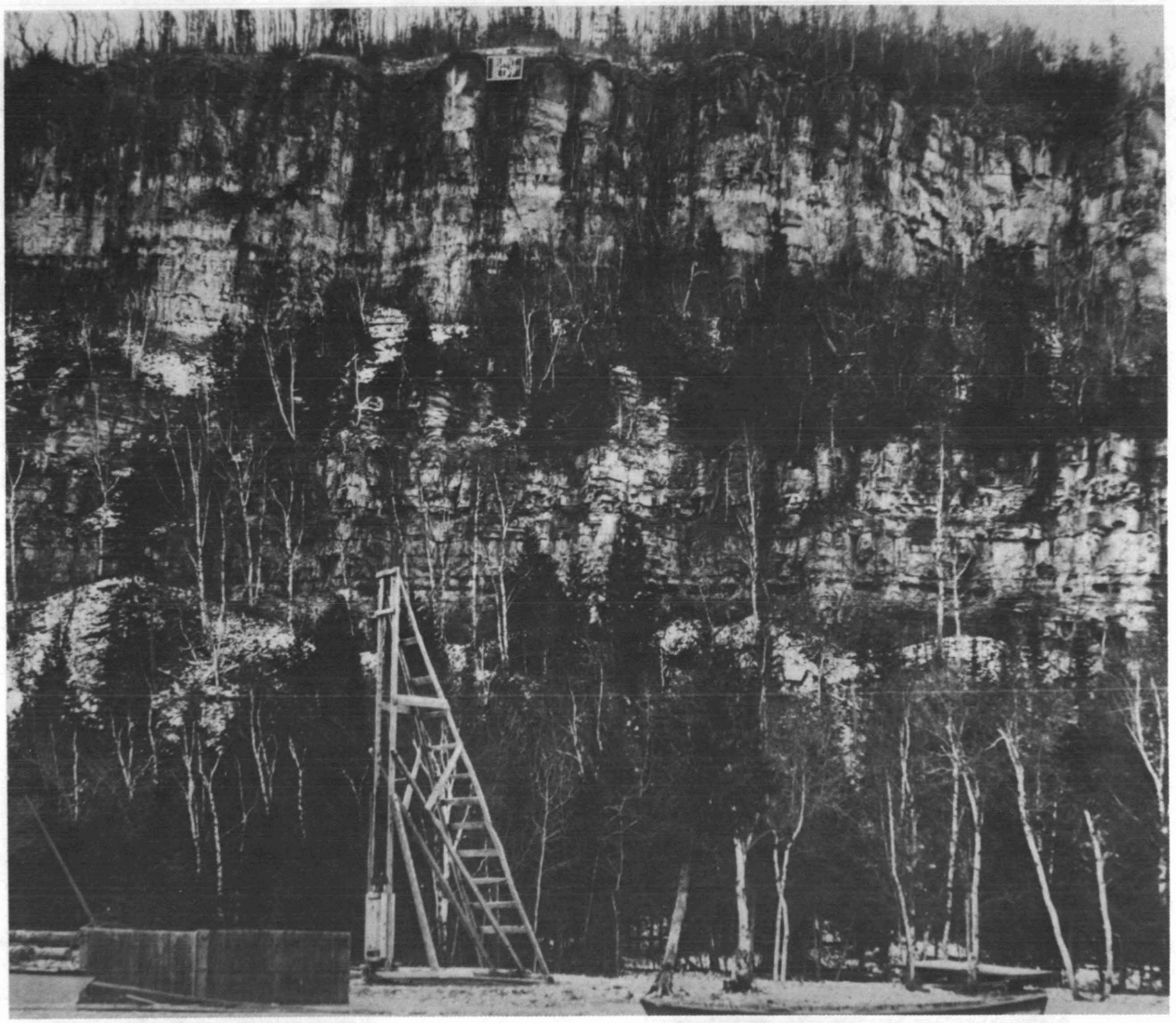


FIG. 11 - Burnt Bluff exposures at the type locality, Burnt Bluff on Garden Peninsula facing Big Bay de Noc. Loc. 36.

533) is incorrect in correlating the Ekwan River Limestone with the Manistique Formation. The only species which have been reported from both of these formations are Alveolites nigarensis, Diphyphyllum multicaule, Favosites favosus, Favosites hisingeri, Halysites catenularia, Paleofavosites aspera, Zaphrentis stokesi, Atrypa reticularis, and Orthis flabellites. All of these species are now considered as long-ranging forms; until they are more finely discriminated, they can be of no value in exact correlation. The only species of the Ekwan River Limestone which suggest a possible faunal relationship between the Ekwan River Limestone and the Burnt Bluff strata are Stokesoceras ekwanense Foerste & Savage, and Stokesoceras cylindratum Foerste & Savage. According to Foerste & Savage (1927, p. 16, 72-74), these species are respectively related to Stokesoceras engadinense Foerste and Stokesoceras romingeri

Foerste, both of which are present in the Burnt Bluff and Manistique strata. A correlation of the Ekwan River Limestone with the Manistique strata on the basis of these specific relationships is not justified, because the Ekwan River species are not identical with Stokesoceras engadinense and S. romingeri and because the two last mentioned species are found in Burnt Bluff as well as Manistique strata. As far as the writer is aware the Ekwan River and Manistique strata do not have a single diagnostic fossil in common.

The writer doubts very much whether the Attawapiskat coral reef should be correlated with the Racine as indicated by Savage (1926, p. 533) and by Foerste & Savage (1927, p. 17-23). According to Foerste & Savage (1927, p. 18) the presence in the Attawapiskat of "... such species as Chicagooceras lingidomum, Cycloceras sinuoliratum, and Ekwanoceras breviconicum suggests approximate contemporaneity with the Racine fauna." These writers (1927, p. 22) also state that "the Attawapiskat limestone is similar to the Racine limestone in containing a considerable variety of species of Phragmoceras and at least one species of Pentameroceras and one of Octameroceras." In addition to these statements supporting a Racine relationship for the Attawapiskat cephalopods, these writers give other evidence indicating a pre-Racine age for the Attawapiskat. They (1927, p. 18) show that Phragmoceras vantuyli of the Attawapiskat Limestone is closely related to Phragmoceras anticostiense from the lower part of the Chicotte, a formation on Anticosti Island which Ulrich refers to the Clinton Group. They also (1927, p. 18) describe the occurrence in the Attawapiskat of a species of Actinoceratidae and state that representatives of this family "are rare in typical Racine faunas but are common in the Burnt Bluff and Manistique in the northern peninsula of Michigan, and are common in the Silurian rocks of Arctic North America, and in the archipelago north of this continent." Furthermore, Foerste & Savage (1927, p. 22) make the very significant statement that the faunal relationships of the Attawapiskat with the Racine "is not close" as shown by the fact that "not one diagnostic cephalopod species is comcon to the Attawapiskat limestone and the Racine." The doubt which these statements raise as to the contemporaneity of the Attawapiskat and Racine faunas is increased by an examination of Savage & Van Tuyl's list of fossils (see table 2) from the Severn River, Ekwan River, and Attawapiskat strata. In this list not a single Attawapiskat species is listed which is restricted to the Racine. The species listed from the Attawapiskat as Pyncostylus elegans (Guelph age) and P. guelphensis (Guelph age) and Hormotoma whiteavesi (Guelph age) actually point to a post-Racine, Guelph age, for this formation; however, other species from the Attawapiskat listed as Lyellia affinis (Ellis Bay-Chicotte ages), Paleofavosites aspera (English Head-Chicotte ages), Zaphrentis patens (Jupiter age), Z. stokesi (Manistique-Jupiter and Chicotte ages), Stropheodonta philomela (Gun River and Jupiter ages), and Strophostylus amplus (Waldron age) clearly indicate a pre-Racine age for this formation. The species listed from the Ekwan River Limestone as Cystostylus infundibulus (Racine-Guelph ages), C. typicus (Waukeska-Racine age), Phanerotrema occidens ? (Racine-Guelph ages), and cf. Pleurotomaria hoyi (Racine) are actually better indicators of Racine age than any species listed from the Attawapiskat. However, the evidence for the Racine age of the Ekwan River is also contradicted by the presence in this formation of several species of pre-Racine age. From an examination of Savage & Van Tuyl's faunal lists and a consideration of Foerste & Savage's statements the writer finds no conclusive evidence that the faunas of the Attawapiskat and Racine were contemporaneous.

In the writer's opinion the Attawapiskat fauna is much more closely related to the Ekwan River, Severn River, and Burnt Bluff faunas than to any other known fauna. This opinion, incidentally, is supported in part by Foerste & Savage's statement (1927, p. 14-15) that "with few exceptions, the species which so far have been identified from the Severn limestone also occur in the overlying Ekwan limestone, and some are known even from the still higher horizon known as the Attawapiskat limestone."

On account of this faunal similarity and the absence of any conclusive evidence that the Attawapiskat Limestone contains a fauna of undoubted Racine relationship, the writer believes that this limestone is older than Racine and very likely is of pre-Manistique age. The occurrence of Armenoceras and Huroniella in the Attawapiskat Limestone and Cordell beds of the Manistique but not in the Burnt Bluff strata suggests a Cordell age for the Attawapiskat Limestone.

However, until more conclusive paleontologic evidence in support of the Cordell age of the Attawapiskat is available the writer believes that the Attawapiskat should be considered as being of pre-Manistique age.

The beds of the Stonewell Limestone which occupy a position above the Virgiana decussatum zone of this formation contain in common with the Burnt Bluff strata Pterinea occidentalis, Isochilina latimarginata, Leperditia hisingeri var. egena, and Leperditia hisingeri var. caeca (see Kindle, 1915, p. 9), and hence are of the same age as these strata.

The presence of Camarotoechia ? winiskensis, Rhynchospira lowi, Pterinea occidentalis, and Leperditia fabulina in the Wabi Formation of the Lake Timiskaming region (see Hume, 1925, p. 32) and the Burnt Bluff Formation, clearly indicates that these formations are of the same age.

The occurrence of Zygobolbina (Zygobolba-Ulrich & Bassler) williamsi Ulrich & Bassler in strata of the Wabi Formation occupying a position above beds of this formation containing Leperditia fabulina Jones (see Hume, 1925, p. 30, 32, 33), has considerable bearing on the age of this formation. This and five other species of ostracods were found in the Dyer Bay Dolomite by M. Y. Williams and studied by Ulrich & Bassler. As the result of their study, Ulrich & Bassler (1923, p. 335-336) concluded that these ostracods indicate a late Lower Clinton age or early Middle Clinton age for the Dyer Bay Dolomite, a late Lower Clinton age being the more likely of the two. On account of the fact that Zygobolbina williamsi is associated with Lower or Middle Clinton ostracods and the fact that Zygobolbina is especially characteristic of rocks of Lower and Middle Clinton ages, the presence of Zygobolbina williamsi in the Wabi Formation is highly indicative of the Lower or Middle Clinton age of this formation.

A close correlation between the Burnt Bluff strata of Michigan and the type Clinton strata of New York cannot be made on account of the fact that the Burnt Bluff fauna is very different from the Clinton faunas of New York. The ostracods noted in the preceding paragraph suggest that the Dyer Bay Dolomite and Wabi Formation, and their correlatives, the Mayville and Burnt Bluff Formations, may be of late Lower Clinton or early Middle Clinton age. It is possible that both the Burnt Bluff and Mayville strata should be correlated in time with either the Lower or Middle Clinton of New York. The fact that the faunas of the Burnt Bluff and Mayville are quite different may indicate that the Mayville is of Lower Clinton age and the Burnt Bluff of Middle Clinton age. Furthermore it is possible that either the Burnt Bluff or Mayville, or both formations, may occupy a stratigraphic position between the typical Lower and Middle Clinton strata of New York. Until more definite paleontologic and stratigraphic evidence is available, however, all that may be said is that the Burnt Bluff strata should be correlated with the Lower or Middle Clinton of New York state.

The Burnt Bluff strata were deposited in an Arctic or sub-Arctic sea which extended southward from Hudson Bay. This is clearly indicated by the occurrence in these strata of numerous species, which are characteristic of the Severn River and Ekwan River Limestones of the Hudson Bay region.

It is possible that in the Lake Timiskaming region this sea was temporarily connected with a sea from the Gulf of St. Lawrence. This is indicated by the presence in the Wabi formation of Zygobolbina williamsi, which is also found in the Dyer Bay Dolomite in association with Anticosti Island types of ostracods.

Manistique Dolomite

General Description. -- The Manistique Dolomite, as previously stated, is divided into a lower, Schoolcraft Member and an upper, Cordell Member.

The lithological and paleontological characteristics of the various beds of the Schoolcraft Member are well indicated in the following type section of this member.

Section of strata exposed in the Inland Lime & Stone Company Quarry (also known as the White Marble Lime Company Quarry) at Manistique, Locality 105

	Thickness Feet	Inches
Manistique Dolomite		
Cordell Member		
13 Dolomite, thin and uneven-		

FIG. 12 - Lower Mayville, near Moss Lake. Loc. 5.

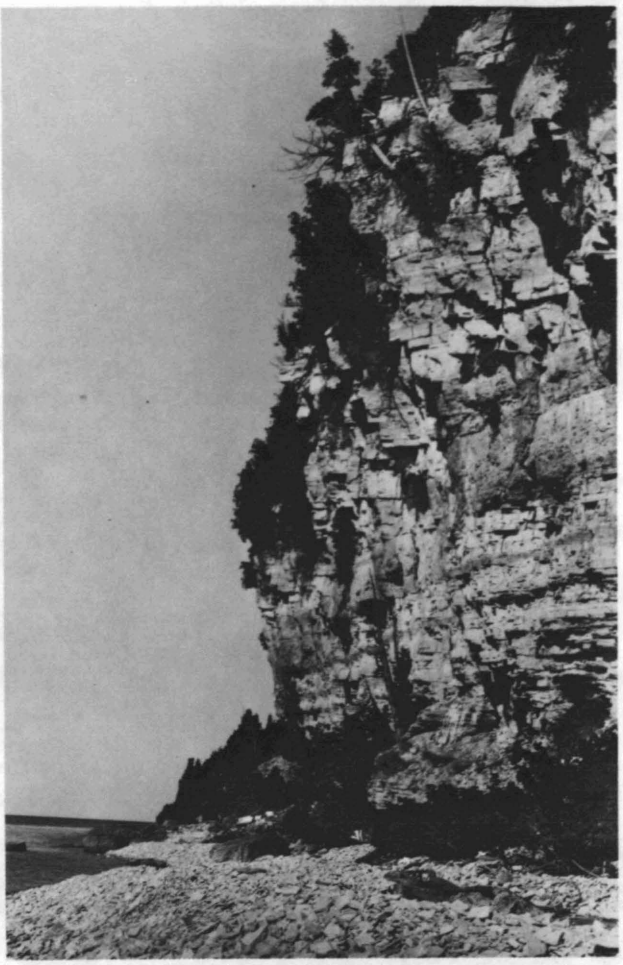


FIG. 13 - Burnt Bluff strata, cliff 1 mile S of Burnt Bluff. S of Burnt Bluff.

bedded, buff, with numerous chert nodules arranged in layers and few silicified fossils..... 10

The remains of the following fossils were found in the dolomite (d) and chert nodules (cn):

Streptelasma conulus (d)
Arachnophyllum pentagonum (d)
Favosites favosus (d)
Favosites aff. F. favosus (cn)
Halysites catenularia (d)
Phaenopora cf. P. keewatinensis (cn)
Orthis flabellites (d)
Atrypa reticularis (cn and d)
Leperditia cf. L. marginata (cn)

12 Dolomite, more finely crystalline than that above, buff, with cavities and very few remains of Camarotoechia sp. and poorly preserved bryozoa.. 5

11 Dolomite, massive, buff and finely crystalline..... 1 8

Streptelasma conulus
Favosites sp.

10 Dolomite, thin and uneven-bedded, buff, with numerous chert nodules arranged in layers..... 7

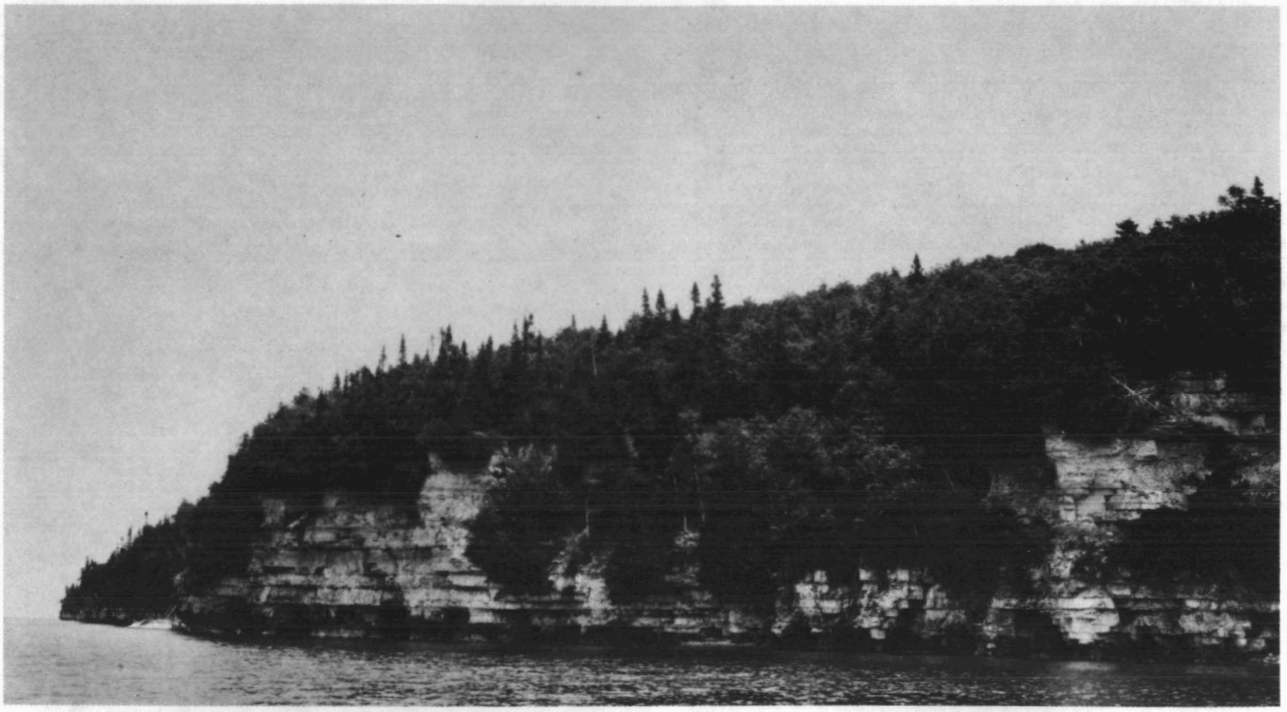


FIG. 14 - Hendricks Member of Burnt Bluff, cliffs on St. Martins Island. Loc. 31.

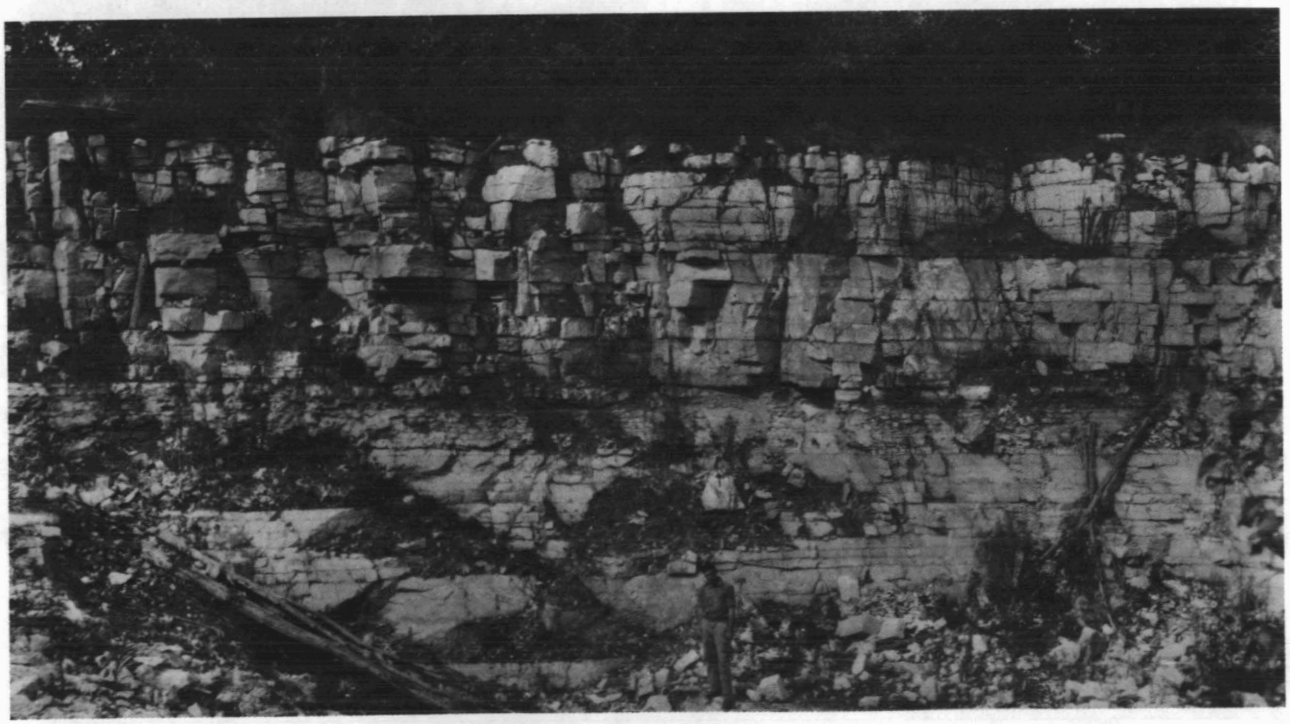


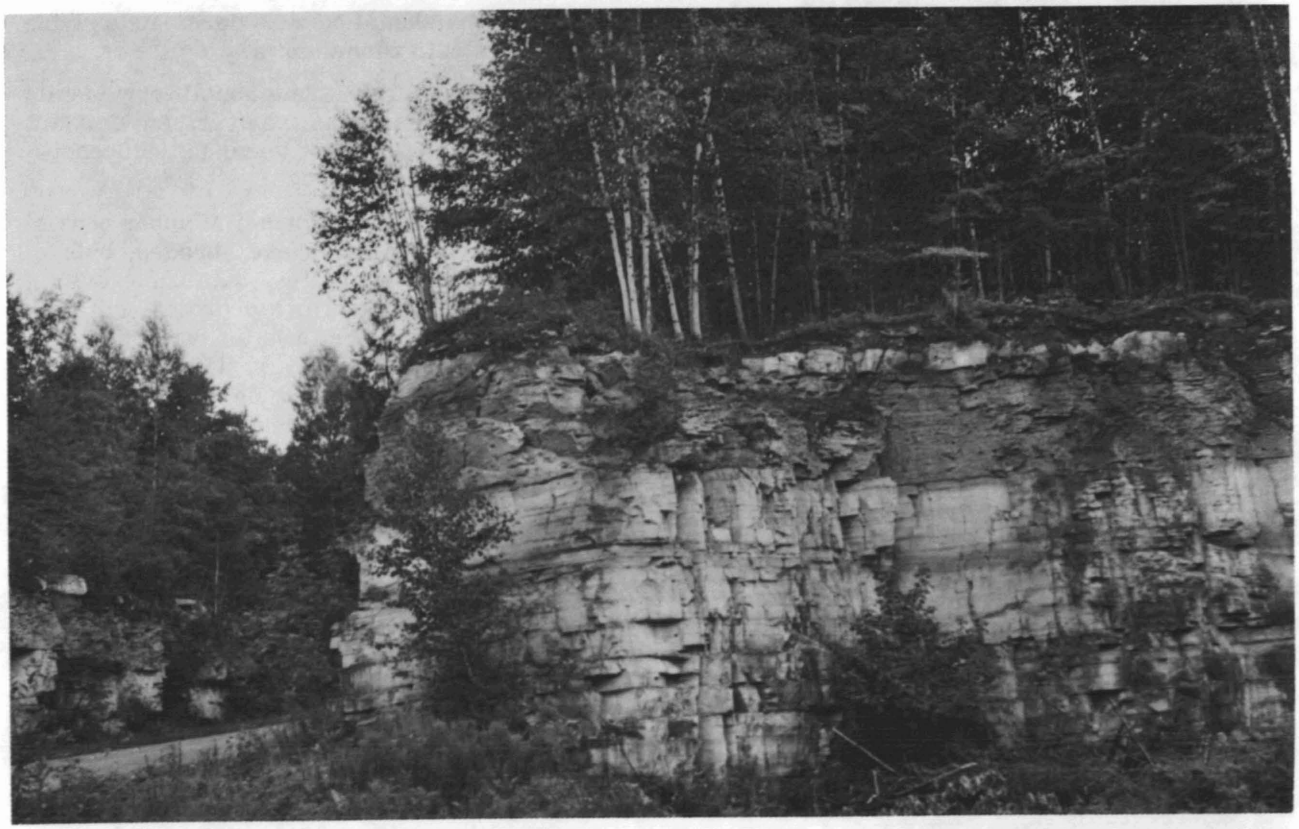
FIG. 15 - Hendricks Member of Burnt Bluff, quarry N of Cooks. Loc. 46.

		Feet	Inches
	Fossils are present in the dolomite, usually in a silicified condition. They are present in greater abundance and better state of preservation in the chert nodules.		
	The remains of the following fossils were found in the dolomite (d), chert nodules (cn), and a thin chert layer at the base of the interval (cb)		
	Clathrodictyon aff. C. cystosum (d) Heliophyllum ? sp. (d) Arachnophyllum striatum (d) Favosites obliquus (d) Favosites sp. no. 1 (d) Favosites sp. no. 2 (d) Alveolites undosus (d) Aulopora ? sp. (d) Halysites catenularia (d) Halysites labyrinthicus (d) Crinoid columnals (cn and d) Lioclema aff. L. asperum (d) Fenestella aff. F. elegans (d) Helopora n. sp. (cb) Pachydictya n. sp. aff. P. crassus (cn) Stropheodonta (Brachyprion) sp. (cb) Pentamerus aff. P. oblongus bisinuatus (cn) Pentamerus sp. (cn and d) Camarotoechia cf. C. neglecta (d) Zygospira ? sp. (cb) Atrypa reticularis var. (cn and d) Whitfieldella sp. (cb) Coelospira n. sp. (cb) Conocardium ? sp. (cb) Liospira ? sp. (d) Tentaculites aff. T. niagarensis (cb) Encrinurus sp. (cb and d) Aparchites n. sp. (cb) Schmidtella ? n. sp. (cb) Apatobolbina n. sp. (cb)		
	Schoolcraft Member		
9	Dolomite, thin and uneven-bedded, light bluish-gray and finely crystalline. Surfaces of many bedding planes covered with a very thin, greenish-gray shale and numerous fucoidal remains. Near the top, the surfaces of some bedding planes are thinly coated with chert.....	11	6
	Fucoids Inocaulis manistiquensis Ehlers & Wilson Mss. Mastigograptus manistiquensis Ehlers & Wilson Mss. Hippurograptus ruedemanni Ehlers & Wilson Mss. Stropheodonta (Brachyprion) sp. Pentamerus sp. Coelospira n. sp. -- the same species as at base of interval 10 above Pterinea cf. P. subplana Encrinurus sp. Leperditia cf. L. marginata		
	With the exception of Pentamerus, all of the fossils were found in the upper 5 to 6 feet of the dolomite of this interval. Pentamerus is present throughout the dolomite.		
8	Dolomite, thin and even-bedded and somewhat laminated; finely crystalline, lighter brownish-gray than underlying dolomite and containing very few cavities.....	2	6
7	Dolomite, similar to that below but having less chert, thicker bedding, and many cavities formed by the solution of corals and stromatoporoids....	1	6
	Stromatoporoids -- indeterminable Amplexus ? sp. Favosites aff. F. favosus Favosites aff. F. venustus Syringopora sp. -- possibly new corallites 3.5 to 4 mm in diameter Halysites aff. H. catenularia		
6	Dolomite, light brownish-gray, more coarsely crystalline than		

		Feet	Inches
	dolomite below, in layers 4 to 10 inches in thickness with many, irregularly shaped masses of chert and few cavities.....	4	
	The dolomite and chert are sparingly fossiliferous, the chert containing the best preserved fossils.		
	Fistulipora ? sp. Pachydictya cf. P. crassa Stropheodonta (Brachyprion) sp. Pentamerus sp. Whitfieldella cf. W. intermedia Whitfieldella sp. Trochoceras ? sp. Goldius n. sp. Encrinurus sp. Cheirurus n. sp.		
	The specimen of Trochoceras ? sp. was collected from the dolomite; all other fossils were found in the chert.		
5	Dolomite, very light brownish-gray, more coarsely crystalline than dolomite below, thin-bedded and with very few irregularly shaped masses of chert..	2	
	Crinoid columnals Pachydictya ? sp. Stropheodonta (Brachyprion) sp. Leperditia sp.		
4	Dolomite, thin and even-bedded, light bluish-gray, very finely crystalline and hard, breaking with conchoidal and splintery fractures. Surfaces of some bedding planes covered with a carbonaceous shale containing fucoids.....	4	4
	Fucoids Inocaulis manistiquensis Ehlers & Wilson Mss. Stropheodonta (Brachyprion) ? sp. Modiolopsis ? sp. Liospira ? sp. Trochoceras ? sp. Oncoceroid Leperditia cf. L. marginata		
3	Upper Pentamerus dolomite. Massive, coarsely crystalline, light grayish-brown dolomite, containing numerous poorly preserved molds of Pentamerus and cavities formed by the partial or complete solution of stromatoporoids and corals. Many cavities lined with small crystals of dolomite and fluorite.....	8	8
	? Actinostroma tenuifilatum Amplexus ? sp. Lyellia aff. L. americana Favosites cf. F. venustus Favosites sp. no. 1 Favosites sp. no. 2 Halysites compactus Pentamerus oblongus		
2	Dolomite, thin and very evenly bedded with carbonaceous partings, light bluish-gray and finely crystalline....	15	
1	Lower Pentamerus dolomite. Massive, light bluish-gray, coarsely crystalline dolomite with darker bluish-gray spots and streaks, and few cavities, which may have been formed by solution of stromatoporoids and corals. On considerable weathering the color of the rocks is changed to a brownish-gray.....	6	6
		75	1

The beds, designated as the lower and upper Pentamerus dolomites and described as intervals 1 and 3 of this section, are exposed at many places in the Northern Peninsula. In the Manistique quarry and at most places in Schoolcraft County, the lower Pentamerus dolomite is light bluish-gray in the unweathered state and brownish-gray when weathered. At these places, furthermore, it contains very few fossils, the molds of shells of Pentamerus usually being found only after considerable search. At most localities in the Northern Peninsula, however, the lower Pentamerus dolomite is exactly like

FIGS. 16, 17 - Hendricks Member of Burnt Bluff, road cut and adjacent Sawheidle Quarry, 5 mi. N and 1 mi. W of Manistique. Loc. 50.



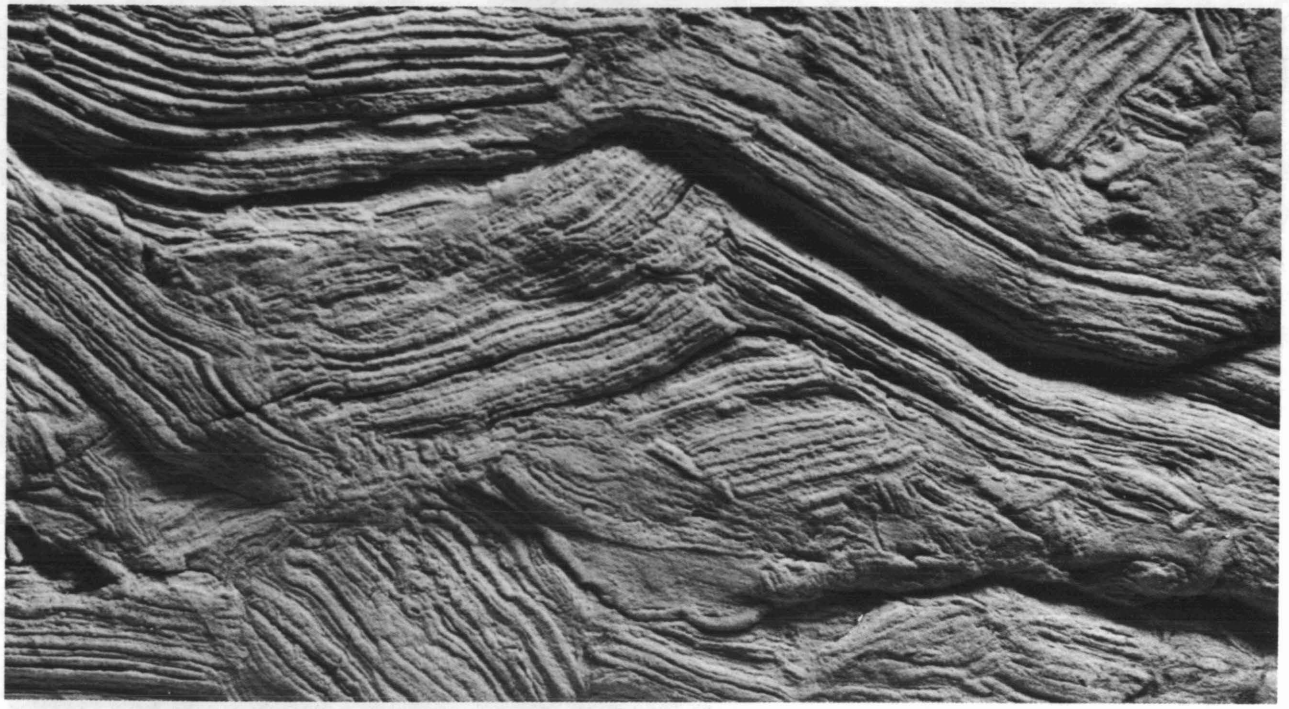


FIG. 18 - Hendricks Member, Sawheidle Quarry, N of Manistique. Near Loc. 50. Weathered edge of unit showing submarine gliding.

the upper Pentamerus dolomite in containing numerous molds of the shells of Pentamerus and in having a buff or buff-gray color. At a few places in Mackinac and Schoolcraft Counties these dolomites are decidedly calcareous, and lithologically are magnesian-limestones instead of dolomites. The higher calcareous content of the dolomites seems to be due in large part to the calcified shells of Pentamerus.

The lower and upper Pentamerus dolomites and the thin, even-bedded gray dolomites between them -- interval 2 of the type section, are remarkable for their continuity from St. Martin's Island, Big Bay de Noc, to Drummond Island. It is the writer's belief that these beds continue for considerable distances into Wisconsin and Ontario.

The terms lower and upper Pentamerus dolomites are applied to the dolomites of intervals 1 and 3 in order to differentiate these dolomites, which are so very much alike that they may easily be mistaken for one another in the field. The terms are used merely as a convenient means of reference. It is not intended that the terms should be considered as applying to distinct stratigraphic units.

The Schoolcraft strata contain few fossils and much less chert than the overlying Cordell beds. The most abundant fossil in the Schoolcraft strata is Pentamerus.

The strata of the Cordell Member consist almost entirely of thin, uneven-bedded, buff to buff-gray, cherty dolomites, with numerous silicified remains of stromatoporoids, corals and brachiopods. Chert nodules and irregularly shaped masses of chert are particularly abundant in the lower part of the member and are distributed in distinct bands along the bedding planes. The occurrence of these cherts is well shown in the basal Cordell strata, exposed in the Inland Lime & Stone Company quarry at Manistique (Locality 105). The most conspicuous fossils of the Cordell Member are silicified corals, which are present in nearly all beds but are most abundant in the strata of the middle and upper parts.

Higher beds of the Cordell Member than those in the quarry at Manistique are shown in

the type section exposed in the Inland Lime & Stone Company Quarry (formerly Scott Quarry Company), about three-quarters of a mile south of Cordell, Chippewa County.

Section of strata exposed in the Inland Lime & Stone Company Quarry (Scott Quarry) about 3/4 mile south of Cordell, Chippewa County, Locality 124

		Thickness Feet
	Manistique Dolomite	
	Cordell Member	
3	Dolomite, thin, uneven-bedded, buff-gray to buff and cherty, containing numerous silicified corals, stromatoporoids and other invertebrates.....	52
	Stromatoporoids - several undetermined species.	
	Amplexus shumardi var.	
	Streptelasma conulus	
	Streptelasma patula	
	Cyathophyllum radicula	
	cf. Cystiphorolites minor	
	Omphyma verrucosa	
	Ptychophyllum stokesi	
	Arachnophyllum pentagonum	
	Arachnophyllum striatum	
	Cystiphyllum niagarense var.	
	Heliolites interstinctus	
	Heliolites megastoma	
	Heliolites megastoma var.	
	Heliolites subtubulatus	
	Lyellia papillata	
	Thecia major	
	Thecia ? cf. T. minor	
	Alveolites undosus	
	Cladopora laqueata	
	Cladpora sp.	
	Coenites crassus	
	Coenites cf. C. laminatus	
	Favosites favosus	
	Favosites obliquus	
	Favosites n. sp. - related to F. venustus	
	Paleofavosites sp.	
	Halysites cf. H. agglomeratus	
	Halysites catenularia	
	Halysites catenularia microporus	
	Halysites labyrinthicus	
	Syringopora (?) (not Ceratopora Grabau, but probably an undescribed genus)	
	Fenestella sp.	
	Pachydictya sp. - related to P. crassa	
	Orthis flabellites	
	Stropheodonta (Brachyprion) cf. S. profunda	
	Pentamerus oblongus - several varieties	
	Pentamerus oblongus bisinuatus	
	Pentamerus oblongus subrectus	
	Atrypa reticularis n. var. or n. sp.	
	Actinoceras sp.	
	Huronia bigsbyi intermedia	
	Huronia ehlersi	
	Huronia paulodilatata	
	Huroniella sp.	
2	Dolomite, massive, buff-gray and containing little chert. Surfaces of some blocks of this dolomite, blasted from the quarry wall, contain remains of an undescribed species of Palaeocyclus related to P. rotuloides, and a species of Pachydictya related to P. crassus. The surfaces bearing these fossils seem to be parts of the upper surface of the dolomite.....	2
1	Dolomite, similar to that of interval 3 but containing more numerous bands of chert, a larger number of Pentamerus and fewer silicified corals.....	13
		67

The strata of interval 1 may represent an eastward continuation of some of the Cordell beds exposed in the Inland which occupy a position near the base of the Cordell Member because the upper Pentamerus dolomite of the lower part of the Schoolcraft Member is present about 20 feet below the base of interval 1 in a path leading to the quarry crusher.

The upper Pentamerus dolomite and the underlying, thin, even-bedded, gray dolomites are better exposed in the brush-covered land a short distance east of the path. The upper Pentamerus dolomite is more calcareous than at most localities and contains numerous green-

ish-gray, calcified shells of Pentamerus.

The writer did not find an outcrop of the lower Pentamerus dolomite. Further search in the nearby brush-covered area will probably show that it is present at the surface.

Detailed sections. -- These are discussed by the counties in which they occur.

Delta County

Garden Peninsula: Manistique rocks underlie most of the surface of the Garden Peninsula, which, as previously stated, is a prominent cuesta. The lower and upper Pentamerus dolomites of the Schoolcraft Member and the thin, even-bedded gray dolomites between them are at the tops, or a short distance east of the tops, of the bluffs which rise above the shore of Big Bay de Noc. The higher beds of the Schoolcraft Member and the overlying Cordell strata compose the back slope of the cuesta, which slopes southeastward to Lake Michigan approximately with the inclination of these rocks.

The occurrences of the lower Pentamerus dolomite and overlying, even-bedded gray dolomite at Burnt Bluff (Locality 36), the lower and upper Pentamerus dolomites and intervening, thin, even-bedded, gray dolomites at Middle Bluff (Locality 37), and the lower Pentamerus dolomite at the top of the bluff about 1 mile east of Garden Bluff (Locality 40) have been noted in sections describing the Burnt Bluff strata.

The lower Pentamerus dolomite and the overlying thin, even-bedded, gray dolomites are exposed in the upper part of a cliff about one-quarter of a mile northwest of Vans Harbor, located about one mile northwest of the village of Garden (see Locality 41). At this place the gray dolomites have a thickness of 22 feet, the maximum thickness observed by the writer.

LOC. 97. Exposures of Schoolcraft strata are very numerous along the roads in and near the village of Garden and in the western part of sec. 18, T 39 N, R 18 W, about $1\frac{1}{2}$ miles west of Garden.

Cordell strata outcrop at few places along the roads leading east from the village.

LOC. 98. Schoolcraft strata are present in glacial-lake terraces in the vicinity of Fairport, a fishing village at the southern end of the Garden Peninsula.

LOC. 99. Higher Manistique strata are shown, at places along the shore between Fairport and Pt. Detour, located at the southeastern extremity of the Garden Peninsula. Low cliffs of thin, uneven-bedded, buff dolomite of the Cordell Member are exposed along the shore about $1\frac{1}{2}$ miles northwest of Pt. Detour.

Islands southwest of Garden Peninsula: The southeastern part of Little Summer Island is composed of Schoolcraft strata. The contact of the lower Pentamerus dolomite with the Hendricks strata is shown in a low cliff on the southern shore just west of a small point of land in the $SE\frac{1}{4}$ sec. 18, T 37 N, R 19 W (Locality 33).

LOC. 100. Typical, thin, uneven-bedded, buff dolomites of the Cordell Member are exposed on the western side of Big Summer Island in cliffs, having an average height of 9 feet. The contact between these strata and the Engadine Dolomite is shown on the shore about three-quarters of a mile north of the southwestern point of the island and is discussed more fully below under the detailed sections of the Engadine.

Strata belonging to the lower part of the Schoolcraft Member are exposed along the eastern shore of St. Martin's Island. Forty-four feet of these strata are present in a cliff near the St. Martin's Island lighthouse and are described above under Locality 32. Higher Schoolcraft and possibly Cordell beds may be present on higher parts of the island.

LOC. 101. The surface of Little Gull Island, situated about $1\frac{1}{2}$ miles east of St. Martin's Island, is composed of six feet of thin, uneven-bedded, buff, cherty Cordell dolomites.

LOC. 102. About five feet of similar dolomite are present in a small outcrop on the eastern shore of Gull Island located about three-quarters of a mile north of Little Gull Island.

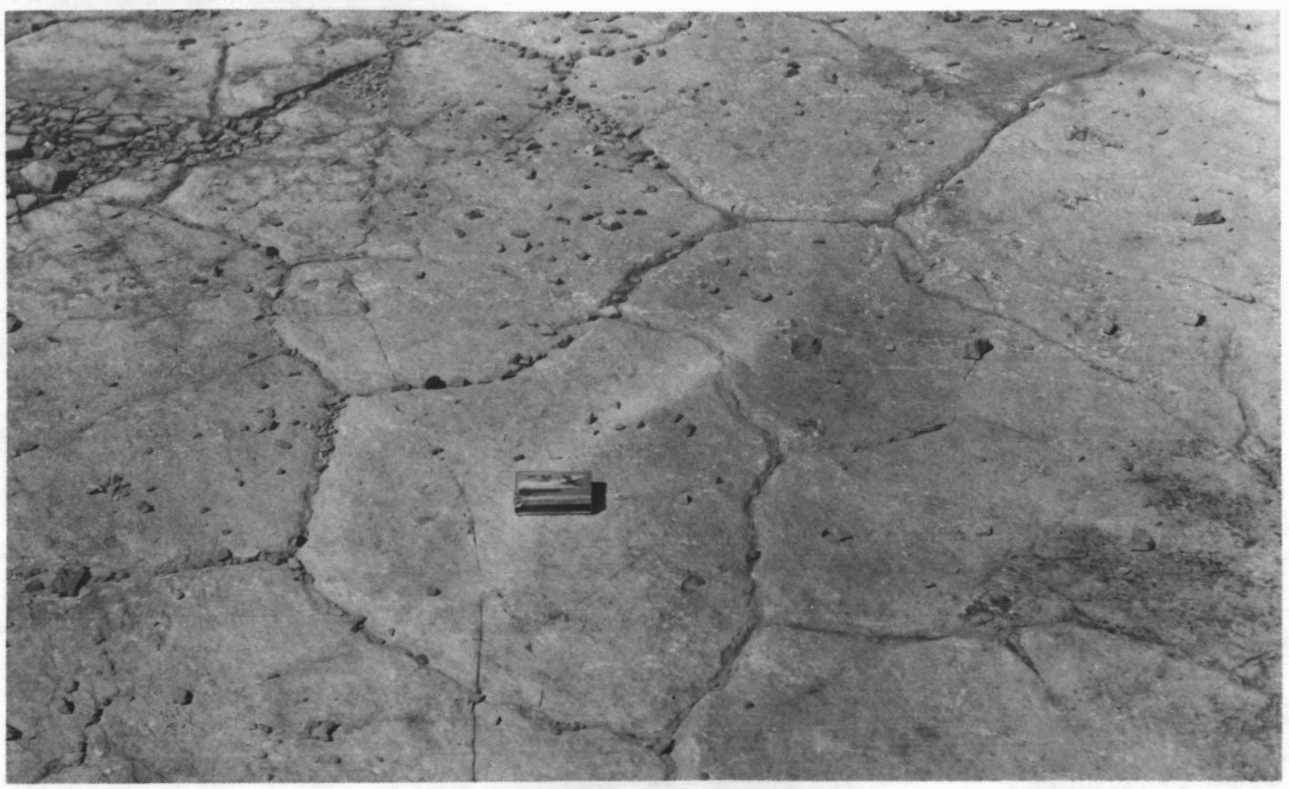
Schoolcraft County

Vicinity of Cooks:

LOC. 103. A massive, hard, light-gray dolomite with few cavities is at or near the surface of much of the $SW\frac{1}{4}$ sec. 17, the $SE\frac{1}{4}$ sec. 18, the $NE\frac{1}{4}$ sec. 19, and the $NW\frac{1}{4}$ sec. 20, T 41 N, R 17 W, about two miles north of Cooks. Six feet of this dolomite are exposed in a low, north-

FIGS. 19, 20 - Fiborn Limestone unit, Hendricks Member of Burnt Bluff, Inland Lime & Stone Company Quarry. Loc. 73. Figure 19 shows a low bioherm.

FIGS. 21, 22 - Hendricks Member of Burnt Bluff, Hendricks Quarry. Loc. 78. Floor of quarry formed by top of limestone bed underlying the Fiborn Limestone, showing large mud cracks in original sediment.



east-southwest trending bluff, which crosses the road about one-third of a mile north of the SW corner sec. 18.

The writer is uncertain whether this dolomite is the lower Pentamerus dolomite or a bed near the top of the Hendricks Member of the Burnt Bluff Formation. The Hendricks position of the dolomite is suggested by the presence of a similar Hendricks dolomite only two-thirds of a mile north of the low bluff noted above. On the other hand, the possibility that this dolomite is the lower Pentamerus dolomite is suggested by the presence of 20 or more feet of thin, even-bedded, gray to buff-gray dolomites which outcrop in the south-central part of sec. 20 and the north central part of sec. 29 and occupy a position just above the lower Pentamerus dolomite. The writer is more inclined to believe that the massive, light-gray dolomite is the lower Pentamerus dolomite rather than a dolomite in the upper part of the Hendricks and hence has mapped it as a part of the Manistique Formation.

Manistique:

LOC. 104. Manistique strata are practically at the surface of the part of Manistique situated east of the Manistique River. Several exposures of these strata are present along the Manistique River between its mouth and the plant of the Charcoal Iron Company, located about one mile above the river's mouth. Other outcrops occur along the shore of Lake Michigan to the south and southeast of the center of Manistique.

LOC. 105. Nearly all of the dolomites exposed at Manistique belong to the Schoolcraft Member; only the cherty dolomites in the abandoned part of the Inland Lime & Stone Company Quarry at Manistique and more elevated, nearby parts of the town belong to the Cordell Member.

Manistique-Shingleton highway near Indian River:

LOC. 106. A massive, light-gray dolomite with mottled bluish-gray areas is exposed along the Manistique-Shingleton highway (Highway 94) less than one-quarter of a mile south of the Indian River (northern part of sec. 2, T 41 N, R 16 W). This dolomite is probably the lower Pentamerus dolomite.

The contact between the Manistique and Hendricks strata crosses the road between this exposure and the Indian River.

Marblehead and vicinity:

LOC. 107. About 8 feet of massive, bluish-gray dolomite with mottled darker bluish-gray areas is exposed in the walls of the Inland Lime & Stone Quarry at Marblehead, located in the SW$\frac{1}{4}$ sec. 36, T 42 N, R 15 W, about 5 miles E of Manistique. The dolomite, which becomes buff when weathered, contains very few remains of Pentamerus and Favosites.

In the writer's opinion this dolomite is without doubt the eastern continuation of the lower Pentamerus dolomite of the quarry at Manistique.

The scarcity of Pentamerus in the lower Pentamerus dolomite, where exposed in these quarries, in the area 2 miles north of Cooks, and along the Manistique-Shingleton highway, is of considerable interest in view of the fact that it is abundantly fossiliferous farther eastward in Mackinac County and farther westward in Delta County. The local scarcity of Pentamerus may be best explained by the lack of abundant food in that part of the Manistique sea, formerly covering Schoolcraft County. The scarcity of remains of other invertebrates in the lower Pentamerus dolomite of this county may also be accounted for in the same way.

About 5 feet of buff, cherty, dolomite underlie the lower Pentamerus dolomite in a test-pit excavated below the floor of the Marblehead Quarry. Some of the cherts near the top of the dolomite contain a few remains of Pentamerus. The presence of this brachiopod in the cherts and the apparent absence of Hendricks fossils seem to indicate that the cherty dolomite is faunally related to the overlying lower Pentamerus dolomite and should be included with it in the Schoolcraft Member.

According to the quarrymen about 5 feet of still lower strata were exposed in the test-pit before it had partly filled with water. In view of the fact that the Hendricks-Manistique contact is never very far below the base of the lower Pentamerus dolomite, it is quite possible that some or all of these water-covered strata are of Hendricks age.

LOC. 108. In a recent road cut of US 2 near the Marblehead Quarry, which by-passes the sharp corner of the old highway in the SW$\frac{1}{4}$ sec. 36, several feet of the cherty beds of Cordell are exposed above the Schoolcraft Member. Both

members are steeply dipping and faulted at this cut.

LOC. 109. About one-half mile east of the Marblehead Quarry, the contact between the Cordell and Schoolcraft beds of the Manistique Formation is well shown on the south side of the road (SE$\frac{1}{4}$ sec. 36, T 42 N, R 15 W) extending from Marblehead to Whitedale. The strata below and above this contact are a continuation of the beds of intervals 9 and 10 of the quarry at Manistique.

At this road-side exposure there is a pronounced southeasterly dip of 8 to 9 degrees, causing 3 feet of cherty, buff Cordell Dolomite to appear only on the south side of the road. This relatively high dip also causes higher and much more fossiliferous Cordell strata to appear in the fields immediately southeast of the road.

Several exposures of Schoolcraft strata and a few outcrops of Cordell beds are present along the road to Whitedale between the road-side exposure and a point about 1 mile to the east.

Whitedale (now Gulliver) and vicinity:

LOC. 110. Very fossiliferous Cordell strata are at the surface of much of the eastern half of sec. 33 and the western half of sec. 34, T 42 N, R 14 W, about 1 3/4 miles west of Whitedale.

LOC. 111. As one proceeds northward along a little-used road from the NE corner sec. 33, lower and lower Manistique strata are encountered. The upper Pentamerus dolomite is exposed on both sides of a low ridge crossing the road about 1 mile N of the NE corner sec. 33.

LOC. 112. Cordell strata are at or near the surface of the land adjacent to two outliers of Engadine Dolomite at Whitedale.

LOC. 113. Buff dolomites, belonging to the upper part of the Cordell Member, are present in a northwest-southeast trending ridge about 1 mile southeast of Whitedale.

LOC. 114. Cordell beds are exposed on the north, south, and southwest shores of McDonald Lake, the western margin of which is about 1$\frac{1}{2}$ miles east of Whitedale.

Mackinac County

Hunt's Spur:

LOC. 115. Thin, uneven-bedded, buff Cordell dolomites containing silicified corals, brachiopods, and other invertebrates are exposed in fields near the west line of sec. 7, T 42 N, R 12 W at points $\frac{1}{4}$ and $\frac{1}{2}$ mile north of Hunt's Spur.

Gould City and vicinity:

LOC. 116. A low ridge composed of Cordell strata is present in the SE$\frac{1}{4}$ sec. 29, T 43 N, R 11 W, about $\frac{1}{2}$ mile southwest of Gould City. It continues southward through the eastern part of sec. 32 and crosses the road on the east line of this section about 1$\frac{1}{2}$ miles south of Gould City.

The best exposures in this ridge are located about 1/8 mile north of the south line of sec. 29. At this place about 4 feet of thin, uneven-bedded, buff, cherty dolomites crop out near the top of the ridge. Similar dolomites are at or very near the surface of the fields, sloping eastward from the base of the outcrop to the road on the east line of sec. 29. The last-mentioned dolomites contain a very large number of silicified corals, many of which have been weathered out and placed along the fences by the owners of the fields.

The following lists of fossils collected from the outcrop in the ridge and the fields sloping eastward from the outcrop, show very well the faunal composition of the Cordell strata at this place.

List of fossils collected from outcrop

Anthozoa

- Streptelasma conulus
- Omphyma verruscosa
- Thecia major
- Cladopora laqueata
- Coenites crassus
- Coenites laminatus
- Favosites favosus
- Halysites catenularia
- Halysites catenularia microporus
- Halysites labyrinthicus
- Syringopora verticillata

Brachiopoda

- Pentamerus oblongus

Cephalopoda

- Huronia vertebralis

FIG. 23 - Fiborn Limestone and overlying Favosites-stromatoporoid bed, Hendricks Quarry. Loc. 78.

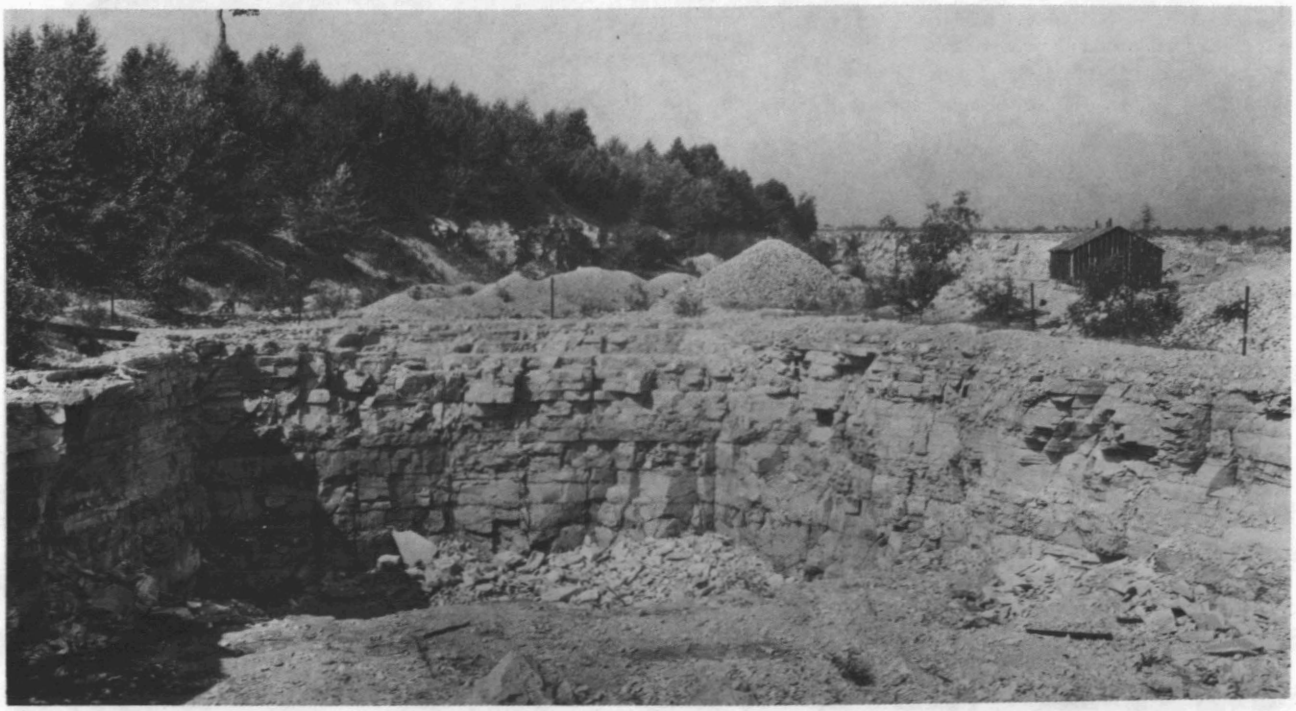


FIG. 24 - Hendricks Member of Burnt Bluff, Fiborn Limestone in distant wall and in wall partly covered by trees, Hendricks Quarry. Loc. 78.

FIG. 25 - Hendricks Member of Burnt Bluff, Fiborn Limestone unit at top, Hendricks Quarry. Loc. 78.

FIG. 26 - Hendricks Member of Burnt Bluff, beds below the Fiborn Limestone unit, Fiborn Quarry. Loc. 80.

List of fossils collected in fields east of outcrop

Hydrozoa

Clathrodictyon cystosum ?
cf. Syringostroma niagarense

Anthozoa

Amplexus shumardi var.
Streptelasma conulus
Streptelasma patula
Zaphrentis umbonata
Blothrophyllum caespitosum
Diphyphyllum stokesi
Arachnophyllum pentagonum
Arachnophyllum striatum
Cystiphyllum niagarense var.
Heliolites subtubulatus
Lyellia papillata
Lyellia sp.
Thecia major
Alveolites undosus
Alveolites sp.
Cladopora laqueata
Coenites crassus
Coenites laminatus
Favosites favosus
Favosites obliquus
Favosites several new species
Halysites cf. H. agglomeratus
Halysites catenularia microporus
Halysites catenularia varieties
Syringopora verticillata
Syringopora sp.

Bryozoa

Pachydictya sp. related to P. crassa

Brachiopoda

Orthis flabellites
Pentamerus oblongus - several variations
Pentamerus oblongus near var. subrectus
Camarotoechia sp. - probably new
Atrypa reticularis - n. var. or n. sp.

Cephalopoda

Orthoceras sp.
Ormoceras sp.
Armenoceras backi
Armenoceras gouldense
Stokesoceras engadinense
Huronia obliqua

Trilobita

Dalmanites ? sp.

The lowest strata at this locality, which are poorly shown in the field and road a short distance west of the SE corner sec. 29, probably occupy a position near the base of the Cordell Member. This is indicated by the fact that they contain very numerous cherts and remains of Pentamerus like the lowest beds of the Cordell Member.

LOC. 117. Exposures of Cordell strata are present at several places along the road leading southward from Gould City between the southeast corner sec. 29, T 43 N, R 11 W, and the southeast corner sec. 17, T 42 N, R 11 W.

The contact between the Cordell Member and the Engadine Dolomite crosses the road leading southward from Gould City near the southeast corner sec. 17, T 42 N, R 11 W.

Northeast of Hazelmere:

LOC. 118. A low bluff of Engadine Dolomite is present in the SW$\frac{1}{4}$ sec. 13 and NW$\frac{1}{4}$ sec. 24, T 43 N, R 11 W, about 1 mile northeast of the station of Hazelmere, located on the Minneapolis, St. Paul, & Sault Ste. Marie Railroad 2 miles east of Gould City.

The presence of Cordell strata in the fields immediately west of the bluff indicates that the contact between these strata and the Engadine Dolomite is at or a short distance below the soil-covered base of the bluff.

Region north of Engadine:

LOC. 119. Manistique strata are at or close to the surface of the region between 1 and 3 miles north of Engadine. A few exposures and considerable drift material from the Manistique Formation are present along the road leading north from Engadine and the north-south trending road 1 mile east.

Five miles south of Fibre:

LOC. 120. According to Ver Wiebe (1928, p. 327), the lower and upper Pentamerus dolomites ("lower and upper Pentamerus layers" of Ver Wiebe) are exposed on both sides of the road in secs. 8 and 9, T 43 N, R 3 W, about 5 miles south of Fibre, a station on the Minneapolis, St. Paul, & Sault Ste. Marie Railroad.

Escarpment southeast of Rudyard:

LOC. 121. A high northward-facing escarpment, capped by the Engadine Dolomite, is present in the western part of sec. 3, T 43 N, R 2 W, about 6 miles south and 2 miles east of Rudyard, Chippewa County. The top of the escarpment is about 225 feet above the level of the swamp, at its base. The descent from the top of the escarpment to the swamp is by means of four distinct bluffs and terraces, which were probably cut by the waves of Lake Algonquin.

The uppermost bluff consists of 5 feet of Engadine Dolomite and 40 feet of thin, uneven-bedded, buff dolomites of the Cordell Member of the Manistique Formation. About 15 feet of similar, more cherty Cordell dolomites are present in the next lower bluff, the top of which is 25 feet below the base of the uppermost bluff. The next lower bluff, which is separated from the base of the bluff above by a covered interval of 12 feet, contains 10 feet of cherty, Cordell dolomites. Between the base of this bluff and the swamp, the rocks are covered with talus and glacial soil. The fourth and lowest bluff is present near the swamp.

At this locality the Cordell Member has a thickness of at least 105 feet. The contact between the Schoolcraft and Hendricks strata is probably 30 feet to 40 feet above the swamp.

About 2 miles southeast of this locality the basal Schoolcraft and upper Hendricks beds are exposed in a road (about 1/8 mile S of NE corner sec. 11, T 43 N, R 2 W) and are separated from each other by a covered interval of only 5 feet. The description of the Schoolcraft and Cordell beds outcropping along this road and on the top of a nearby hill has been given under the discussion of Localities 81 and 82.

Chippewa County

Escarpment 3 miles E of Trout Lake:

LOC. 122. Manistique and Engadine strata are exposed in the high escarpment $3\frac{1}{2}$ miles east of Trout Lake. The massive Engadine Dolomite, which caps the escarpment, has a thickness of 25 feet at the north end of the escarpment and 55 feet about $\frac{1}{2}$ mile farther south.

The buff, thin-bedded, Cordell dolomites are exposed in small bluffs and terraces, which have been cut in the sides of the escarpment by the waves of glacial Lake Algonquin. They are fairly well shown in two bluffs and two terraces below a higher bluff of Engadine Dolomite at the north end of the escarpment. The lowest strata, which appear in the lowest bluff about 10 to 15 feet above the road-bed of the Minneapolis, St. Paul, & Sault Ste. Marie Railroad, are very cherty, indicating that they probably are the very cherty beds usually found at the base of the Cordell Member. The total thickness of the Cordell beds at this end of the escarpment is at least 100 feet. A sharp contact between the Cordell beds and the Engadine Dolomite is shown at a few places on the western side of the escarpment a short distance south of its north end.

LOC. 123. Several blocks of the lower or upper Pentamerus dolomite, or both, are present about 1 mile west of the top of the escarpment in the $SE\frac{1}{4}$ sec. 19, T 44 N, R 5 W, less than 100 feet north of the road on the south line of sec. 19. The blocks are relatively high in calcium carbonate, the calcified, greenish-gray shells of Pentamerus contributing largely to their calcareous content. The fact that these blocks are so numerous indicates that the ledges of the lower and upper Pentamerus dolomites, and hence the contact between the Schoolcraft and Hendricks strata, must be at the surface near this locality.

South of Cordell:

LOC. 124. The strata exposed at Scott Quarry, about 3/4 mile south of Cordell, have been described in the detailed section already presented.

Taylor's Mill, 4 miles southeast of Pickford:

LOC. 125. According to Ver Wiebe (1928, p. 327), a fine section of Manistique strata is shown at Taylor's Mill, located in sec. 20, T 43 N, R 1 E, about 4 miles southeast of Pickford. He states that the "lower" and "upper Pentamerus layers," lower and upper Pentamerus dolomites of this paper, each have a thickness of 7 feet at this locality and that the thin, even-bedded, gray dolomites between these layers are 13 feet thick. According to this writer, the "upper Pentamerus layer" is overlain by 95 feet of "upper Manistique strata."

Most of the "upper Manistique strata" noted by Ver Wiebe at this and other localities in Chippewa and Mackinac Counties, without doubt belong to the Cordell Member of the Manistique Formation, the lowest beds being a part of the Schoolcraft Member.

FIG. 27 - Byron Member of Burnt Bluff, abandoned quarry at old lime kiln, Lime Island. Loc. 90. Base of exposure about 5 feet above Virgiana zone exposure.

FIG. 28 - Burnt Bluff strata, Somne's Quarry, NE¼ SE¼ sec. 23, T 42 N, R 5 E, Drummond Island. Near Loc. 91.

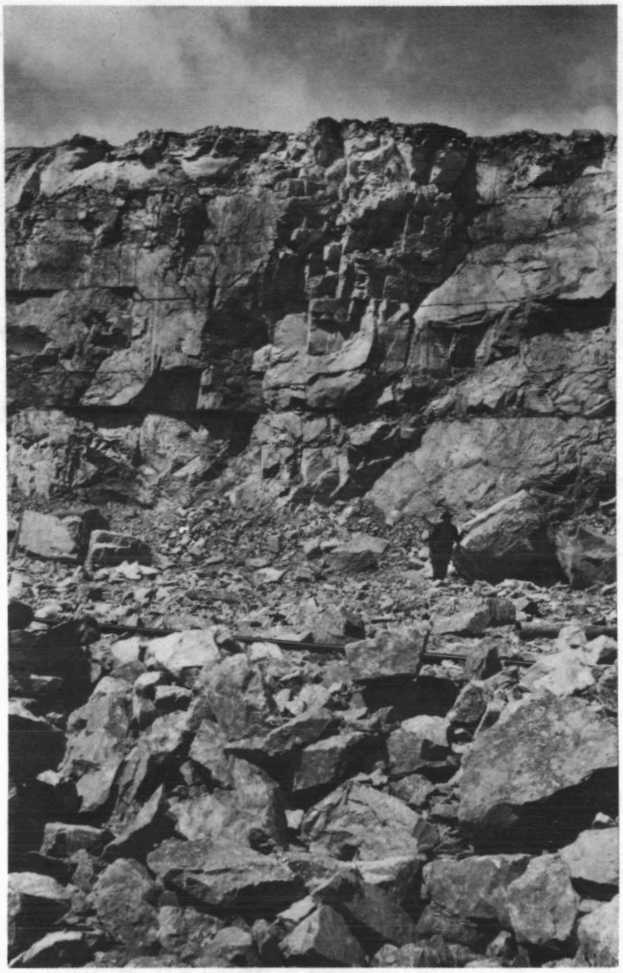


FIG. 29 - Hendricks Member of Burnt Bluff, Fiborn Limestone unit, Inland Lime & Stone Company Quarry. Loc. 73.

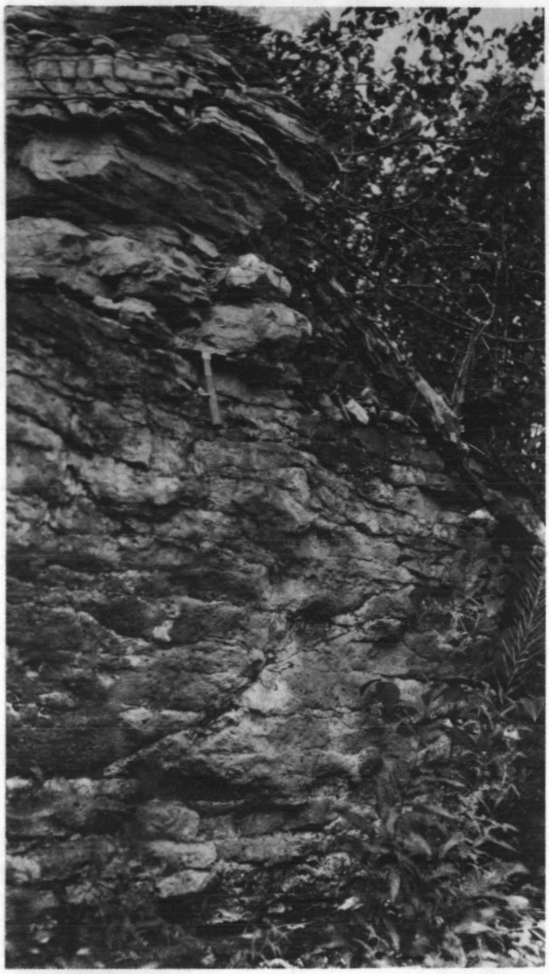


FIG. 30 - Schoolcraft Member of Manistique, bluff at Raber. Loc. 126. Contact of lower Pentamerus dolomite and overlying thin-bedded gray dolomite unit.

Escarpment south of Raber:

LOC. 126. About 97 feet of Manistique strata are present in the upper part of the escarpment, 3/4 mile south of Raber. The lower Pentamerus dolomite, where shown in a small bluff of the escarpment near an old road leading southeastward from Raber, has an exposed thickness of 6 feet, its basal part and contact with the Hendricks strata being covered with drift and talus. The upper Pentamerus dolomite has a thickness of 10 feet and is separated from the lower Pentamerus dolomite by 11 feet of thin-bedded, gray dolomite. About 10 feet of thin-bedded, buff to buff-gray dolomites rest on the upper Pentamerus dolomite. Above these dolomites there is a covered interval of about 25 feet. The uppermost 35 feet of strata of escarpment consist of thin, uneven-bedded, buff Cordell dolomites, the lowest beds of which are very cherty and occupy a position near the base of the Cordell Member.

The Cordell dolomites contain an exceedingly large number of silicified corals and stromatoporoids and a smaller number of re-

mains of other invertebrates. Thirty-five distinct species of invertebrate fossils, most of which are corals, were collected from the dolomites by the writer. Further collecting from these abundantly fossiliferous strata will undoubtedly yield many more species. The fauna is the same as that of the Cordell beds exposed about one-half mile south of Gould City, Mackinac County.

Detour:

LOC. 127. The contact between the Cordell dolomites and the Engadine Dolomite is shown in the northern part of the village of Detour (NW$\frac{1}{4}$ sec. 35, T 42 N, R 4 E) about 48 feet above the level of the Detour Passage, connecting Lake Huron with Potagannissing Bay. About 14 feet of thin-bedded, buff Cordell dolomites, containing very few cherts and silicified fossils, are present below the contact.

The contact is a short distance below the floor of a small, abandoned quarry, excavated in the Engadine Dolomite near the NW corner sec. 35. Along the road west of this section corner are several exposures of Engadine Dolomite, the highest beds of which are about 50 feet above the contact of this dolomite with the Cordell beds.

Point St. Vital, Lake Huron: Point St. Vital is located at the extremity of a prominent peninsula which projects southward into Lake Huron about 4 miles west of Point Detour at the southern entrance of the Detour Passage.

LOC. 128. Small exposures of some of the uppermost Cordell dolomites are present at one place along the eastern shore of this peninsula about 3/4 mile north of Point St. Vital and on some very small, almost lake-covered islands, located just off-shore about 1/3 mile north of the Point.

If the general southward to southwestward dip of the Niagaran strata of southeastern Chippewa County were uniform, the Engadine Dolomite should compose the Point St. Vital Peninsula. The presence of Cordell dolomites on this Peninsula, however, indicates that the dip is not uniform and that these dolomites are exposed as the result of erosion of a minor structure involving an upbending of the strata.

Drummond Island: Several beds of the Manistique formation are present along the southwestern shore of Drummond Island.

LOC. 129. The lower and upper Pentamerus dolomites are present on the shore near the north line of sec. 30, T 42 N, R 5 E. Higher Schoolcraft and lower Cordell beds are shown along the shore as one proceeds southward for a distance of about one-half mile.

LOC. 130. Strata near the top of the Cordell Member are exposed on the shore about 2 miles farther south in the east-central part of sec. 36, T 42 N, R 4 E.

The Engadine dolomite is exposed along the shore 1 mile farther south in the NW$\frac{1}{4}$ sec. 1, T 41 N, R 4 E, and in a cliff, located a short distance northeast in sec. 36, T 42 N, R 4 E.

Several exposures of the lower and upper Pentamerus dolomites and other beds of the Schoolcraft Member are present in the bluffs above the quarries near Drummond village. The lithologic character of these strata and their thickness have been previously noted in connection with the description of the Burnt Bluff strata exposed at these places (Localities 91-93).

LOC. 131. Cordell dolomites are present in a bluff in the SE$\frac{1}{4}$ sec. 19, T 42 N, R 6 E, about 1 mile southeast of Drummond village. A thickness of 65 feet is shown between the top of the bluff and the lowest bed, exposed in the cleared land about 500 feet northeast of the bluff. The lower beds are very cherty; the higher ones contain less chert and a larger number of silicified remains of corals and other invertebrates.

Cappings of the upper Pentamerus dolomites are present about 1/3 mile north of the bluff in the NE$\frac{1}{4}$ sec. 19. These cappings are about $\frac{1}{2}$ mile southeast of the abandoned limekiln quarry on the shore of Potagannissing Bay, and are noted as interval 9 of the section of this quarry and vicinity described under Locality 93.

LOC. 132. According to Ver Wiebe (1928, p. 328), the "lower" and "upper Pentamerus beds" - lower and upper Pentamerus dolomites of the writer, "can be traced across Drummond Island from Marblehead almost mile after mile." He (1928, p. 325, 326) notes the occurrence of these two dolomites on the Victor Hilden Ranch in the NW$\frac{1}{4}$ sec. 26, T 42 W, R 6 E (Locality 94), and at a place 3 miles west of Marblehead in the NW$\frac{1}{4}$ sec. 3, T 41 N, R 7 E.

LOC. 133. Several exposures of the upper Cordell strata occur along the southern shore

of Drummond Island. Their presence is due to the erosion of the overlying Engadine Dolomite from the tops of minor structures, which most likely are small lakeward-plunging anticlines or anticlinal noses.

Houghton County

Big Limestone Mountain: In 1915 Case & Robinson (1915, p. 173) reported the occurrence of the corals Streptelasma (probably Lindstromia) spongaxis and Zaphrentis stokesi in the Niagaran rocks of Big Limestone Mountain (Locality 30).

The presence of these corals in the rocks at this place is of considerable interest because these species of corals were originally described as occurring in strata, which undoubtedly belong to the Cordell member of the Manistique formation.

The writer has compared the Big Limestone Mountain specimens of these corals with those found in undoubted Manistique strata, in an effort to learn whether they belong to the same species and whether the Manistique fauna reached the Big Limestone Mountain region. The Big Limestone Mountain specimens, identified as Zaphrentis stokesi, are poorly preserved as molds in cherts and in the writer's opinion are very doubtfully related to this species. Some of the specimens probably belong to the genus Amplexus. The single fragmentary specimen identified as Streptelasma (probably Lindstromia) spongaxis, resembles the Manistique forms of the species in general structure but differs from these in having thinner, more numerous and more closely spaced septa. More and better-preserved specimens (having structures identical with those of the Manistique forms) may possibly be found at Big Limestone Mountain. The similarity in general structure between the Big Limestone Mountain individual and the typical Manistique forms suggests that the Manistique sea and fauna may have reached the Big Limestone Mountain region. More conclusive paleontological evidence, however, is necessary to prove this point.

Correlation and faunal relationships of the Manistique Dolomite. -- The Schoolcraft strata of the Manistique Dolomite may be represented in part by the "Syringopora tenella" and "Pentamerus oblongus" beds of the Hopkinton described by Calvin (1898, p. 71; 1898, p. 147-150; 1907, p. 195) and by Calvin & Bain (1900, p. 445, 452-459). This is suggested by the abundance of Pentamerus in the Schoolcraft strata - especially in the lower and upper Pentamerus dolomites, and by the occurrence in these dolomites of a coral which is closely related to or identical with Syringopora tenella.

The remarkable continuity of the Schoolcraft strata across the eastern half of the Northern Peninsula leads the writer to predict that some or all of these strata will be found in northeastern Wisconsin and the Cockburn-Manitoulin Islands region. In Wisconsin these strata should be found in the upper part of the Lower Coral beds and in the Cockburn-Manitoulin Islands region in the "undivided Lockport" beneath the Fossil Hill Coral horizon of Williams (see Williams, 1919, p. 61).

In the Lake Timiskaming region, Hume (1925, p. 35) has found Pentamerus in beds just above the basal sandstone of his so-called Lockport Formation, which rests disconformably on the Wabi Formation. The stratigraphic relationship existing between these formations, is very similar to that present between the Burnt Bluff and Schoolcraft strata; the Burnt Bluff strata which have the same fauna as the Wabi Formation, are overlain disconformably by the lower Pentamerus dolomite of the Schoolcraft Member. This striking similarity in stratigraphic relationship, which is supported by the occurrence of higher Manistique-Cordell fossils in higher strata of the Lockport of Lake Timiskaming, suggests very strongly that lower Lockport strata of Lake Timiskaming are equivalent in age to the Schoolcraft beds. The presence of Halysites compactus Rominger in the Lockport of the Lake Timiskaming area (see Hume, 1925, p. 38) and in the upper Pentamerus dolomite of the Schoolcraft also points to the same stratigraphic relationship.

The Cordell Member of the Manistique is represented in Iowa by some of the strata of the Hopinkton Dolomite. As pointed out by Foerste (April 1929, p. 61, 62, and August, 1929, p. 142) this relationship is shown by the presence in the Hopkinton of Cordell types of cephalopods. The Hopkinton cephalopods were described by A. O. Thomas (1915, p. 292-300) as Huronia vertebralis, H. obliqua, H. subcylindrica, H. hopkintonensis, H. turbinata, Discosorus (?)

FIG. 31 - Burnt Bluff strata, Seaman's Quarry, Drummond Island. Loc. 91.

FIG. 32 - Schoolcraft Member of Manistique, White Marble Lime Company Quarry in town of Manistique. Loc. 105.

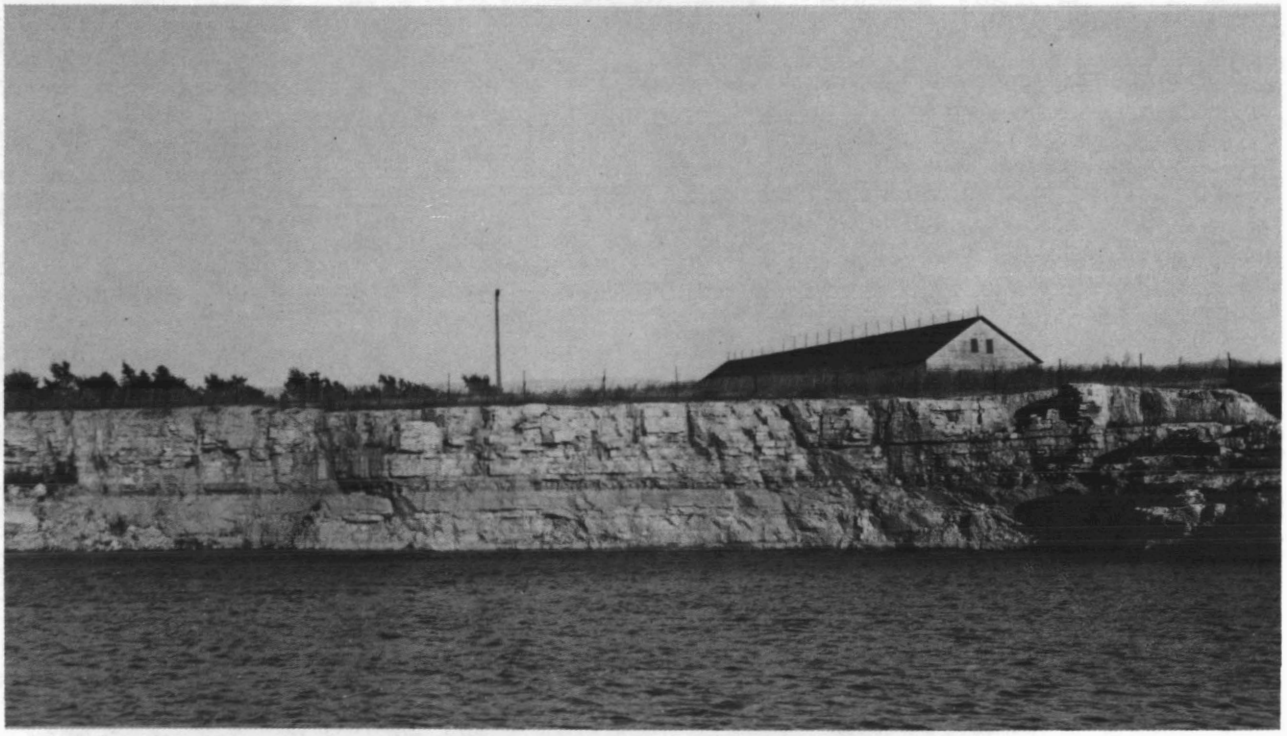


FIG. 33 - Schoolcraft Member of Manistique, White Marble Lime Company Quarry in town of Manistique. Loc. 105.

FIG. 34 - Cordell Member of Manistique, extension of White Marble Lime Company Quarry on property of George Nicholson. Loc. 105.

biconoideus, and Actinoceras cf. richardsoni. In the writer's opinion the two specimens described and figured as Huronia vertebralis are Huronia bigsbyi Stokes. The specimen noted as Huronia obliqua seems to be more closely related to a variety of Huronia minuens Barrande. Although unlike any Cordell species, the specimen of Huronia hopkintonensis resembles H. paulodilatata Foerste. The Hopkinton form of Huronia turbinata seems to be identical with Cordell forms of this species. The specimens described as Discosorus (?) biconoideus suggest very much Stokesoceras gracile (Foord) and S. romingeri Foerste. The cephalopod noted as Actinoceras cf. richardsoni Stokes is probably identical with Armenoceras gouldense Foerste. With one exception, all of the species to which the present writer has referred the Hopkinton cephalopods are characteristic of the Cordell strata. The excepted species, Stokesoceras romingeri, has been reported from Burnt Bluff as well as Cordell strata. Several characteristic Cordell corals (see Table 5), including Streptelasma (probably Lindstromia) spongaxis Rominger, S. patula Rominger, Zaphrentis stokesi Edwards & Haime, Cystiphorolites major (Rominger), C. minor (Rominger), Arachnophyllum pentagonum Rominger, Lyellia americana Edwards & Haime, L. decipiens Rominger, Alveolites undosus Miller, Cladopora laqueata Rominger, Favosites favosus (Goldfuss), F. hispidus Rominger, F. obliquus Rominger, Syringopora tenella Rominger, and S. verticillata Goldfuss, which have been listed by Calvin (1896, p. 63, 80; 1898, p. 156-157) as occurring in the Hopkinton (= Delaware of Calvin's earlier reports), also show that some of the Hopkinton strata and the Cordell beds are of the same age.

The Upper Coral beds of northeastern Wisconsin undoubtedly are continuous with the Cordell beds of the Northern Peninsula. When all of the fossils of these beds are described and compared it will be evident that these beds have the same fauna.

It is possible that the Waukesha Formation in the Milwaukee-Waukesha region of Wisconsin contains beds which are equivalent in age to the Upper Coral beds and some of the Lower Coral beds of northeastern Wisconsin and their correlatives, the Cordell and Schoolcraft strata of the Northern Peninsula. On account of the fact that the typical Waukesha fauna is somewhat different from those of the strata noted above, further paleontological studies seem necessary to determine whether these strata are exactly equivalent in age to the Waukesha Formation.

If the Upper Coral and some of the Lower Coral beds of Wisconsin should prove to be faunally different from the Waukesha and, as the writer believes are a continuation of the Cordell and Schoolcraft strata of the Northern Peninsula, it would then be advisable to drop the terms "Upper Coral beds" and "Lower Coral beds" and apply the names Cordell and Schoolcraft or Wisconsin locality names to these deposits.

The Cordell Member is undoubtedly represented on Manitoulin Island and the adjacent part of Ontario to the southeast of this island by strata of M. Y. Williams' "undivided Lockport," the Fossil Hill coral horizon of the prolific coral-bearing Cordell strata. This is shown by the fact that nearly all of the fossils listed by Williams (1919, p. 64-68) as occurring in the "undivided Lockport" of Fossil Hill are also present in the Cordell Member. It is of particular interest to note that the Fossil Hill corals figured by Williams (1919, pls. 14-20) have exact representatives in the Cordell strata.

The Cordell Member is undoubtedly represented by strata in the Lockport formation of Lake Timiskaming. This is clearly shown by an examination of Hume's (1925, p. 38, 39) list of fossils from the Lockport, which contains the names of such characteristic Cordell species as Zaphrentis stokesi Edwards & Haime, Arachnophyllum pentagonum (Goldfuss), Lyellia americana Edwards & Haime, Alveolites undosus Miller, Cladopora laqueata Rominger, Coenites crassus (Rominger), Favosites favosus (Goldfuss) - if exactly like the topotype from Cordell strata, Favosites hispidus Rominger, Syringopora verticillata Goldfuss, Halysites labyrinthicus (Goldfuss), Pentamerus oblongus subrectus Hall & Clarke, Armenoceras gouldense Foerste, Huronia obliqua Stokes, and Huronia cf. paulodilatata Foerste.

The similarity of the Cordell fauna to the Lockport fauna of the Lake Timiskaming area was pointed out by Foerste (1925, p. 64) in his statement that

> the relationship of this (Lockport) fauna to the Niagaran of Drummond Island and northern Michigan is indicated by the presence of Armenoceras cf. gouldense, Huronia paulodilatata,

Huronia obliqua, Stokesoceras cf. romingeri, Stokesoceras cf. engadinense, Stokesoceras perobliquum, and Discosorus ehlersi, forms identical with, or closely related to, Michigan and Lake Huron species.

The Niagaran fauna of Drummond Island and northern Michigan to which Foerste refers the Cordell fauna.

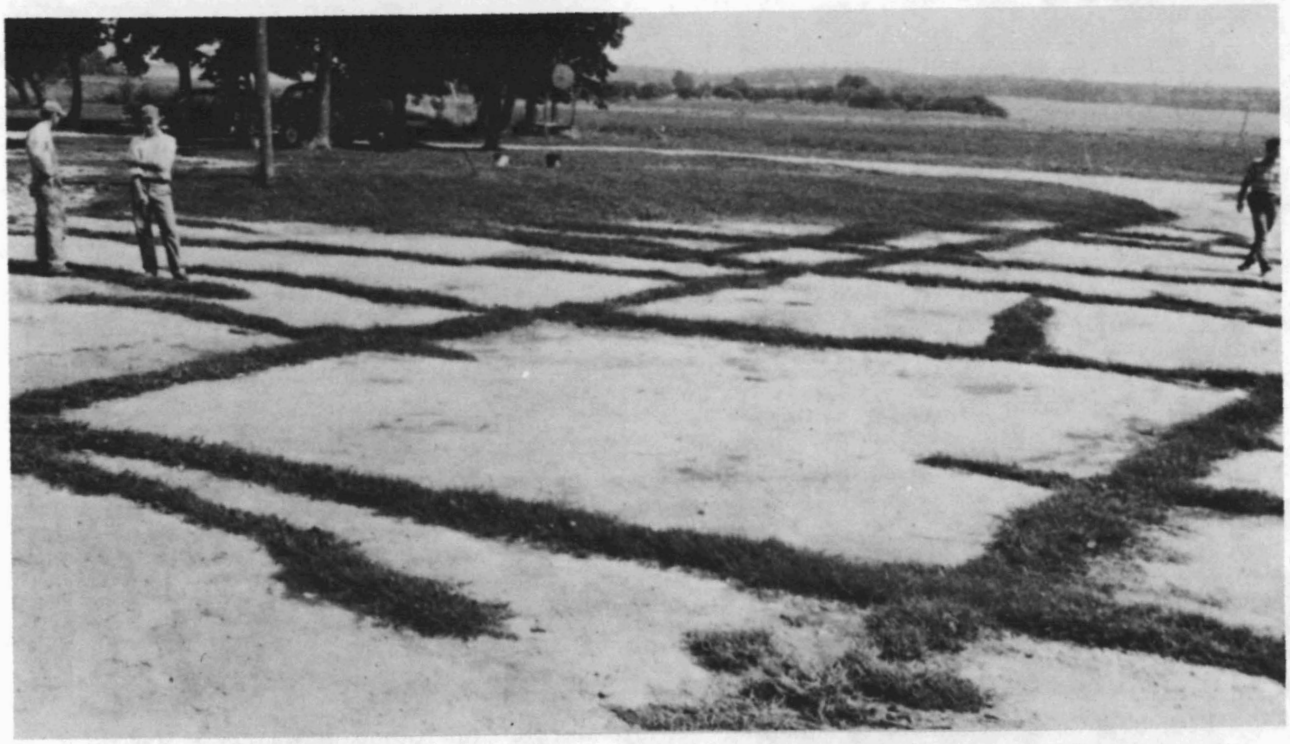
The name Lockport should not be applied to most if not all of the so-called Lockport strata of the Lake Timiskaming region and most of the "undivided Lockport" strata of the Manitoulin Island region because these strata are older than the typical Lockport of New York state. It is quite probable that names Manistique, Cordell, and Schoolcraft, which are used for Michigan strata of equivalent age, can also be applied to these strata. However, a direct comparison of the rocks and faunas of the three regions may show the existence of minor lithologic and paleontologic differences, which will make it seem advisable to substitute Canadian locality names for the Lockport of the Lake Timiskaming and Manitoulin Island regions.

From his studies of Silurian cephalopods, Doctor Foerste (1929, p. 61, 62) concludes that the Manistique is approximately equivalent to the Jupiter and Chicotte Formations of Anticosti Island. The Jupiter contains remains of Huronia obliqua Stokes which, according to Foerste (1928, p. 300), differs from the typical Manistique-Cordell form of this species only in its smaller obliquity. Huroniella persiphonata (Billings) of the Jupiter is closely related to Huroniella ehlersi Foerste of the Cordell beds. Huroniella persiphonata (Billings) is also related to Huronia timiskamingensis Foerste, which occurs in the Lockport Formation of the Lake Timiskaming area, a correlate of the Manistique formation. Discosorus (?) infelix (Billings) of the Jupiter is closely related to forms of Discosorus found in the Cordell beds. Megadiscosours crassisegmentatus orientalis Foerste of the Jupiter is remarkably close to Megadiscosorus crassisegmentatus Foerste of the Lockport Formation of the Lake Timiskaming area. The presence of Megadiscosorus remotus (Foord) in the Cordell strata of Michigan is additional evidence in support of the faunal similarity of the Cordell strata, the Lockport of Lake Timiskaming, and the Jupiter strata. The Chicotte Formation of Anticosti Island contains remains of Huronia vertebralis Stokes which are very similar to forms of the species occurring in the Cordell strata. According to Foerste (1928, p. 300, 301), Huronia chicottense Foerste resembles Huronia paulodilatata Foerste which is present in the Cordell strata of the Manistique. From Foerste's study of the above-mentioned cephalopods it is evident that the Cordell Member of the Manistique is very probably equivalent in age to the Jupiter and Chicotte formations of Anticosti Island.

The correlation of the Jupiter with the Cordell strata is supported by the presence in the latter of a species of Palaeocyclus, which is exceedingly close in its structure to Palaeocyclus rotuloides (Hall), a characteristic coral of zone 5 of the Jupiter (see Twenhofel, 1928, p. 85).

It is possible that some of the higher beds of the Gun River Formation should also be correlated with the Cordell strata. According to Foerste (1928, p. 301, 302), Discosorus gunensis Foerste, which occurs in zone 3 of the Gun River, has its nearest relative in "Stokesoceras engadinense Foerste from the Manistique formation."

It is also possible that some of the higher Gun River strata may be equivalent in age to the Schoolcraft Member of the Manistique Formation. In the Anticosti Island section Pentamerus oblongus Sowerby makes its first appearance in zone 2 of the Gun River Formation. Pentamerus was reported by Case & Robinson (1914, p. 173) as occurring in the Niagaran (Mayville Dolomite of the present paper) of Big Limestone Mountain, Houghton County, Michigan. The specimens identified by Case & Robinson are very poorly preserved and in the writer's opinion are too poorly preserved to warrant a definite generic identification. They are associated with Virgiana decussata (Whiteaves) and may very likely belong to this species. At some places in the Northern Peninsula the writer has found a few remains of Pentamerus in strata a very few feet below the lower Pentamerus dolomite of the Schoolcraft Member. Pentamerus first appears in considerable numbers in the lower Pentamerus dolomite of the Schoolcraft Member and is the most common fossil in this member of the Manistique; all of the specimens of Pentamerus found in this member are referable to one or more of the forms generally identified as Pentamerus oblongus. A new species of Coelospira which is very closely related to Coelospira hemispherica (Hall, Sowerby ?) is present in the uppermost



FIGS. 35, 36 - Cordell Member of Manistique, barnyard in SW$\frac{1}{4}$ NW$\frac{1}{4}$ sec. 19, T 38 N, R 19 W, Delta County, about 1 mile E of Burnt Bluff. Flat rock bedding plane with corals in living positions.

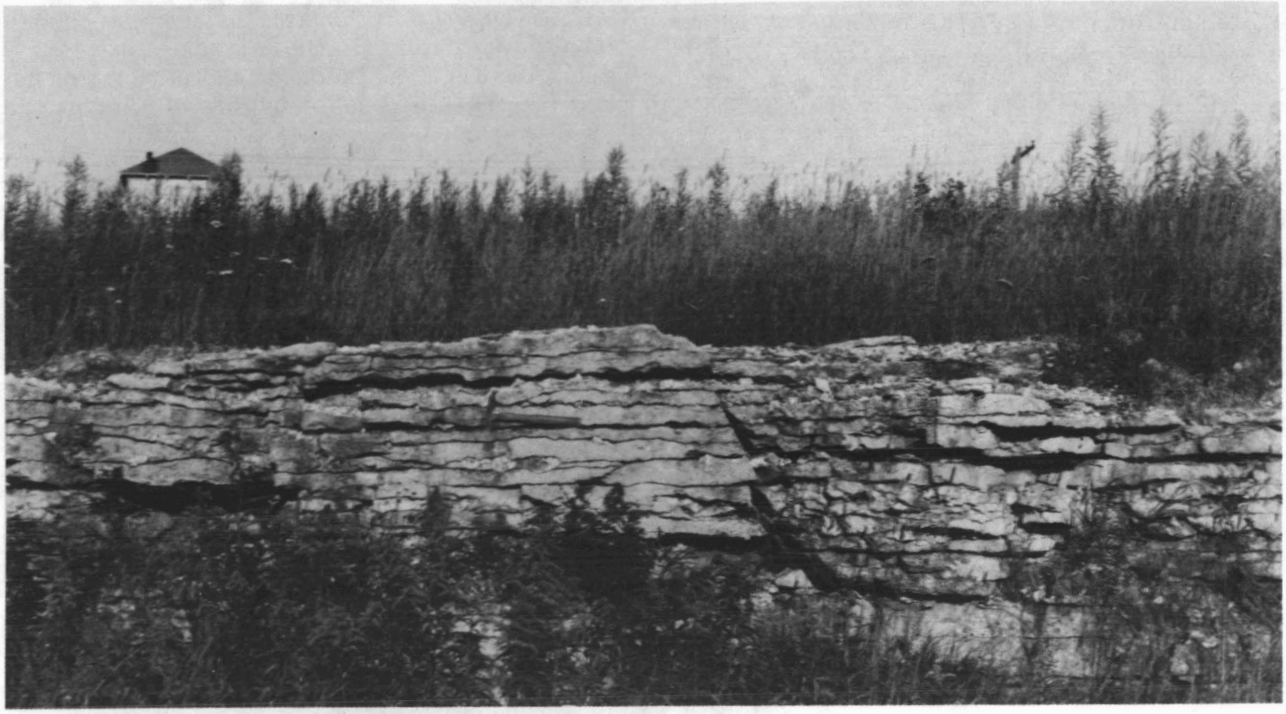


FIG. 37 - Cordell Member of Manistique, White Marble Lime Company Quarry in town of Manistique. Loc. 105.

FIG. 38 - Lower part of Cordell Member, S-facing cliff (perhaps part of old quarry wall) in front of Schoolcraft Memorial Hospital in town of Manistique. Loc. 105.

half-inch of the Schoolcraft member, exposed in the Inland Lime & Stone Company Quarry at Manistique. The occurrence in the Schoolcraft strata of this Coelospira and Pentamerus oblongus and in the higher Gun River strata of Coelospira hemispherica and Pentamerus oblongus suggests, therefore, that some of the higher Gun River strata may be equivalent in age to the Schoolcraft strata.

Certain paleontological evidence suggests that the Schoolcraft Member may be of the same age as the Lower Clinton of New York. As pointed out above, Pentamerus oblongus is the most characteristic fossil of the Schoolcraft. It is found in nearly every bed of this member, being particularly abundant in the lower and upper Pentamerus dolomites. At the top of the Schoolcraft is the new species of Coelospira which is closely related to Coelospira hemispherica (Hall, Sowerby?). As pointed out by Ulrich & Bassler (1923, p. 330, 333, 370, 371), Pentamerus oblongus occurs in the upper third of the "Reynales" Limestone and Wolcott Limestone of the lower Clinton of New York. According to these writers (1923, p. 326, 330-333, 370), Coelospira hemispherica makes its first appearance in the "Reynales" Limestone below the Pentamerus oblongus bed of this limestone and is found in the higher "Bear Creek shale" above the "Reynales" Limestone. Ulrich & Bassler (1923, p. 332) report that two species of Coelospira, neither of which is strictly the same as Coelospira hemispherica, are also present in the lower Clinton Sodus Shale which is underlain by the "Bear Creek shale" and overlain by the Wolcott Limestone. The occurrence of Pentamerus oblongus and the new species of Coelospira in the Schoolcraft suggest that the Schoolcraft strata are of lower Clinton age. A lower Clinton age for the Schoolcraft is further supported by the fact that the upper part of the Gun River, which also contains Pentamerus oblongus and Coelospira hemispherica, is correlated with the lower Clinton of New York by Ulrich & Bassler (1923, p. 369) and by Twenhofel (1928, p. 73).

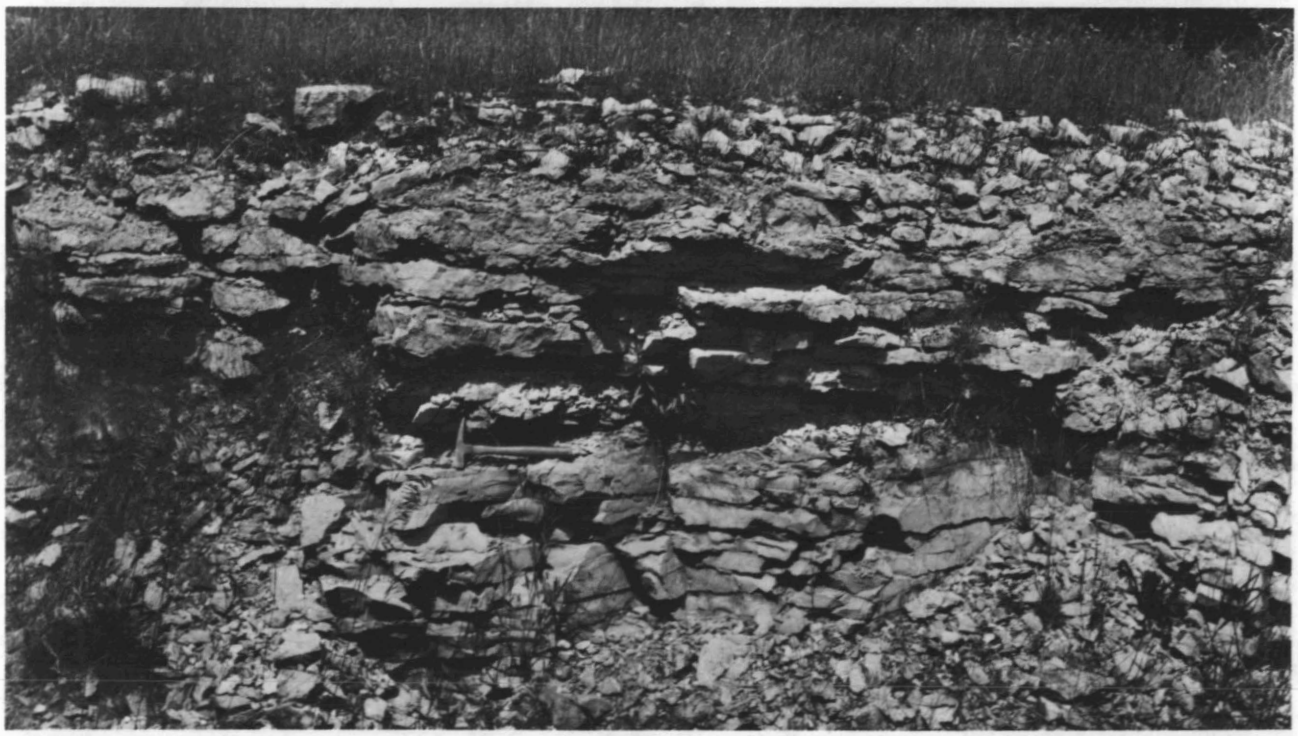
In spite of the seemingly strong evidence suggesting the lower Clinton age of the Schoolcraft the writer believes that the lower Clinton age of this member of the Manistique is not definitely established. This belief is substantiated by a consideration of the geological range of Pentamerus oblongus and Coelospira. Pentamerus oblongus and Coelospira hemispherica are present in every zone of the Jupiter which overlies the Gun River. Pentamerus oblongus is also found throughout the Cordell Member and lower part of the Engadine Dolomite and is reported as occurring in numerous formations of Silurian age. The new species of Coelospira occurring at the top of the Schoolcraft Member is also present in the basal half-inch of the Schoolcraft. Until the numerous, long-ranging forms of Pentamerus oblongus and Coelospira hemispherica are more closely discriminated and more definite paleontologic and stratigraphic evidence is available, the exact relationship of the Schoolcraft strata to the Clinton of New York must remain in doubt.

Certain paleontologic evidence indicates very strongly that the Cordell Member of the Manistique should be correlated with the upper Clinton of New York. In strata less than 7 feet above the Coelospira layer exposed at the base of the Cordell Member in the Inland Lime & Stone Company Quarry at Manistique, the writer found specimens of Fenestella and Lioclema which are closely related to the upper Clinton (Rochester) species Fenestella elegans Hall and Lioclema asperum (Hall). On the top of a dolomite, which is exposed in the Inland Lime & Stone Company quarry about three-quarters of a mile south of Cordell (Scott Quarry) and which apparently occupies a position about 20 feet above the base of the Cordell Member, Drs. Ulrich, Foerste, and Shideler and the writer found several specimens of a Palaeocyclus which is strikingly similar to Palaeocyclus rotuloides (Hall), a diagnostic fossil of the upper Clinton of New York. Palaeocyclus rotuloides is also present in zone 5 of the Jupiter, a formation which Twenhofel (1928, p. 74) correlates with the Williamson and Irondequoit divisions of the upper Clinton of New York. The upper Clinton age of the Cordell Member, which this evidence indicates so strongly, is supported further by the correspondence in stratigraphic position of certain Cordell and Anticosti Island cephalopods. As far as the writer is aware, most, if not all of the Cordell species of Huroniella, Huronia, Discosorus, and Megadiscosorus are present in strata above the dolomite containing Palaeocyclus. With the exception of Discosorus gunensis, which occurs in zone 3 of the Gun River and which, as stated by Foerste (1928, p. 301, 302), finds its nearest relative in "Stokesoceras engadinese Foerste from the Manistique formation (Cordell member)," and an unidentified species of Huroniella, which occurs in zone 1 of the Gun River (see Twenhofel, 1928, p. 93, 94), all of the Anticosti Island species of Huroniella, Huronia, Discosor-

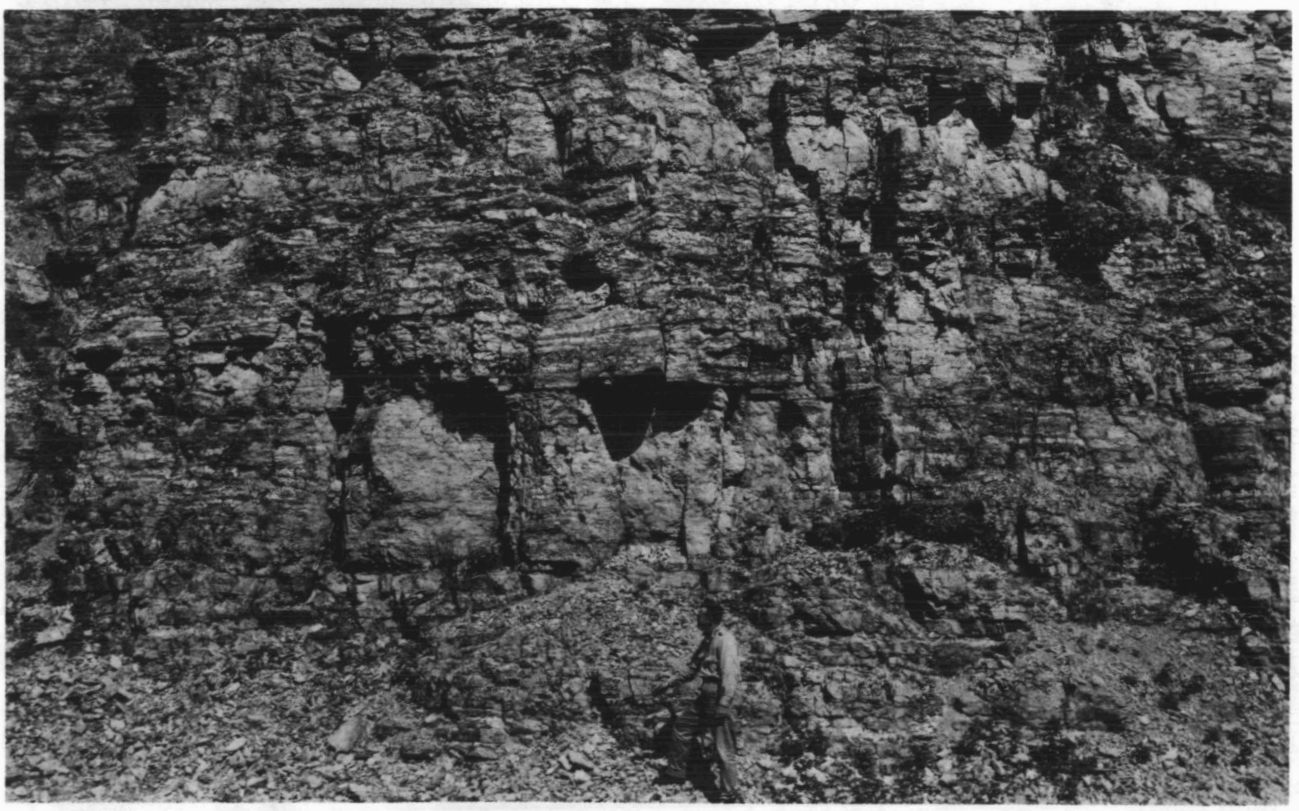
us, and Megadiscosorus are found either in the Palaeocyclus rotuloides zone (zone 5) of the Jupiter, higher zones of the Jupiter, or zones of the overlying Chicotte, which Twenhofel (1928, p. 74) believes is in part largely of Rochester-upper Clinton age. The upper Clinton age of the Cordell Member, which is indicated by the stratigraphic occurrences of these cephalopods, is emphasized by the presence in the Cordell Member of species of Huroniella, Huronia, Discosorus, and Megadiscocorus, which have exact or closely related representatives in the Jupiter or Chicotte Formations.

The appearance in the Manistique and Anticosti strata of Coelospira in association with Pentamerus oblongus, followed by that of Palaeocyclus and then by several related species of Huroniella, Huronia, Discosorus, and Megadiscosorus may be repeated in the Niagaran strata of the Lake Timiskaming and Manitoulin Island regions, Wisconsin, and Iowa. In the Lake Timiskaming region, the appearance of Pentamerus oblongus in the basal part of the Lockport corresponds exactly to the appearance of this brachiopod in the Schoolcraft Member of the Manistique. In higher beds of the Lockport of this region species of cephalopods are present which are identical with or are closely related to species occurring in the Cordell strata of the Manistique and related Anticosti deposits. Neither Coelospira nor Palaeocyclus has been reported as occurring in the Lockport of this region. Their absence, however, may be more apparent than real. In the Northern Peninsula, Coelospira was found in a band of rock only one inch thick and Palaeocyclus was found on the upper surface of a dolomite, brought to view by the blasting of the dolomite from the quarry wall. If Coelospira and Palaeocyclus were present in the Lockport of Lake Timiskaming region in small numbers and were confined to such thin bands of rock, their discovery would be largely a matter of chance. Pentamerus-bearing beds are present below the Fossil Hill coral horizon of the Lockport of the Manitoulin Island region. Some of these beds, if not all, are with little doubt an eastward continuation of the lower and upper Pentamerus dolomites and other Pentamerus-bearing strata of the Schoolcraft Member. Two typical Cordell cephalopods, Huronia vertebralis and Discosorus gracilis Foord (= Stokesoceras gracile), were reported as occurring in the Lockport of Manitoulin Island by Williams (1919, p. 68). Although their exact stratigraphic position in the Lockport was not given by Williams, these cephalopods most probably came from the Fossil Hill coral beds or strata just above or below these beds. So far as known no specimens of Palaeocyclus or Coelospira have been found in the Lockport of this region. However, it is reasonable to expect that they may be found because the Manistique Formation, containing remains of these genera, must be well represented in the so-called Lockport of this region. In northeastern Wisconsin Pentamerus oblongus is present in considerable abundance in the Lower Coral beds. Huronia annulata Hall, which is present with other species of Huronia, Huroniella, Discosorus, and Megadiscosorus in Cordell strata above the Palaeocyclus-bearing dolomite, was reported by Chamberlain (1878, p. 353) as occurring in the Upper Coral beds, which as previously stated are continuous with the Cordell Member of the Manistique. No species of Palaeocyclus has been reported from the Upper Coral beds or other Niagaran strata of northeastern Wisconsin. Whitfield (1882, p. 356) listed two species of Coelospira, C. planoconvexa (Hall) and C. plicatula (Hall), from the "Niagara" of Wisconsin. The first of these species may have been collected from the Mayville Dolomite, in view of the fact that it was previously reported by Chamberlin (1878, p. 340) as occurring in this dolomite. The exact stratigraphic position of the second species, Coelospira plicatula, in the Wisconsin Niagaran Series is not known. According to Chadwick (1918, p. 343-345), this species is present in the Furnaceville iron ore in association with Coelospira hemispherica and in the Reynales Limestone in association with Pentamerus oblongus. Both of these stratigraphic units are of lower Clinton age. Pentamerus oblongus is present in considerable abundance in the Hopkinton Dolomite of Iowa. As previously stated, the "Pentamerus oblongus bed" of Calvin and Calvin & Bain may be equivalent to some part of the Schoolcraft Member of the Manistique. Traces of Coelospira were found by Calvin (1896, p. 87) in the "upper part of the Delaware stage (= Hopkinton)" of Wyoming township, Jones County, Iowa. Further studies may show that this Coelospira is Coelospira hemispherica or the closely related Manistique species and that it occupies a stratigraphic position similar to the latter species. As far as the writer is aware no specimens of Palaeocyclus have been reported from the Hopkinton Dolomite. In the Museum of Paleontology of the University of Michigan are

FIGS. 39, 40 - Cordell Member of Manistique, road cut of US 2 about 10 miles E of Manistique. Loc. 108. Beds contain much chert but yield few weathered fossils.



FIGS. 41, 42 - Cordell Member of Manistique, Scott Quarry. Loc. 124.



two specimens of Palaeocyclus which are catalogued under the number 5384 and are accompanied by a label in Dr. Carl Rominger's handwriting bearing the inscription "Palaeocyclus iowensis n. sp. - Niagara grp. - Iowa". These specimens, which are larger than Palaeocyclus rotuloides and the related Cordell species and seemingly belong to a new species as Rominger has indicated, probably were collected from the Hopkinton Dolomite. This is indicated by the fact that these corals are silicified like many of the Hopkinton fossils and by the fact that the matrix adhering to the corals is similar to that adhering to many other corals which Rominger collected from the Hopkinton Dolomite. Many of the Hopkinton corals collected by Rominger and deposited at the University of Michigan, are identical with or very closely related to Cordell species, which are found in greatest abundance above the Palaeocyclus-bearing dolomite in association with Armenoceras, Huroniella, Huronia, Discosorus, and Megadiscosorus. The occurrence of these cephalopods and Palaeocyclus in the Cordell suggests the possibility that the Hopkinton species of Palaeocyclus may occupy a position just below strata with Hopkinton species of Armenoceras, Huronia, and Discosourus, which as previously shown have exact or closely related representatives in the Cordell.

In the Chaleur (Niagaran) series of the Port Daniel-Cascons area of southeastern Quebec, Professor Schuchert found a similar order of occurrence of Coelospira hemispherica, Palaecyclus rotuloides, and Huronia and a still higher zone containing a Monograptus related to Monograptus clintonensis (Hall). The presence of a Monograptus of the Monograptus clintonensis type above beds containing Huronia, which eventually may prove to be related to one or more of the Jupiter, Chicotte, and Cordell species, is of considerable stratigraphic interest. Monograptus clintonensis is one of the most characteristic fossils of the Williamson Shale of New York. In view of the fact that this shale is the basal formation of the upper Clinton of this state, it is reasonable to suppose that the formations of the Port Daniel-Cascons area containing Huronia, Palaeocyclus rotuloides, and Coelospira hemispherica and also the Jupiter containing the same fossils are of Pre-upper Clinton age. The pre-upper Clinton age of these formations would seem to be supported by the evidence of certain ostracods, which lead Ulrich & Bassler (1923, p. 347, 368-371) to correlate the Jupiter with the Sodus Shale of the lower Clinton of New York. Twenhofel (1928, p. 73, 74), however, disagrees with these geologists and states that the Jupiter is the much enlarged equivalent of the Williamson and Irondequoit divisions of the upper Clinton of New York. The presence (see Twenhofel, 1928, p. 84, 85) of the characteristic upper Clinton fossils, Monograptus clintonensis in zones 2, 3, and 4 of the Jupiter and Palaeocyclus rotuloides in zone 5 of this formation is certainly very strong evidence in support of the upper Clinton age of the Jupiter. Furthermore, the occurrence of Palaeocyclus rotuloides above Monograptus clintonensis in both the Jupiter and the upper Clinton at Clinton, New York (see Ulrich & Bassler, 1928, p. 346, 382) points to the essential contemporaneity of these deposits. If the Jupiter is of upper Clinton age as Twenhofel's evidence strongly indicates, then the lower Clinton types of ostracods found in this formation by Ulrich & Bassler must be considered as recurrent forms. Similarly, the Monograptus of the Port Daniel-Cascona area represents a second, later appearance of a graptolite of the Monograptus clintonensis type.

From the discussion of the various paleontological and stratigraphical relationships given in the preceding paragraphs it is evident that several interpretations may be made in regard to the correlation of the Manistique with the typical Clinton of New York. The Schoolcraft Member of the Manistique may be correlated with the lower Clinton and the Cordell Member with the upper Clinton. The Manistique as a whole may be correlated either with the lower, middle, or upper Clinton.

As a result of his studies the writer is inclined to believe that the entire Manistique should be tentatively correlated with the upper Clinton. Until the Manistique fauna is compared with the numerous Clinton faunas of North America it seems unwise to make a more definite correlation.

It is possible that the solution to the problem of correlation of the Manistique with the Clinton of New York may be found in Ontario. The New York Clinton has been traced westward from the Niagara River to the Hamilton, Ontario, region, beyond which it is thought to be absent. Some of the Manistique strata, which are certainly represented in the "undivided Lockport" of the Manitoulin Island region, probably continue southeastward into Ontario for a consider-

able distance. An attempt to trace these strata to the Hamilton region may result in the finding of physical and faunal evidence showing the exact stratigraphic relationship of the Manistique to the New York Clinton.

The faunal and stratigraphic evidence given on previous pages indicates that the sea in which the Manistique strata were deposited, extended southwestward from the Gulf of St. Lawrence to the Lake Timiskaming region, Michigan, Wisconsin, and Iowa. The presence in the New York Clinton and Manistique strata of a few closely related species suggests an extension of this sea into New York State. However, distinct differences between the Manistique and New York Clinton faunas raises considerable doubt as to whether there was a direct sea connection between New York and Michigan. In the writer's opinion it is very doubtful whether the Manistique sea ever reached the area west of Hudson Bay. The presence in the Attawapiskat Limestone of Armenoceras and Huroniella, which are characteristic of the Cordell strata of the Manistique, suggests the possibility of an extension of the Manistique sea in this direction. However, on account of the fact that the fauna of the Attawapiskat Limestone is more closely related to those of the Ekwan River, Severn River, and Burnt Bluff strata than to that of the Manistique, it seems more likely that the Attawapiskat Limestone was deposited in a sea of earlier date than the Manistique. This Attawapiskat sea like those of the Severn River and Ekwan River probably came from the Arctic. In this connection it is interesting to note that Actinoceras, Armenoceras, Huronia, Stokesoceras, and Discosorus have been reported from several places in the Arctic (see Foerste, 1921, p. 258; 1924, p. 25; 1928, p. 3, 6, 76, 77, 88-91; April 1929, p. 62, 63; Foerste & Savage, 1927, p. 19, 21, 22). Some of these actinoceroids may belong to the fauna of the Attawapiskat sea. The occurrence of two Cordell species of actinoceroids, Armenoceras sphaeroidale (Stokes) and Armenoceras backi (Stokes), in the Arctic suggests an extension of the Manistique sea into this region. The Arctic specimens of Armenoceras sphaeroidale, which were found in Dobbin Bay, Ellesmere Land, have been studied by Doctor Foerste (1928, p. 6, 76, 77), who states that the identification of these specimens as Armenoceras sphaeroidale is not satisfactory. The Arctic specimens of Armenoceras backi, which were collected from Bessels Bay, Greenland, and Cape Louis Napoleon, Ellesmere Land (see Foerste 1921, p. 258; 1924, p. 37, 38), were identified many years ago at a time when species were not as finely differentiated as at present. In view of the doubt as to the specific identity of these Arctic cephalopods with the Manistique species, the presence of the Manistique sea in the Arctic is not definitely established.

Engadine Dolomite

General Description. -- The Engadine Formation consists of very thick beds of hard, highly crystalline dolomite of a predominant white color. Some beds are bluish-white or very light gray. On weathering the color of the beds, especially the bluish-white ones, changes to a light-buff or brown. The weathered surfaces of the dolomite, however, are strikingly white; as a result, outcrops and detached blocks of the rock can be recognized at long distances. Some of the higher beds lack well-defined bedding planes and have many cavities, which are more or less completely lined with crystals of dolomite. In the unweathered state the dolomite (especially in the lower part of the formation) generally appears very massive, but in the weathered condition often shows numerous, closely spaced and uneven planes of bedding.

The Engadine is practically without impurities, its chemical composition being that of the mineral dolomite. At some places, numerous grains of quartz sand and few grains of almandite garnet are present in the dolomite. The much-rounded and frosted surfaces of these grains suggest that the latter were abraded by the wind and perhaps blown into the Engadine sea.

At most exposures, the basal beds of the Engadine are decidedly different lithologically from the uppermost beds of the Manistique and as a result the contact between the formations is sharply defined. At some localities, however, the basal strata are thinner-bedded, buff-tinted, and more finely crystalline and hence seem transitional in lithology to the uppermost Manistique beds. These transitional strata are well shown on the shore of a small point of land in the $SW\frac{1}{4}$ sec. 33, T 37 N, R 19 W, about three-quarters of a mile north of the southwestern point of Big Summer Island (Locality 138). At this locality about 7 feet of typical white Engadine Dolomite overlies 5 feet of dolomite, which is more buff in color than the typical Engadine

FIG. 43 - Cordell Member of Manistique, Scott Quarry. Loc. 124.

FIG. 44 - Cordell Member of Manistique, top of bluff S of Raber. Loc. 126. Silicified fossils in natural exposure.

FIG. 45 - Engadine Dolomite, exposure NE of Cedarville.

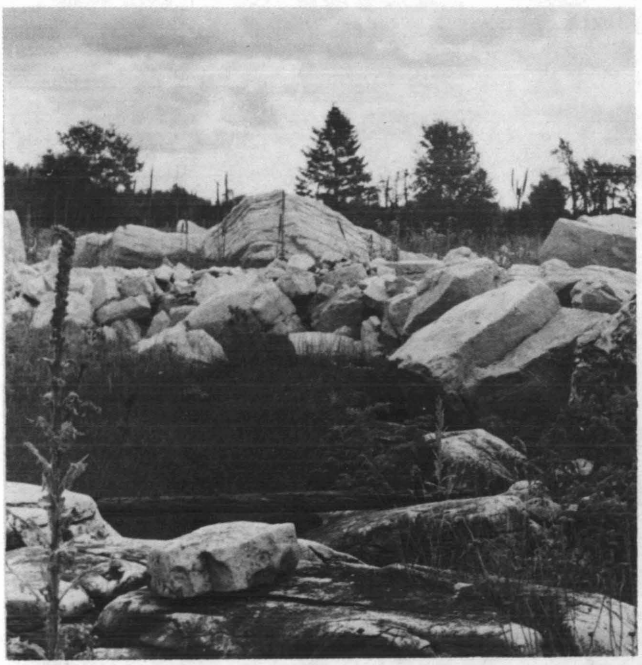


FIG. 46 - Engadine Dolomite, about 1 mile WSW of Engadine. Trenches formed by solution along joints.

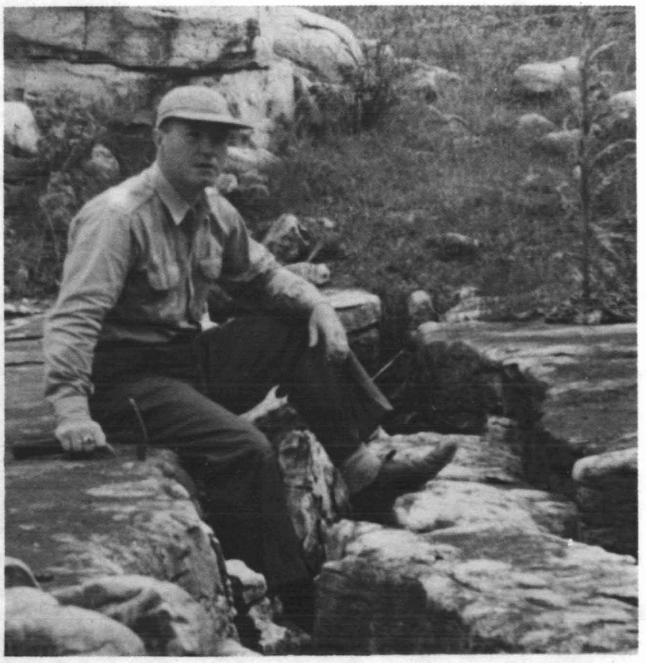


FIG. 47 - Engadine Dolomite, about 1 mile W of Engadine. Natural blocks the result of weathering.

and shows somewhat thinner bedding. The last-mentioned dolomite rests on 3 feet of thin-bedded, brown dolomite of the Manistique Formation. The 5 feet of dolomite are transitional in lithological character to the typical Engadine and Manistique strata. They resemble the Engadine Dolomite more closely than the Manistique strata, however, and hence are included by the writer in the former stratigraphic unit.

The contact between the Engadine Dolomite and the overlying, so-called Monroe-Salina strata has never been seen. The contact probably is not far from McDonald's Rapids of the Carp River, located about 4 miles northwest of Charles in Mackinac County. A hard, closely jointed, earthy-appearing, bluish to buff-gray "Monroe-Salina" dolomite with reddish-tinged areas is present in the bottom of the river at these rapids. Along the stream at this place are numerous blocks of Engadine dolomite and a darker, brownish-gray, more finely crystalline dolomite, which probably is of "Monroe-Salina" age. The presence of numerous detached blocks of Engadine Dolomite may indicate that ledges of this dolomite are not far away and that the contact between the Engadine Dolomite and the "Monroe-Salina" strata crosses the Carp River a short distance to the northwest of McDonald's Rapids.

Detailed sections. -- These are listed and discussed by counties.

Delta County

The Engadine Dolomite in Delta County underlies most of the Point Detour peninsula, a large part of Big Summer Island, and all of Poverty Island.

Some of the more lakeward-extended peninsulas between Point Detour and Point aux Barques, Lake Michigan, may possibly be underlain by the formation. James Hall's (1851, p. 158) description of exposures between these points as consisting of extremely hard rock with considerable magnesia and a small amount of silica suggests the presence of the Engadine.

In the writer's opinion, however, it seems more probable that the land adjoining this part of the Lake Michigan shore is underlain by Manistique strata. This opinion is supported by the fact that several localities along this part of the Lake Michigan shore visited by the writer, are underlain by Manistique strata.

Point Detour Peninsula:

LOC. 134. The Engadine is present in low exposures on the sides and extremity of the Point Detour Peninsula. It consists almost entirely of massive, white to bluish-white dolomite with few cavities, which may have been occupied originally by favositoid corals and stromatoporoids.

LOC. 135. On the southwest shore of the peninsula about 1 mile northwest of Point Detour, the Engadine is thinner-bedded and more brownish-gray in color, suggesting the transitional phase of the dolomite just above the contact with the Manistique.

Big Summer Island:

LOC. 136. The Engadine dolomite underlies the eastern two-thirds of Big Summer Island, being exposed at many places along its north, east, and south shores. On the north shore, it appears in low cliffs, usually 3 to 5 feet in height.

LOC. 137. The outcrops on the east and south shores usually do not reach a height of more than 4 feet above the lake. Along a large part of the east shore, the dolomite outcrops as a natural pavement. Such a pavement is present for a distance of nearly a quarter of a mile along the central portion (sec. 35, T 37 N, R 19 W) of the eastern shore. The dolomite of this pavement contains numerous molds of Pentamerus.

LOC. 138. The Engadine-Manistique contact is shown near the southwestern point of the island ($SW\frac{1}{4}$ sec. 33) and has been described above.

Poverty Island:

LOC. 139. Poverty Island, located a short distance southwest of Big Summer Island, seems to be entirely underlain by the Engadine dolomite. Nearly continuous exposures of the dolomite are present on the east, south and west shores.

On the west shore the rock outcrops in vertical cliffs, rising 10 to 12 feet above the lake. A somewhat thinner bedding of the dolomite in the basal part of the cliffs, suggests the presence of the transitional beds noted on Big Summer Island and perhaps indicates the proximity of the contact with the Manistique. Unfortunately, it could not be determined whether the contact is actually visible, owing to the fact that

high waves prevented the writer from coming alongside the cliffs in a boat.

Schoolcraft County

The only exposures of the Engadine dolomite in Schoolcraft County are in two outliers at Whitedale (Locality 112), on the side of the Seul Choix Point peninsula, and at several places in a narrow strip of land bordering the Lake Michigan shore to the northeast of Seul Choix Point.

LOC. 140. On both sides of the Seul Choix Point peninsula, the Engadine strata show prominent dips. Those on the southwest shore dip in that direction, some beds offshore standing prominently above the lake as a broken line of huge blocks. Those on the opposite shore dip toward the northeast.

LOC. 141. At several places along the shore between Seul Choix Point and the outlet of Bulldog Creek to the northeast, Engadine strata occur on the beaches or as pavements in the shallows near shore.

Mackinac County

Exposures of the Engadine Dolomite are very numerous in Mackinac County. Many of the large exposures have been described in detail by R. A. Smith (1916, p. 151, 152, 234, 240-242) and hence are not discussed in the present paper.

South and southeast of Gould City:

LOC. 142. The Engadine dolomite is at or near the surface of most of the west half of sec. 20, the east half of sec. 21, the NW$\frac{1}{4}$ sec. 28, and the NE$\frac{1}{4}$ sec. 29, T 42 N, R 11 W, about 5$\frac{1}{2}$ miles south of Gould City (adjacent to Locality 117).

LOC. 143. Several sinks have been formed in the dolomite in the southeast-quarter of sec. 20. The largest of these sinks, 150 feet in diameter, is located about one-quarter of a mile west of the SE corner of sec. 20 and about 500 feet north of the south line of this section. A stream flowing from the northwest disappears in this sink and apparently reappears at the surface in the NW$\frac{1}{4}$ sec. 28 about one-half mile to the southeast. A small sink, opening into a cave, is present about 75 feet west of the east line of sec. 20 and about 200 feet north of the south line of the section. In this cave there is a southerly flowing stream, which is either the underground stream flowing southeasterly from the large sink or a tributary to this stream.

Narrow, linear, depressed areas of thin soil, intersecting each other at right angles in the vicinity of the sinks, indicate that considerable solution has taken place along the joints of the underlying Engadine Dolomite.

LOC. 144. Southeast of Gould City the dolomite is at the surface of a very large area about three-quarters of a mile in width, extending northeastward for 2 miles from the NE$\frac{1}{4}$ sec. 22 to the western part of sec. 12, T 42 N, R. 11 W.

Lake Michigan shore near Epoufette:

LOC. 145. The Engadine Dolomite is exposed along the shore of a point of land, designated by fishermen as East Epoufette Point and located about 1 mile southeast of the village of Epoufette in sec. 10, T 42 N, R 7 W.

Specimens of Clathrodictyon sp., Pycnostylus guelphensis Whiteaves, and two species of Favosites were collected by the writer from the dolomite at this point.

LOC. 146. A larger exposure of the Engadine Dolomite is shown on Epoufette Point - West Epoufette Point of local fishermen - located a little more than a mile west of East Epoufette Point, in sec. 8.

LOC. 147. A small, though very interesting outcrop of the Engadine Dolomite is present on the eastern shore of Epoufette Point Island. The dolomite in this outcrop contains abundant grains of sand, composed largely of quartz and some almandite garnet. The frosted surfaces of these grains of sand suggest very strongly that the grains were subject to wind abrasion and probably were blown into the Engadine sea. The dolomite, which contains few remains of Pycnostylus guelphensis, differs from its typical lithologic character in being thinner-bedded and in having a darker bluish-gray color. An apparent radial dip of the beds indicates the presence of a small, low, dome-like structure in the dolomite of this island.

Ozark and vicinity: The prominent escarpment, located 3 miles east of Trout Lake, Chippewa County, extends southward to Ozark, Mackinac County.

LOC. 148. About 22 feet of Engadine Dolomite

FIG. 48 - Engadine Dolomite in Drummond Dolomite Quarry, Drummond Island. This photo and figures 49-51 taken by Woodrow Jarvis, Spring Bay Studio, Detour, Michigan, in 1955.

FIG. 49 - Engadine Dolomite being quarried in Drummond Dolomite Quarry, Drummond Island.

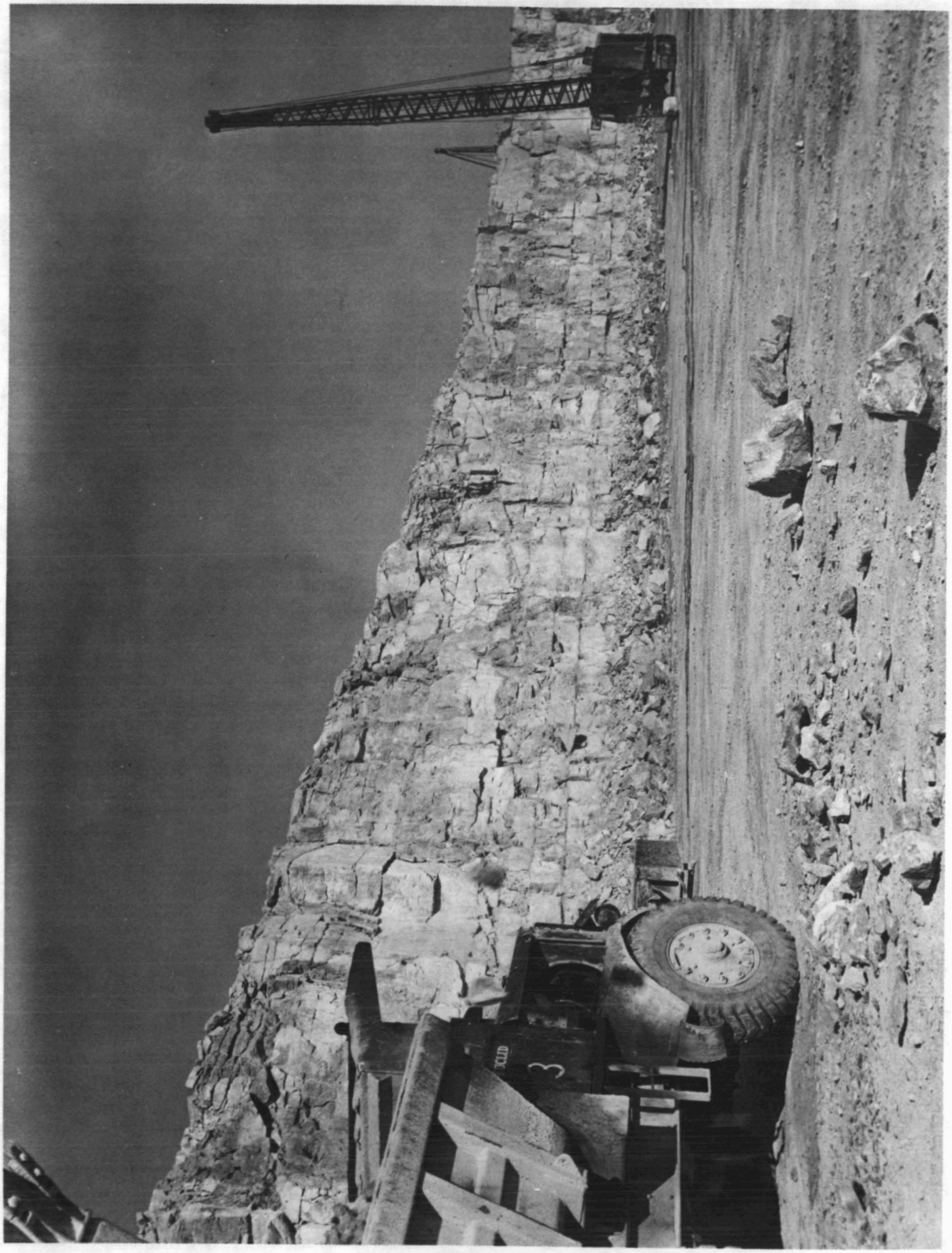


FIG. 50 - Engadine Dolomite, Drummond Dolomite Quarry, Drummond Island.

are well shown in a quarry, excavated in this escarpment about one-third of a mile northeast of the railroad depot at Ozark. From the dolomite of this quarry, which has been described in detail by R. A. Smith (1916, p. 240, 241), the writer collected poorly preserved specimens of Amplexus cf. A. whitfieldi Miller, Amplexus ? sp., Pycnostylus guelphensis Whiteaves, Zaphrentis ? sp., Arachnophyllum cf. A. pentagonum (Goldfuss), Cystiphyllum sp., Favosites sps. nos. 1, 2, and 3, Dalmanella sp., Pentamerus cf. P. oblongus bisinuatus (McChesney), Pentamerus sp., Camarotoechia ? sp., Atrypa ? sp., Cyrtia ? sp., and Spirifer ? sp. - an unplicated form.

LOC. 149. The Engadine is exposed in the railroad cut about 1½ miles south of the depot at Ozark and at the surface of the land on the east and west sides of the railroad cut.

At the south end of the cut there is a southward-facing bluff, which extends for a considerable distance east and west of the railroad. About 40 feet of Engadine Dolomite are shown in the vicinity of a quarry, excavated in the bluff a short distance east of the railroad.

LOC. 150. A small exposure of the Engadine Dolomite is exposed on the railroad cut near Murray about 2 miles south of Ozark.

Kenneth:

LOC. 151. Exposures of the Engadine Dolomite are present in a railroad cut just south of Kenneth and in a small, abandoned quarry a short distance east of this cut, sec. 28, T 43 N, R 5 W.

From the dolomite near the south end of the railroad cut the writer collected poorly preserved specimens of Clathrodictyon ? sp., Favosites sps. nos. 1, 2, and 3, Trimerella aff. T. grandis Billings, Monomerella ? sp. (possibly beak of Pentamerus), Clorinda ? cf. C. ventricosa (Hall), Spirifer ? cf. S. (Delthyris) crispus (Hissinger), Straparolus cf. S. mopus Hall, Poleumita cf. P. scamnata Clarke & Reudemann, Poleumita ? sp., Diaphorostoma niagarense (Hall), cf. Pycnomphalus solarioides (Hall), Dawsonoceras sp., Kionoceras aff. K. scammoni (McChesney), and Leperditia ? sp.

LOC. 152. The Engadine is at the surface of a large part of sec. 29, T 43 N, R 5 W, about 1 mile west of Kenneth.

According to residents at Kenneth, it outcrops in the eastern parts of secs. 19 and 30 of this township.

It is also present along the banks of the Carp River in the vicinity of a small dam, located near the south line of sec. 30.

Areas southeast and east of Pine River:

LOC. 153. A low bluff of Engadine Dolomite is present along the shore of Lake Huron about 1 mile southeast of the mouth of Pine River. It extends southeastward from the south-central part of sec. 11 to the northwestern part of sec. 13, T 42 N, R 3 W.

A second, higher bluff of this dolomite is present a short distance farther inland in sec. 11.

The dolomite is also at the surface of a considerable portion of the eastern part of sec. 11 and the western part of sec. 12.

LOCS. 154, 155. Outcrops of the Engadine Dolomite are present along the St. Ignace-Sault Ste. Marie highway at points 3 and 6 miles east of the Pine River (south lines of secs. 6 and 3, T 42 N, R 2 W).

LOC. 156. A low southward-facing bluff of Engadine Dolomite nearly three-quarters of a mile in length is present in sec. 15, T 42 N, R 2 W, about 6 miles southeast of the mouth of Pine River.

From the dolomite of this bluff the writer collected poorly preserved specimens of Diphyphyllum ? cf. D. caespitosum (Hall), Halysites catenularia (Linnaeus), Syringopora cf. S. verticillata Goldfuss, and a Syringopora with corallites 1 mm in diameter.

Hessel:

LOC. 157. A prominent east-west trending ridge of Engadine Dolomite is present in secs. 21 and 22, T 42 N, R 1 W, about three-quarters of a mile north of Hessel.

Northeast and east of Cedarville:

LOC. 158. A large area of Engadine Dolomite occurs about 2 miles northeast of Cedarville in secs. 20, 21, 28, and 29, T 42 N, R 1 E.

LOC. 159. A much larger area of the dolomite is present a few miles farther north in secs. 1, 2, 3, 4, 5, 10, and 11.

According to Ver Wiebe (1928, p. 328), the Engadine Dolomite exposed along the road between secs. 10 and 11, has a dip of 30 degrees to the northwest. In Ver Wiebe's opinion, this reversal in the southerly dip of the dolomite is due to an underlying coral reef or to faulting, more probably the latter.

LOC. 160. Low outcrops of the dolomite are shown at several places along the shore of Lake Huron between Cedarville and the eastern extremity of Mackinac County.

Chippewa County

Rockview: The Engadine-capped escarpment, which extends southeastward with few interruptions through Mackinac and Chippewa Counties from a point 3 miles east of Trout Lake to Drummond Island, is a particularly prominent topographic feature between Rockview and a place about 8 miles to the southeast.

LOC. 161. About 100 to 110 feet of Engadine Dolomite are present in the escarpment at Rockview a short distance east of the road leading from Pickford to Cedarville. The uppermost 40 feet to 50 feet of the dolomite are very massive and white to bluish-white in color and show little evidence of a thinner-bedding on weathering. This part of the dolomite contains numerous molds of Pentamerus and many cavities, formed by the solution of the shells of this brachiopod and remains of Favosites. The next lower 20 to 30 feet of dolomite contain poorly preserved remains of stromatoporoids and a smaller number of molds of Pentamerus. The lowest 30 feet of the dolomite are incompletely exposed in terraces and low bluffs. The lowest beds above the contact with the Manistique strata, 15 feet of which are poorly exposed near the base of the escarpment, are buff-gray in color.

Ver Wiebe (1928, p. 328) states that the full thickness of the Engadine Dolomite at this locality is 55 feet. He measured only the uppermost 55 feet of the Engadine Dolomite exposed at this locality, and in the writer's opinion either failed to note the presence of 45 to 55 feet of lower Engadine strata or erred in believing that these strata belonged to the Manistique Formation.

The Engadine Dolomite is at the surface of many square miles of land adjacent to the top of the escarpment, extending southeastward from Rockview to a point about 8 miles distant.

Gatesville and vicinity:

LOC. 162. The Engadine dolomite is exposed in a high ridge about one-third of a mile east of Gatesville. It is possible that there are 75 feet of the dolomite in the ridge; the drift covers the lower part of the ridge, thus making it impossible to determine the exact thickness of the dolomite.

LOC. 163. A small outlier of Engadine Dolomite is located a short distance west of the NE corner sec. 6, T 42 N, R 3 E, about 1 mile north of Gatesville. Its presence at this place is due either to a local reversal in the southerly dip of the dolomite or to faulting. The writer is more inclined to believe that its presence is due to a reversal in the dip, because reversals in the dip of the Niagaran strata are very numerous and no faults in these strata are known with a displacement of more than a few inches.

LOC. 164. About 50 feet of Engadine dolomite are exposed in a ridge located in the $SE\frac{1}{4}$ sec. 23 and $SW\frac{1}{4}$ sec. 24, T 42 N, R 3 E, about 4 miles southeast of Gatesville.

Drummond Island:

LOC. 165. The Engadine Dolomite outcrops at numerous places in the southern part of Drummond Island. It is well shown in the southwestern part of the island (sec. 36, T 42 N, R 4 E, and sec. 1 and 12, T 41 N, R 4 E), in the vicinity of Johnswood, and at many places along its southern shore.

Correlation and faunal relationships of the Engadine Dolomite. -- The lower third or less of the Engadine Dolomite, which incidentally includes the strata of the type locality of this formation, contains numerous remains of Pentamerus oblongus Sowerby and a few poorly preserved specimens of stromatoporoids, Amplexus, Arachnophyllum, Favosites, Syringopora, and Halysites. Some of these fossils somewhat resemble species found in the Manistique Dolomite, but their poor preservation makes it impossible to determine their relationship with the latter.

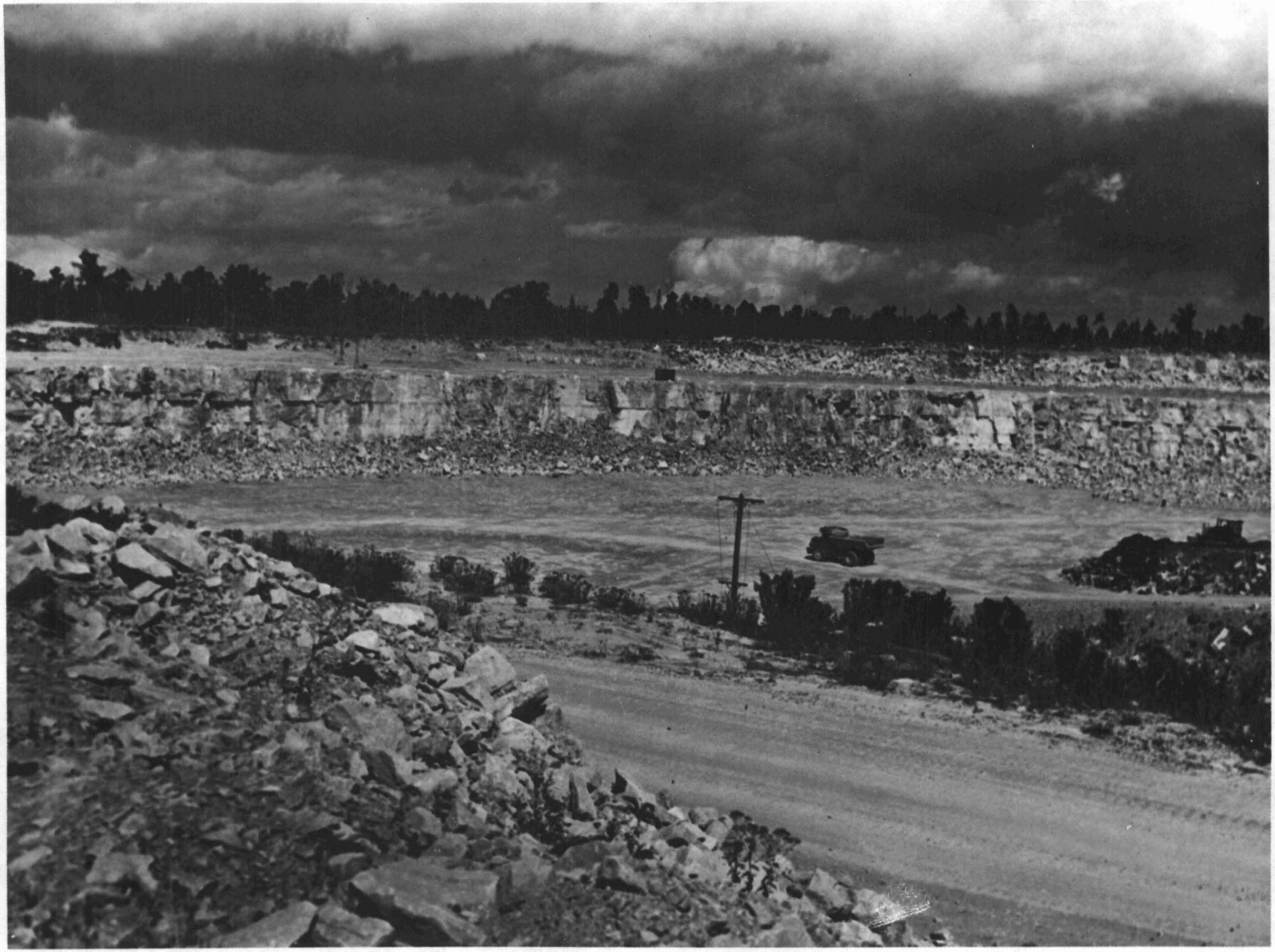


FIG. 51 - Engadine Dolomite, Drummond Dolomite Quarry, Drummond Island.

FIG. 52 - Robert V. Kesling and the author in the field, preparing to photograph a Silurian outcrop.

Better preserved fossils may eventually be found in the lower part of the Engadine which will show that this part of the formation is faunally related to the Manistique and should be included in the Clinton Group. However, most of the fossils, supposedly related to Manistique forms, also occur in the higher Engadine strata. On this account and on account of the striking lithological similarity between the lower and higher Engadine strata, the lower third of the Engadine is considered as a part of the Engadine Dolomite and included in the Lockport Group.

The so-called Racine strata of the Sturgeon Bay, Wisconsin, area and probably most of northeastern Wisconsin are without doubt a continuation of the strata of the lower part of the Engadine Dolomite. These supposed Racine strata apparently lack the typical assemblage of fossils found in the Racine of the Milwaukee-Waukesha region farther south. If the Racine fauna is entirely a reef fauna, as is quite possible, then the absence of Racine fossils in these strata may be due to conditions unfavorable to the formation of reefs in this region. However, until the Racine fauna is definitely proven to be entirely a reef fauna, the writer does not believe that these strata and the continuous lower Engadine strata of Michigan should be correlated with the typical Racine of the Milwaukee-Waukesha region.

The massive, sparingly fossiliferous beds of dolomite at the top of the so-called Lockport of the Manitoulin-Island region and the lower strata of the Engadine Dolomite are lithologically similar and with little doubt continuous.

In a communication to the writer, Dr. M. Y. Williams states that the highest Lockport strata at Dawson Point, Lake Timiskaming, are lithologically similar to the highest Lockport strata of Manitoulin Island, which as stated above are continuous with the lower beds of the Engadine. The former continuity of the Engadine strata of Michigan with the highest Lockport strata of the Lake Timiskaming area is further suggested by the fact that these strata in both areas rest on beds containing the Cordell fauna.

It is possible that the higher Engadine strata containing Guelph fossils is represented by the

higher Lockport strata of the Lake Timiskaming area. This is indicated by the fact that Hume (1925, p. 38, 39) has reported the occurrence of the Guelph species, Pycnostylus guelphensis Whiteaves and Trimerella cf. acuminata, from the Lockport of this area. Unfortunately, the exact strata of the Lockport from which these fossils came, is unknown. Further collecting may show the presence of these species in the higher Lockport strata, thus proving definitely that these beds are equivalent in age to the higher Engadine strata.

The upper two-thirds or more of the Engadine Dolomite contains remains of Amplexus cf. A. whitfieldi Miller, Pycnostylus guelphensis Whiteaves, Favosites aff. F. occidens Whitfield, Trimerella cf. T. acuminata Billings and T. grandis Billings, Poleumita cf. P. scamnata Clarke & Ruedemann, and cf. Pycnomphalus solariodes (Hall), which are indicative of its Guelph age and its correlation with the Guelph of Ontario and Wisconsin (see Table 6).

The Port Byron Limestone of Illinois, Bainbridge of Missouri and some of the Gower strata of Iowa have been correlated with the Guelph by Savage (1926, p. 533) and hence would seem to be the time equivalents of the upper two-thirds of the Engadine.

There is a difference of opinion regarding the relationship of the Guelph and Racine faunas to one another, some geologists believing that these faunas are distinct, and others that they may be considered as a single fauna.

An exceedingly interesting and important paper by Cumings & Shrock on the Niagaran coral reefs of Indiana and adjacent states has considerable bearing on this problem. In this paper Cumings & Shrock (1928, p. 582, 597) postulate the existence in the Michigan Basin of a Niagaran sea opening out at the north into the Arctic realm and demonstrate the existence of numerous stromatoporoid-coral reefs about the margins of this sea in Ontario, Indiana, Illinois, and Wisconsin. These writers show that some of the most extensive reefs of this sea are now preserved in the Huntington Formation of Indiana which contains both Guelph and Racine fossils. In their discussion of the Guelph and Racine faunas of this formation, Cumings & Shrock (1928a, p. 596) state that "the Guelph fauna of Ohio, Indiana, Illinois and Wisconsin invaded the region in the midst of a great period of reef-building and coral sand deposition, which extended throughout Huntington or Racine-Guelph time." Their study would seem to show, therefore, that the Guelph and Racine faunas were contemporaneous.

The contemporaneity of these faunas is further suggested by other evidence. In the Engadine Dolomite the writer has found three poorly preserved and doubtfully determined Racine types of fossils: Clorinda ? cf. C. ventricosa (Hall), Straparollus cf. S. mopaus Hall, and Kionceras aff. K. scammoni (McChesney) in association with Guelph species. According to Williams (1919, p. 73), a fauna very similar to that of the Racine beds of Wisconsin is present in the Guelph Formation at Wiarton, Ontario. The occurrence of Oncoceras pettiti Billings, O. teuceri Billings, Streptoceras heros Billings, and S. janus Billings at Grimsby, Ontario, may also indicate that the Guelph and Racine faunas were contemporaneous. In a letter to the writer, Doctor Foerste states that these cephalopods seem to be related to Racine species. According to Billings (1866, p. 86-90), these cephalopods were collected from the "Niagara" at Grimsby, Ontario. The horizon "Niagara" gives little information regarding the exact stratigraphic occurrence of these cephalopods. Obviously, it is quite possible that they may have been collected from the Guelph Formation, which is present only 2 miles south of Grimsby.

The scarcity and possible absence of Racine fossils in the Engadine - the three fossils noted above are too poorly preserved to establish their specific identity with Racine fossils - may be due to conditions in the Engadine sea which were unfavorable to the existence of Racine life. The remains of the typical Racine fauna are now found in Ohio, Indiana, Illinois, and Wisconsin in association with reefs, which were built by stromatoporoids, corals, and other organisms in the shallow, marginal areas of the Huntington or Racine-Guelph sea. This occurrence indicates that the Racine fauna was restricted to a shallow-water reef environment. According to Cumings & Shrock (1928a, p. 582, fig. 1) the sea was probably deeper in the central part of the Michigan Basin and the Northern Peninsula during the time of formation of the Huntington or Racine-Guelph reefs. If the Engadine sea was co-extensive with the Racine-Guelph sea, then it is possible that the deeper water in the Northern Peninsula was unfavorable

to the formation of reefs and the existence of the reef-loving Racine fauna.

In spite of this strong array of evidence indicating that the Engadine Dolomite may include strata which were deposited during Racine-Guelph time, the writer believes that the Racine and Guelph faunas may be distinct from one another. Until further studies of the Engadine fauna and also the Racine and Guelph faunas of Wisconsin and other regions are made, the writer believes that the Engadine Dolomite, particularly its upper third, is most closely related to the Guelph Dolomite in its fauna and probably contains no strata as old as the Racine Dolomite of Wisconsin. Definite proof that the Racine and Guelph faunas are essentially a single fauna will necessitate the use of the name Racine for the Engadine Dolomite as previously proposed by the writer (Ehlers, 1919, p. 87-90).

For many years American geologists have believed that the Guelph fauna, which is represented in the Engadine Dolomite, and also the Racine and certain other Niagaran faunas reached the interior of the North American continent by direct southerly invasions of the Arctic sea. Recently, however, Schuchert & Dart (1926, p. 44) have pointed out that some of these supposed Arctic faunas probably reached the interior by way of a connection with the St. Lawrence sea. They make the very significant statement that the various faunas of the Chaleur Series, which lie in the same trough as that of Anticosti,

> show that the Niagaran ones of the interior America probably came largely from the St. Lawrence geosyncline and northwestern Europe. When the Silurian faunas of Anticosti and Quebec are fully described, it probably will be seen that many of the species now best known from the Chicago-Racine area are also common to the St. Lawrence trough. All of us have heretofore been inclined to agree with Weller that most of the interior faunas came from the Arctic realm, and whereas some of them did, most of them were in connection with the St. Lawrence sea and so on to Europe.

The same opinion has been expressed more recently by Foerste (April 1929, p. 72), who states that "the path along which Silurian faunas migrated between Europe and the Racine area of the interior of America is not determined so readily as once supposed. At present, this path appears to have been south of both the Canadian and Baltic shields." The presence of the fairly characteristic Guelph genus, Monomerella, in strata near the top of the Bouleaux Formation of the Chaleur Series of the Port Daniel-Gascons area (see Schuchert & Dart, 1926, p. 49) suggests the possibility of a migration of the Guelph into the interior from the Gulf of St. Lawrence. Obviously, further studies may alter our long-standing opinion regarding the Arctic origin of the Guelph fauna.

SUMMARY

Two widely separated areas in the northern Peninsula are underlain by rocks of Niagaran age. The larger of these areas has the form of a broad, arcuate belt, extending from St. Martin, Poverty, Big, and Little Summer Islands at the entrance of Green Bay to the eastern side of Drummond Island. It borders the north shores of Lakes Michigan and Huron except where it extends across the base of the St. Ignace Peninsula. The smaller of these areas is at Big Limestone Mountain, Houghton County, about 117 miles distant from the nearest rocks of the larger area.

Except for a few thin beds of shale the Niagaran strata consist entirely of limestones and dolomites, both of which are represented by several lithologic types. Most of the limestones and dolomites, however, show little change in lithologic character when traced from one locality to another.

The strata are remarkable for their continuity, very few of them being interrupted in their continuity from the Green Bay region to the eastern side of Drummond Island. Several beds extend into Wisconsin and Ontario for considerable distances. The unusual continuity of the strata is of much assistance in determining the superposition of the Niagaran rocks of the Northern Peninsula and in correlating these strata with those of Wisconsin and Ontario.

The estimated maximum thickness of the Niagaran Series, based largely on a possibly inaccurate well record at Gilchrist, Mackinac County, is 1020 feet. More dependable well records and actual measurements of exposed rocks show that this thickness is probably nearer 900 feet.

When traced from Delta County to the

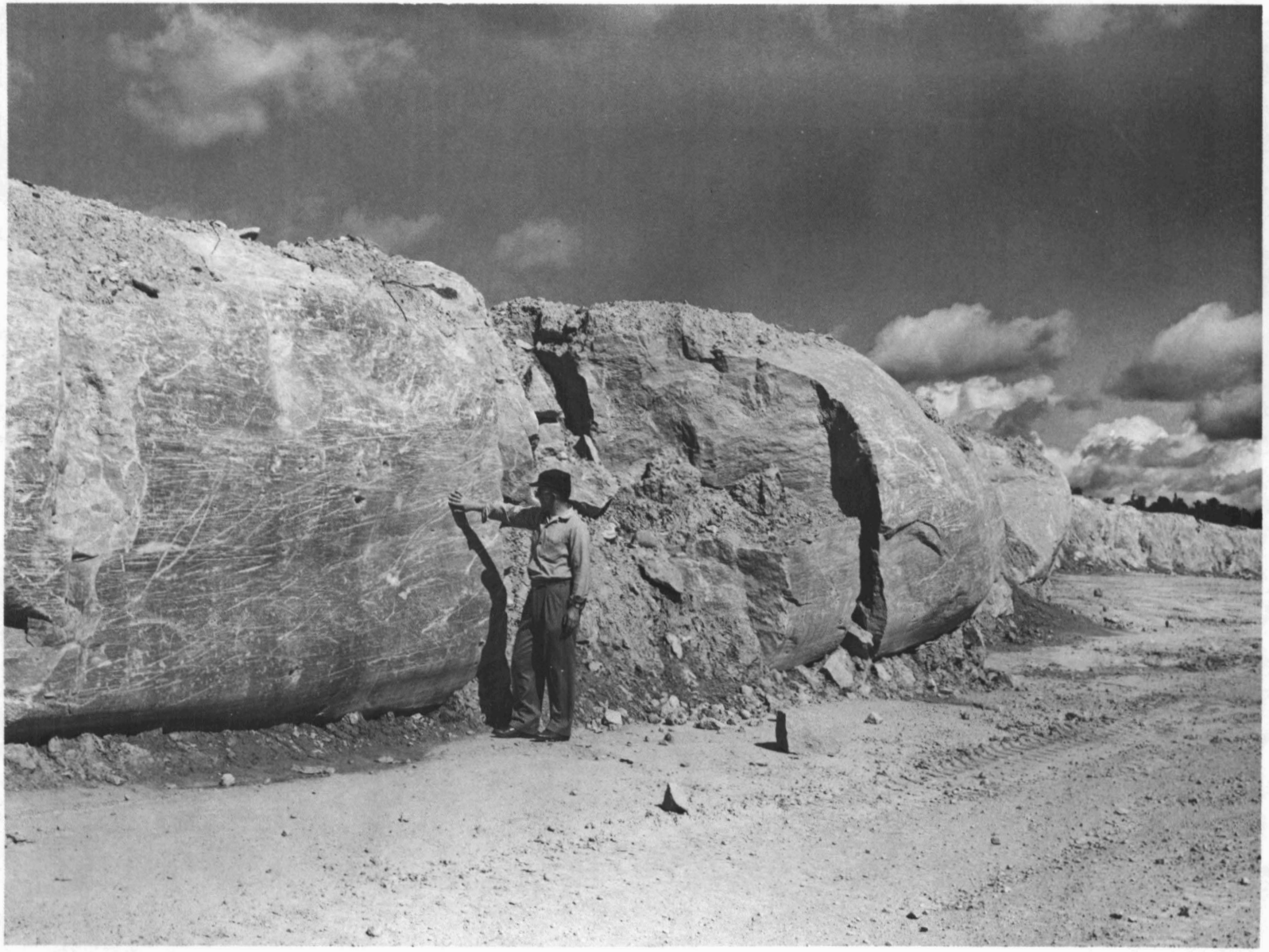


FIG. 53 - Engadine Dolomite, Drummond Dolomite Quarry, showing massive bedding and surface apparently scoured by glacial action. Photo by Woodrow Jarvis, Detour, Michigan, 1956.

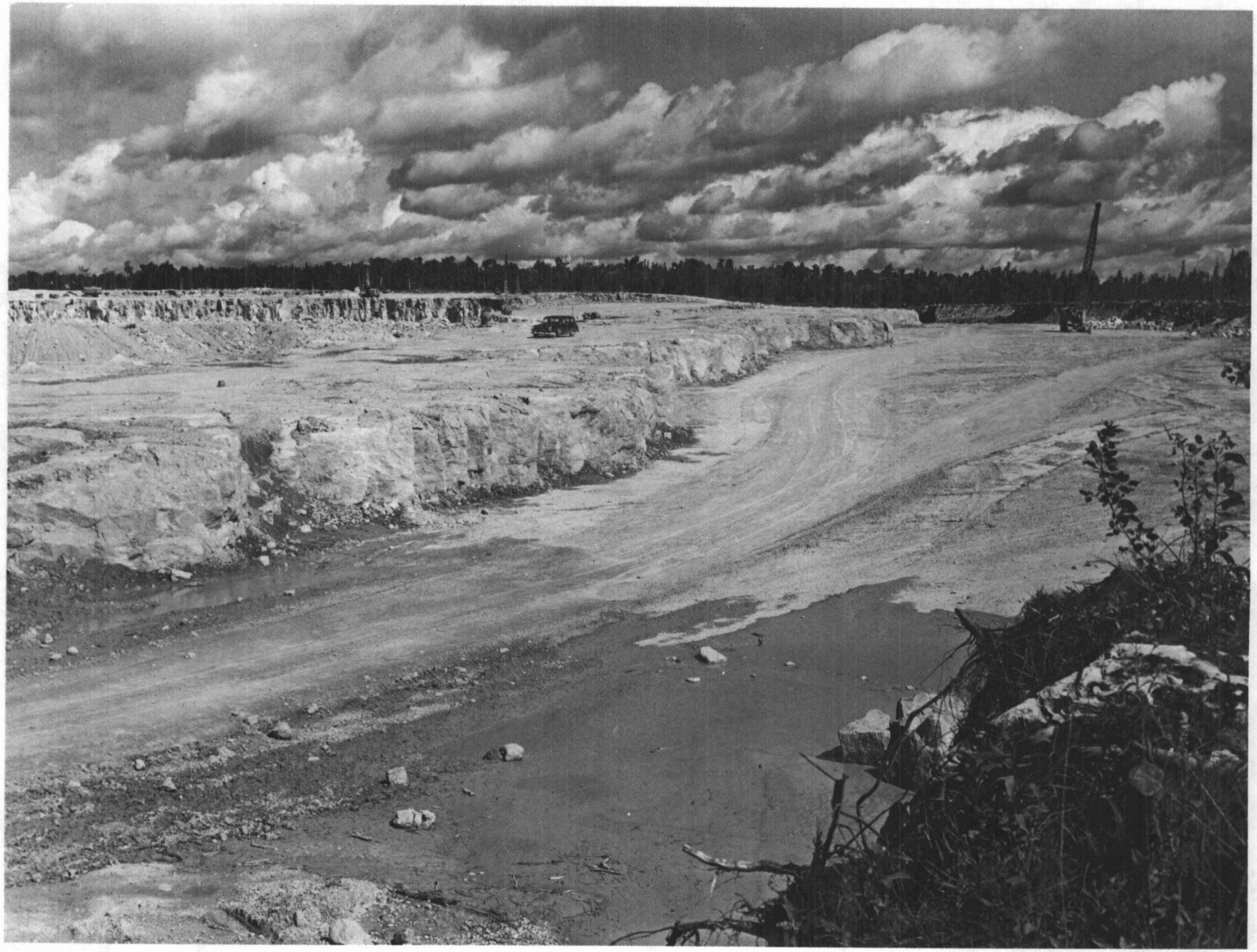


FIG. 54 - Engadine Dolomite, Drummond Dolomite Quarry, Drummond Island, showing gentle undulations of the strata. Photo by Woodrow Jarvis, Detour, Michigan, in 1956.

eastern end of the Northern Peninsula, the Niagaran Series shows a decided decrease in thickness. In Delta County the thickness is 800 to 900 feet, in south-central Mackinac County 650 to 750 feet, and in the Drummond Island region probably 500 to 600 feet.

The major structural feature of the Niagaran rocks bordering the north shores of Lakes Michigan and Huron is a monocline with a very gentle dip or inclination towards the lakes. The general dip of the strata of this monocline seemingly ranges from 40 to 60 feet per mile, the average dip probably being about 50 feet per mile.

The major monoclinal structure of the Niagaran rocks is modified by numerous small plunging anticlines and synclines and a smaller number of terraces. Most of the plunging anticlines and synclines are "radial linear folds" which are located on the margins of the Michigan Basin and have axes pointing toward the center of this Basin.

Because they were more resistant to erosion by pre-glacial streams than the underlying Medinan and Cincinnatian rocks and the overlying Monroe-Salina strata, the Niagaran rocks stand in relief as a cuesta. This cuesta has a general east-west orientation more or less parallel to the strike of the Niagaran strata. Its steep slope or escarpment faces northward. Its gentle back slope descends southward to Lakes Michigan and Huron, the descent at many places conforming closely to the dip of the strata. Superimposed on the large cuesta are smaller cuestas, residuals of more resistant Niagaran strata.

The Niagaran Series consists of four formations which are designated as the Mayville Dolomite, Burnt Bluff Limestone and Dolomite, Manistique Dolomite, and Engadine Dolomite. The Burnt Bluff Limestone and Dolomite is divided into a lower, Byron Member and an upper, Hendricks Member and the Manistique Dolomite into a lower, Schoolcraft Member and an upper, Cordell Member.

The Mayville Formation, which is a continuation of the Mayville Dolomite of Wisconsin, consists of dolomites and a few magnesian-limestones of various lithologic character. Exposures of these rocks are few in number owing to the fact that they are covered by drift at most places. A thick-bedded buff to buff-gray dolomite, containing numerous molds of the shells of Virgiana mayvillensis Savage, is present at the top of the formation. This dolomite which is exposed only at Big Limestone Mountain, Houghton County, and on Lime Island in Potagannissing Bay, has been traced from eastern Wisconsin to the Manitoulin Island region.

The Mayville Dolomite decreases in thickness when traced eastward from Delta County, Michigan. In Delta County, it may have a thickness of approximately 200 feet. In southeastern Schoolcraft County, a thickness of only 70 feet is indicated by a fairly dependable well record. On the eastern side of Drummond Island the thickness is probably less than 50 feet and may not be more than 25 feet.

When traced northeastward from Wisconsin, the Mayville Dolomite is found to overlap younger strata. In eastern Wisconsin, the dolomite rests on Richmond strata. In Delta County it rests with little doubt on higher Richmond beds. On the eastern side of Drummond Island it probably overlies the Cataract Formation but may rest on Richmond strata which are possibly a little older than the highest Richmond deposits of Delta County. In the Manitoulin Island region only the highest beds of the Mayville are present; these overlie Cataract strata.

The contact between the Mayville Dolomite and the overlying Burnt Bluff Limestone and Dolomite is tentatively drawn at the top of the Virgiana mayvillensis-bearing bed of the Mayville.

Except for a few thin beds of shale, the Burnt Bluff Formation consists entirely of limestones and dolomites, differing greatly in lithologic character. The lower, Byron Member, which represents a northeastward continuation of the Byron beds of Wisconsin, consists chiefly of light-gray, buff-gray, and light-buff, thin-bedded and laminated dolomites, many of which are argillaceous and contain "sun-cracks" and ripple-marks. At its type locality in Hendricks Quarry and in the region between southeastern Schoolcraft County and south-central Chippewa County, the Hendricks Member consists chiefly of light-gray to buff-gray, thin- and thick-bedded limestones and magnesian-limestones and a small number of white, gray, and buff dolomites, most of which are thick-bedded. In the areas west of southeastern Schoolcraft County and east of south-central Chippewa County, the Hendricks Member consists chiefly of dolomites

and a very few thin beds of limestone and magnesian-limestone; the dolomites in the upper part of the member are thick-bedded and buff-gray to brown in color and those in the lower part are thin-bedded or laminated and light-gray to grayish-buff in color. When traced to the central area of more calcareous rocks, many of the dolomites of these areas grade laterally into magnesian-limestones or pure limestones. The limestone unit designated as Fiborn by R. A. Smith provides an outstanding example of the lateral dolomitization of some of the Hendricks high-calcium strata.

The thickness of the Burnt Bluff Formation is probably between 275 and 300 feet. In the type exposure at Burnt Bluff, Big Bay de Noc, its thickness is about 238 feet, the Byron Member having a thickness of 117 feet and the Hendricks about 121 feet. It is probable that the Byron strata, covered by Big Bay de Noc at this locality, have a thickness of at least 50 feet, thus giving the Byron Member a total thickness of 167 feet and the Burnt Bluff Formation 288 feet.

The contact between the Byron and Hendricks members is tentatively drawn at a plane corresponding to the top of bed 14 of the type section at Burnt Bluff.

Some of the most characteristic fossils of the Hendricks Member are Camarotoechia winiskensis Whiteaves, Rhynchospira lowi Whiteaves, Leperditia fabulina Jones, and Isochilina latimarginata (Jones).

No fossils have been found in the Byron strata of Michigan. In Wisconsin, however, a few ostracods have been found in the Byron which indicate that the Byron beds are faunally related to the Hendricks strata.

The contact between the Burnt Bluff Formation and overlying Manistique Formation is at or a short distance below the base of a thick-bedded buff to buff-gray dolomite containing numerous remains of Pentamerus. On account of the fact that there is a very distinct faunal break at this contact, the writer believes that this contact is a disconformity.

The Schoolcraft Member of the Manistique Formation, which is typically exposed in the Inland Lime & Stone Company at Manistique, Schoolcraft County, consists of thick- and thin-bedded, buff-gray to buff dolomites and thin, even-bedded, finely crystalline, gray to bluish-gray dolomites. A few of the thinner-bedded, buff dolomites contain chert.

Some of the Schoolcraft strata are remarkably continuous across the eastern half of the Northern Peninsula and with little doubt continue into Ontario and Wisconsin. Two beds which are most noteworthy in this respect are the lower and upper Pentamerus dolomites.

The Schoolcraft Member decreases in thickness in passing from Delta County to Drummond Island. In Delta County it probably has a thickness of about 65 feet. In the type section shown in the quarry at Manistique its thickness is 56 feet. On Drummond Island the thickness is probably not more than 35 feet.

The most characteristic and abundant fossil of the Schoolcraft Member is Pentamerus oblongus Sowerby.

The Schoolcraft Member is closely related to the Cordell Member in its fauna. On account of slight differences in their faunas and greater differences in lithology, however, they are separated as distinct members of the Manistique Formation.

The Cordell Member consists of thin, uneven-bedded, buff to buff-gray, cherty dolomites, with numerous silicified remains of corals, stromatoporoids, and brachiopods. Chert nodules and irregularly shaped masses of chert, which are distributed in distinct bands along bedding planes, are particularly abundant in the lower part of the member.

The Cordell strata also are remarkably continuous, extending into Ontario and Wisconsin and probably into Iowa. Further studies may show that some of these Cordell strata continue into Illinois and Indiana.

The maximum thickness of the Cordell Member is probably near 100 feet. In Delta County it may be slightly greater than 100 feet. On Drummond Island it is probably not more than 75 feet.

The numerous and characteristic fossils of the Cordell Member are silicified corals, which are present throughout the member but are most abundant in its upper three-fourths. The more common and characteristic species are Streptelasma conulus Rominger, S. patula Rominger, Zaphrentis stokesi Edwards & Haime, Blothrophyllum caespitosum Rominger, Diply-

phyllum huronicum Rominger, Omphyma verrucosa Rafinesque & Clifford, Ptychophyllum stokesi Edwards & Haime, Arachnophyllum pentagonum (Goldfuss), A. striatum (D'Orbigny), Cystiphyllum niagarense (Hall) var., Lyellia papillata Rominger, Alveolites undosus Miller, Cladopora laqueata Rominger, Coenites crassus (Rominger), C. laminatus (Rominger), Favosites favosus (Goldfuss), F. obliquus Rominger, F. hispidus Rominger, Halysites labyrinthicus (Goldfuss), and Syringopora verticillata Goldfuss. Further study will probably show that the corals of the Manistique Member occur in definite zones and hence prove to be of great service in correlation.

Pentamerus oblongus Sowerby and a new species of Atrypa or a new variety of A. reticularis (Linnaeus) are common throughout the Cordell strata.

Certain fossils are present at definite positions in the Cordell Member. A new species of Coelospira, which is closely related to C. hemispherica (Hall, Sowerby ?), occurs in the basal layer of the Cordell and uppermost bed of the Schoolcraft. About 20 feet above the base of the Cordell, specimens of a Palaeocyclus have been found which are closely related to P. rotuloides (Hall). Above this Palaeocyclus zone are remains of Armenoceras gouldense Foerste, Armenoceras spheroidale (Stokes), Huroniella ehlersi Foerste, Huronia bigsbyi Stokes, H. bigsbyi intermedia Foerste, H. engadinensis Foerste, H. obliqua Stokes, H. paulodilatata Foerste, H. vertebralis Stokes, Stokesoceras gracile (Foord), Megadiscosorus remotus (Foord), and other characteristic actinoceroids.

The Engadine Formation consists of very thick beds of white, grayish-white and bluish-white dolomite of very great purity. On weathering the color of some of the beds, especially the bluish-white ones, changes to a light-brown or buff. The weathered surfaces of the Engadine Dolomite, however, are strikingly white. The dolomites of the lower third of the formation contain few cavities and on weathering show closely spaced, uneven planes of bedding. Many of the dolomites in the upper two-thirds of the formation contain numerous cavities, some of which were formed by the solution of corals and stromatoporoids.

The thickness of the Engadine Dolomite as shown by a deep well at St. Ignace is 278 feet and by a deep well at Cheboygan 320 feet. It is probable that the dolomite is not less than 200 feet at any place in the Northern Peninsula.

The lower third or less of the Engadine Dolomite, which includes the strata of the type locality of this formation, contains numerous remains of Pentamerus oblongus Sowerby and a few poorly preserved specimens of corals and stromatoporoids which somewhat resemble the Manistique species. The poor preservation of these Engadine fossils, however, makes it impossible to determine their relationship to the Manistique species. On account of the fact that most of these fossils have been found in higher Engadine strata and in view of the fact that the lower and higher Engadine strata are strikingly similar in lithological character, the strata of the lower third of the formation are considered as a part of the Engadine Formation.

A few remains of Guelph species and three, doubtfully identified specimens of Racine species were found in the upper two-thirds of the formation.

The contact between the Engadine and Manistique Formations at most places is sharply defined. At some localities a few feet of transitional strata intervene between the typical strata of these formations. The transitional strata are more closely related in their lithology to the typical Engadine Dolomite and hence are included in this formation.

The contact between the Engadine and the overlying, so-called Monroe-Salina strata has never been seen.

All paleontologic and stratigraphic evidence indicates that the Mayville, Burnt Bluff, and Manistique Formations are of Clinton age and the Engadine of Lockport age. The Mayville is probably of late lower Clinton or early middle Clinton age, the former interpretation according to Ulrich & Bassler being the more likely of the two. The Burnt Bluff is either of lower or middle Clinton age. The Manistique Formation is tentatively considered as being of upper Clinton age. Further studies may show that the Schoolcraft member is of lower Clinton age. The upper two-thirds of the Engadine is definitely of Guelph age. The lower third of the formation may tentatively be considered as being of Guelph age. Further study may show that it is older than Guelph and hence should be separated from the upper two-thirds of the formation as a distinct stratigraphic unit.

The relationship of the Niagaran Series of the Northern Peninsula to the Niagaran deposits of neighboring areas is summarized in Table 7. This table shows that the Clinton Group of the Niagaran Series is represented by a far greater number of formations in Canada and the north-central part of the United States than heretofore supposed; in Michigan the formations of Clinton age have an aggregate thickness of 600 or more feet.

The present study also presents important information in regard to the paths taken by the Niagaran seas in reaching the Northern Peninsula of Michigan and neighboring regions. The Mayville sea, in which the Virgiana decussata beds were deposited, probably came from the Arctic by way of Hudson Bay. Further studies may show that the Virgiana mayvillensis beds of Ontario, the eastern half of the Northern Peninsula, and Wisconsin, and possibly all of the Mayville Dolomite were deposited in another sea from the Arctic or a sea from the Gulf of St. Lawrence. The Burnt Bluff sea appears to have been part of an Arctic or sub-Arctic sea which extended southward from Hudson Bay. In the Lake Timiskaming region the sea may have been connected temporarily with a sea from the Gulf of St. Lawrence. The Manistique sea with little doubt spread southwestward from the Gulf of St. Lawrence, invading the interior at least as far west as Iowa. In the writer's opinion, it is doubtful whether this sea ever reached New York State or the area west of Hudson Bay. A few cephalopods, which are related to Manistique forms, have been found in the Arctic and sub-Arctic regions. These suggest an extension of the Manistique sea into these regions. However, further studies will be necessary to establish the former existence of the Manistique sea in these regions. The Guelph fauna, which is found in the upper two-thirds of the Engadine Dolomite, has for many years been considered as an Arctic fauna by most geologists. Further studies, however, may show that this fauna reached the interior by a Gulf of St. Lawrence connection.

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FIG. 55 - R. A. Smith, who named the Engadine in 1915, photographed 42 years later beside a boulder of the dolomite at the type locality.

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TABLES

(Table 1 on page 48)

TABLE 2 -- Species from the Burnt Bluff Limestone and Dolomite Compared with Species Listed by Savage & Van Tuyl (1919) from the Severn River Limestone, Ekwan River Limestone, and Attawapiskat Coral Reef in the Hudson Bay Region. x? - identity uncertain of species listed only as "sp."; cf., aff. - qualifications added to species identification; ? - identification questioned.

Species	Burnt Bluff	Severn River	Ekwan River	Attawapiskat
Hydrozoa				
Actinodictyon sp.	x	0	0	0
Actinostroma ? sp.	x	0	0	0
Clathrodictyon aff. fastigiatum	x	0	0	0
Clathrodictyon vesiculosum minutum	x	0	0	0
Clathrodictyon vesiculosum var.	x	0	0	0
Clathrodictyon sp.	0	x	0	0
Labechia n. sp.	x	0	0	0
Stromatopora sp.	x	0	0	0
Corals				
cf. Acervularia austini	0	0	0	x
Alveolites niagarensis	0	cf.	x	0
Alveolites ? sp.	0	x	0	0
Amplexus severnensis	x	0	x	0
Amplexus ? sp.	x	0	0	0
Aphyllostylus gracilis	0	0	x	x
Aulopora ? sp.	x	0	0	0
Calapoecia cf. canadensis	0	0	x	0
Ceratopora ? sp.	x	0	0	0
Chonophyllum canadense	0	0	x	0
Cladopora sp.	x	0	0	0
Cystiphyllum niagarense	0	0	0	x
Cystostylus infundibulum	0	0	x	0
Cystostylus typicus	0	0	x	0
Diphyphyllum multicaule	0	0	x	x
Duncanella spp.	x	0	0	0
Favosites favosus	0	x	x	x
Favosites forbesi	var.	0	0	cf.
Favosites hisingeri	0	x	x	x
Favosites cf. occidens	0	0	0	x
Favosites sp.	x?	x?	x?	x?
Halysites catenularia	x	0	x	0
Halysites sp.	x	0	0	0
Heliolites interstincta	0	0	0	x
Heliolites cf. interstincta	0	0	0	x
Heliolites cf. subtubulata	0	0	0	x
Heliolites sp.	0	0	0	x
Lyellia affinis	0	0	0	x
Lyellia cf. decipiens	x	0	0	0
Lyellia sp.	x?	0	x?	0

Paleofavosites aspera	x	0	x	x
Pycnostylus elegans	aff.	0	0	x
Pycnostylus guelphensis	0	0	0	x
Ptychophyllum stokesi	x	0	cf.	0
Streptelasma pymaeum var. occidentale	0	x	x	0
Streptelasma sp.	x?	0	x?	x?
Strombodes sp.	0	0	0	x
Syringopora bifurcata	0	0	x	cf.
Syringopora sp.	x	0	0	0
Tyrrellia severnensis	0	0	x	0
Vesicularia cf. major	0	0	0	x
Zaphrentis patens	0	0	x	x
Zaphrentis stokesi	cf.	x	x	x
Zaphrentis sp.	x?	0	0	x?
Bryozoa				
Fenestella subarctica	0	0	0	x
Phaenopora keewatinensis	0	0	0	x
Brachiopoda				
Atrypa putilla	x	0	0	0
Atrypa cf. reticularis	0	x	x	x
Atrypa ? sp.	x	0	0	0
Camarotoechia ekwanensis	0	x	x	0
Camarotoechia winiskensis	x	x	x	0
Camarotoechia sp.	0	x?	0	x?
Clorinda mesoplicata	0	x	0	x
Dalmanella elegantula	0	x	x	x
Dinobolus ? sp.	x	0	0	0
Glassia variabilis	x	x	x	x
Glassia variabilis var.	0	0	0	x
Gypidula sp.	0	0	0	x
Leptaena parvula	0	x	x	0
Lingula sp.	x	0	0	0
Meristina expansa	0	0	x	x
Orthis flabellites	x	x	x	aff.
Orthis cf. flabellites	0	0	x	x
Parastrophia sp.	x	0	0	0
Pentamerus sp.	0	0	x?	x?
Plectambonites cf. transversalis	var.	0	0	x
Reticularia septentrionalis	0	0	0	x
Rhynchospira lowi	x	x	x	0
Schuchertella aff. curvistriata	0	x	0	0
Schuchertella cf. propinqua	x	0	0	0
Schuchertella sp.	0	x	0	0
Spirifer crispus	x	0	aff.	aff.
Spirifer sp.	x?	0	x?	x?
Stropheodonta acanthoptera	0	x	x	0
Stropheodonta philomela	0	cf.	x	x
Stropheodonta sp.	x?	x?	x?	x?
Stropheodonta sp. 1	0	0	0	x
Stropheodonta sp. 2	0	0	0	x
Trimerella cf. acuminata	x	0	0	0
Trimerella borealis	0	0	x	0

Trimerella ekwanensis	x	x	x	x
Trimerella aff. grandis	x	0	0	0
Trimerella sp.	x	0	0	0
cf. Whitfieldella julia	0	x	0	0
Whitfieldella n. sp.	x	0	0	0
Gastropoda				
Coelidium sp.	?	0	0	x
Coelocaulus cf. macrospira	x	0	0	0
Colpomya n. sp.	x	0	0	0
Cyclonema cf. daytonensis	x	0	0	0
Diaphorostoma perforata	0	0	x	x
Diaphorostoma ? sp.	x	0	0	0
Eotomaria sp.	x	0	0	0
Euomphalopterus tyrrelli	0	0	x	0
Euomphalopterus cf. tyrrelli	0	0	x	0
Euomphalopterus sp.	x?	x?	x?	0
Euomphalus minor	0	0	x	0
Euomphalus rotundus	0	x	x	0
Fusispira ? sp.	x	0	0	0
Gyronema brevispira	0	0	0	x
Gyronema cf. dowlingi	0	0	x	0
Gyronema speciosa	0	0	0	x
Hormatoma attenuatum	x	0	0	0
Hormatoma whiteavesi	x	x	x	x
Hormatoma sp.	x?	x?	0	0
Liospira stevensoni	x	0	x	x
Liospira sp.	x	0	0	0
Megalomphala robusta	0	0	x	x
Phanerotrema occidens ?	0	0	x	0
Platyceras compactum	0	0	0	x
cf. Pleurotomaria hoyi	0	0	x	0
Pleurotomaria ? sp.	x	0	0	0
Pycnomphalus colemani	0	0	0	x
Pycnomphalus sp.	x?	0	x?	0
Salpingostoma boreale	0	0	0	x
Straparolus sp.	0	cf.	x	0
Strophostylus amplus	0	0	0	x
Strophostylus filicinctus	0	x	x	x
Strophostylus inflatus	0	0	0	x
Tentaculites sp.	0	0	x	0
Trochonema sp.	x?	0	x?	0
Pelecypoda				
Ambonychia septentrionalis	0	0	0	x
Ambonychia undulata	0	0	0	x
Ambonychia sp.	0	0	0	x
Colpomya ? sp.	x	0	0	0
Conocardium sp.	0	0	0	x
Ctenodonta subovata	0	x	cf.	0
Ctenodonta 3 n. sp.	x	0	0	0
Cypricardinia sp.	0	x	0	0
Cyrtodonta ? sp.	x	0	0	0
Ilionia ? cf. parvula	x	0	0	0

Ilionia ? sp.	x	0	0	0
Mytilarca pernoides	0	0	0	x
Pterinea occidentalis	x	x	0	0
Pterinopecten ? sp.	x	0	0	0
Whitella n. sp.	x	0	0	0
Cephalopoda (compare with Table 3)				
Actinoceras cf. clowei	0	0	0	x
Actinoceras gouldense	x	0	0	0
Actinoceras keewatinensis	0	x	x	0
Actinoceras sp.	0	0	x	0
Barrandeoceras sp.	0	0	x	0
Cycloceras sp.	0	0	0	x
Huronia sp.	0	0	0	x
Kionoceras cancellatum	0	0	x	0
Ormoceras sp.	x	0	0	0
Orthoceras sp.	x?	x?	x?	x?
Phragmoceras whitneyi	0	0	x	0
Phragmoceras cf. whitneyi	x	0	x	0
Phragmoceras sp.	x?	0	0	x?
Stokesoceras engadinense	x	0	0	0
Stokesoceras romingeri	x	0	0	0
Trochoceras sp.	0	0	x	0
Trilobita				
cf. Amphilichas sp.	0	0	0	x
Bronteus aquilonarius	0	0	0	x
Bronteus ekwanensis	0	0	0	x
Bronteus sp.	0	0	x?	x?
Calymene sp.	0	0	x	0
Ceraurus sp.	0	0	0	x
Encrinurus cf. laevis	0	0	x	0
Encrinurus sp.	x?	x?	x?	x?
Goldius n. sp.	x	0	0	0
Illaenus cf. ioxus	0	0	0	x
Illaenus sp.	x?	0	x?	x?
Scutellum (Scutellum) sp.	x	0	0	0
Ostracoda				
Aparchites sp.	x	0	0	0
Bythocypris sp.	x	0	0	0
Isochilina grandis var. latimarginata	x	x	x	0
Isochilina aff. armata	x	0	0	0
Isochilina sp.	0	x	0	0
Leperditia hisingeri var. aff. caeca	x	0	0	0
Leperditia hisingeri var. egena	x	0	0	0
Leperditia hisingeri var. fabulina	x	x	0	0
Leperditia hisingeri var.	0	x?	x?	x?
Leperditia phaseolus	0	0	0	x
Leperditia whiteavesi	x	0	0	0
Leperditia sp.	x	0	0	0

TABLE 3 -- Species of Cephalopods Described by Foerste & Savage (1927) from the Severn River Limestone, Ekwan River Limestone, and Attawapiskat Coral Reef in the Hudson Bay Region. ?-x-? : formation of occurrence uncertain.

Species	Severn River	Ekwan River	Attawapiskat
Armenoceras hearsti	?	-x-	?
Armenoceras severnense			x
Cameroceras vantuyli			x
Chicagooceras ? longidomum	?	-x-	?
Cycloceras sinuoliratum			x
Cyrtorizoceras ? sp.	?	-x-	?
Discosorus parksi	x		
Ekwanoceras breviconicum			x
Endoceras ? hudsonicum	?	-x-	?
Ephippiorthoceras ekwanensis			x
Gomphoceras ? sp.	?	-x-	?
Huroniella inflecta	?	-x-	?
Huroniella subinflecta			x
Kionoceras cancellatum			x
Kionoceras septentrionale		x	
Kionoceras sp.		x	
Lyroceras boreale		x	
Octameroceras walkeri	?	-x-	?
Oocerina severnense			x
Oocerina sp.			x
Orthoceras sp.	?	-x-	?
Pentameroceras rarum	?	-x-	?
Pentameroceras sp.	?	-x-	?
Phragmoceras lineolatum			x
Phragmoceras parksi			x
Phragmoceras severnense	x		
Phragmoceras whiteavesi			x
Phragmoceras whitneyi	?	-x-	?
Phragmoceras vantuyli			x
Phragmoceras sp.			x
Phragmoceras sp.	?	-x-	?
Protokionoceras submedullare			x
Protophragmoceras ? boreale			x
Protophragmoceras spp.			x
Stokesoceras cylindratum		x	
Stokesoceras ekwanense		x	
Tuyloceras percurvatum		x	
Westonoceras ? septentrionale			x

TABLE 4 -- Genera shared by Burnt Bluff Limestone and Dolomite with One or More Formations in Hudson Bay Region, Based on Lists of Savage & Van Tuyl (1919) and Foerste & Savage (1927). X - one or more species shared; x - only generic occurrence shared.

Genus	Burnt Bluff	Severn River	Ekwan River	Attawapiskat
Corals				
Amplexus	X	0	X	0
Favosites	x	x	x	x
Halysites	X	0	X	0
Lyellia	x	0	x	0
Pycnostylus	x	0	0	x
Ptychophyllum	x	0	x	0
Streptelasma	x	0	x	x
Syringopora	x	0	x	x
Zaphrentis	x	x	x	x
Brachiopoda				
Atrypa	x	x	x	x
Camarotoechia	X	X	X	x
Glassia	X	X	X	X
Orthis (Dolerorthis)	X	X	X	x

Plectambonites	x	0	0	x
Rhynchospira	X	X	X	0
Schuchertella	x	x	0	0
Spirifer	x	0	x	x
Stropheodonta	x	x	x	x
Trimerella	X	X	X	X
Whitfieldella	x	x	0	0
Gastropoda				
Hormatoma	X	X	X	X
Liospira	X	0	X	X
Pycnomphalus	x	0	x	0
Trochonema	x	0	x	0
Pelecypoda				
Ctenodonta	x	x	x	0
Pterinia	X	X	0	0
Cephalopoda				
Orthoceras	x	x	x	x
Phragmoceras	x	x	x	x
Stokesoceras	x	0	x	0
Trilobita				
Illaenus	x	0	x	x
Ostracoda				
Isochilina	X	X	X	0
Leperditia	X	X	x	x
Total X	12	9	10	4
Total X and x	32	18	27	19

TABLE 5 -- Fossils Present in the Manistique Dolomite of Michigan.
S - Schoolcraft Member; C - Cordell Member.

Hydrozoa	
? Actinostroma tenuifilatum	S
Clathrodictyon aff. cystosum	C
cf. Syringostroma niagarense	C
Corals	
Alveolites undosus	C
Alveolites sp.	C
Amplexus shumardi var.	C
Amplexus ? sp.	S
Arachnophyllum pentagonum	C
Arachnophyllum striatum	C
Aulopora ? sp.	C
Blothrophyllum caespitosum	C
Cladopora laqueata	C
Cladopora sp.	C
Coenites crassus	C
Coenites laminatus	C
Coenites cf. laminatus	C
Cyathophyllum radicula	C
Cystiphorolites major	C
Cystiphorolites minor	C
Cystiphyllum niagarense var.	C
Diphyphyllum stokesi	C
Favosites favosus	C
Favosites cf. favosus	C
Favosites aff. favosus	S
Favosites hispidus	C
Favosites obliquus	C
Favosites cf. venustus	S
Favosites aff. venustus	S
Favosites n. sp. aff. venustus	C

Favosites sp. no. 1	S	C
Favosites sp. no. 2	S	C
Favosites n. spp.		C
Halysites cf. agglomeratus		C
Halysites catenularia		C
Halysites catenularia micropora		C
Halysites catenularia vars.		C
Halysites aff. catenularia		S
Halysites compactus		S
Halysites labyrinthicus		C
Heliolites interstinctus		C
Heliolites megastoma		C
Heliolites megastoma var.		C
Heliolites subtubulatus		C
Heliophyllum ? sp.		C
Lyellia americana		C
Lyellia aff. americana		S
Lyellia decipiens		C
Lyellia papillata		C
Lyellia sp.		C
Omphyma verrucosa		C
Palaeocyclus n. sp. aff. crassus		C
Palaeocyclus cf. rotuloides		C
Paleofavosites sp.		C
Ptychophyllum stokesi		C
Streptelasma conula		C
Streptelasma patula		C
Streptelasma spongaxis		C
Syringopora tenella		C
Syringopora verticillata		C
Syringopora sp.		S
Thecia major		C
Thecia cf. minor		C
Zaphrentis stokesi		C
Zaphrentis umbonata		C

Bryozoa

Fenestella cf. crassa		C
Fenestella aff. elegans		C
Fistulipora ? sp.		S
Helopora n. sp.		C
Lioclema aff. aspera		C
Pachydictya cf. crassa		C
Pachydictya n. sp. aff. crassa		C
Pachydictya ? sp.	S	C
Phaenopora cf. keewatinensis		C

Brachiopoda

Atrypa reticularis		C
Atrypa reticularis n. var. or n. sp.		C
Camarotoechia cf. neglecta		C
Camarotoechia sp.		C
Coelospira aff. hemispherica		S
Coelospira n. sp.	S	C
Orthis flabellites		C
Pentamerus oblongus		S
Pentamerus oblongus vars.		C
Pentamerus oblongus bisinuatus		C
Pentamerus aff. oblongus bisinuatus		C
Pentamerus oblongus subrectus		C
Pentamerus oblongus aff. subrectus		C
Pentamerus sp.	S	C
Stropheodonta (Brachyprion) cf. profunda		C
Stropheodonta (Brachyprion) sp.	S	C
Whitfieldella cf. intermedia		S
Whitfieldella sp.	S	C
Zygospira ? sp.		C

Gastropoda

Liospira sp.		C
Liospira ? sp.		S
Tentaculites aff. niagarensis		C

Pelecypoda

Conocardium ? sp.		C
Modiolopsis ? sp.		S
Pterinea cf. subplana		S

Cephalopoda

Actinoceras sp.		C
Armenoceras backi		C
Armenoceras gouldense		C
Armenoceras sphaeroides		C
Discosorus ehlersi		C
Discosorus gracilis (= Stokesoceras gracile)		C
Huronia bigsbyi intermedia		C
Huronia ehlersi		C
Huronia obliqua		C
Huronia paulodilatata		C
Huronia vertebralis		C
Huroniella ehlersi		C
Huroniella sp.		C
Megadiscosorus sp.		C
Oncoceroid		S
Ormoceras sp.		C
Orthoceras sp.		C
Stokesoceras engadinense		C
Stokesoceras perobliquum		C
Stokesoceras cf. romingeri		C
Trochoceras ? sp.		S

Trilobita

Cheirurus n. sp.		S
Dalmanites ? sp.		C
Encrinurus sp.		S
Goldius n. sp.		S

Ostracoda		
Aparchites n. sp.	C	
Apatobolbina n. sp.	C	
Leperditia cf. marginata	S	C
Leperditia sp.	S	
Schmidtella ? n. sp.	C	
Graptolites (manuscript names)		
Hippurograptus ruedemanni	S	
Inocaulis manistiquensis	S	
Mastigograptus manistiquensis	S	

TABLE 6 -- Fossils Present in the Engadine Dolomite of Michigan.

Hydrozoa

Clathrodictyon ? sp.

Corals

Amplexus ? shumardi
Amplexus whitfieldi
Amplexus sp.
Cladopora reticulata
Cystiphyllum sp.
Diplophyllum caespitosum
Favosites cf. favosus
Favosites cf. hisingeri
Favosites cf. niagarensis
Favosites cf. occidens
Favosites sp.
Halysites cf. catenularia
Halysites cf. catenularia micropora
Halysites compactus
Omphyma ? sp.
Pycnostylus guelphensis
Strombodes pentagonus
Syringopora cf. verticillata
Syringopora sp., probably new

Brachiopoda

Clorinda ventricosa
Cyrtia ? sp.
Dalmanella cf. elegantula
Monomerella ? sp.
Pentamerus oblongus
Pentamerus oblongus bisinuatus
Pentamerus ? sp.
Spirifer (Delthyris) crispus
Trimerella sp.

Gastropoda

Coelidium sp.
Diaphorostoma niagarense
Poleumita cf. scammata
Poleumita ? sp.
cf. Pycnomphalus solaroides
Straparolus cf. mopsus

Cephalopoda

cf. Dawsonoceras annulatum
Kionoceras cancellatum

TABLE 7 -- Silurian formations of Michigan and their tentative equivalents.

System	Series	Group	Iowa	Wisconsin (Milwaukee Region)	Wisconsin (Northeastern Part)	Michigan (Northern Peninsula)		Manitoulin Island Region	Hudson Bay Region	Manitoba	Lake Timiskaming Region
SILURIAN	NIAGARAN	Lockport		Guelph	Guelph	Engadine		Guelph and probably upper part of Lockport			Lockport (possibly highest beds)
				Racine							
		Clinton	Hopkinton	Waukesha (in part)	"Upper Coral Beds"	Manistique	Cordell Member	Fossil Hill Coral Beds of Lockport			Lockport (may or may not contain beds as low as Schoolcraft Member of Manistique)
					"Lower Coral Beds" (in part)	Manistique	Schoolcraft Member	Lockport (in part)			
									Attawapiskat (may prove to be of later age)	Stonewall (in part)	
					"Lower Coral Beds" (in part) "Transition Beds"	Burnt Bluff	Hendricks Member	Lockport (in part)	Ekwan River		Wabi
					Byron	Burnt Bluff	Byron Member		Severn River		
				Mayville	Mayville	Mayville		Dyer Bay	Port Nelson	Stonewall (in part)	

LOCALITIES OF NIAGARAN EXPOSURES

Compiled by Robert V. Kesling from
Notes of George M. Ehlers

MAYVILLE DOLOMITE

1. Nahma peninsula, blocks of siliceous dolomite along shore of Stony Point, NE$\frac{1}{4}$ sec. 28 and NW$\frac{1}{4}$ sec. 27, T 40 N, R 19 W, about 4 mi. S of Moss Lake, eastern Delta County.
2. Nahma peninsula, field exposures bordering both sides of Nahma-Isabella road, central and southern parts sec. 15, T 40 N, R 19 W, about 2 miles northeast of Nahma, eastern Delta County.
3. Isabella vicinity, pavement beside Nahma-Isabella road, about 1$\frac{1}{2}$ mi. S of Isabella, NW$\frac{1}{4}$ sec. 11, T 40 N, R 19 W, eastern Delta County.
4. Isabella vicinity, abandoned quarry, test pit, and old lime-kiln, about $\frac{1}{2}$ mi. S of Isabella, SE$\frac{1}{4}$ sec. 2, T 40 N, R 19 W, eastern Delta County. 9 feet of dolomite exposed.
5. Isabella vicinity, low, westward-facing escarpment, can be traced northward along E side of Moss Lake, from just S of N line of SW$\frac{1}{4}$ sec. 3, T 40 N, R 19 W, to just W of center of E line of sec. 35, T 41 N, R 19 W, about 1$\frac{1}{2}$ mi. W of Isabella, Delta County. Gentle slopes said to continue southward for additional 3/4 mi. to about center of E line of sec. 9, T 40 N, R 19 W, and northward to near center of E line of sec. 26, T 41 N, R 19 W. Escarpment 10 to 15 feet high.
6. Isabella vicinity, part of escarpment (loc. 5), exposed near SE corner of Moss Lake and only a few yards N of track of Minneapolis, St. Paul, & Sault Ste. Marie Railroad. 8 feet of dolomite exposed.
7. Isabella vicinity, railroad cut a short distance E of locality 6. 3 feet of siliceous dolomite exposed.
8. Exposure on escarpment (loc. 5) about 1/3 mi. N of Minneapolis, St. Paul, & Sault Ste. Marie Railroad. A few feet of dolomite.
9. Small road quarry excavated in top of escarpment (loc. 5) beside little-used N-S road, about 2/3 mi. N of railroad. 3 feet of dolomite with chert.
10. Exposure on slope a short distance SE of center of E line of sec. 26, T 41 N, R 19 W, northeast of Moss Lake, Delta County. 2 feet of dolomite.
11. Bottom of spring a short distance E of locality 10, in W part of sec. 25, T 41 N, R 19 W.
12. Bottom of spring in NW$\frac{1}{4}$ NW$\frac{1}{4}$ sec. 25, about $\frac{1}{2}$ mi. N of locality 11.
13. Bottom of spring in NE$\frac{1}{4}$ sec. 24, T 41 N, R 19 W, Delta County.
14. Surface exposure of 4 or 5 acres just E of a branch of the Nahma & Northern Railroad, NE$\frac{1}{4}$ SW$\frac{1}{4}$ sec. 13, T 41 N, R 19 W.
15. Garden vicinity, drift blocks along shore of Garden Bay about $\frac{1}{4}$ mi. SE of Ansel's Point on Big Bay de Noc, about 2 mi. NW of Garden, NW$\frac{1}{4}$ sec. 7, T 39 N, R 18 W, Delta County. Virgiana.
16. Garden vicinity, drift blocks along N-S road 2 mi. N of Garden, just N of center of sec. 5, T 39 N, R 18 W, Delta County. Virgiana.
17. Drift blocks about 3/4 mi. N of Nicholsonville Quarry and about 3$\frac{1}{2}$ mi. N of Blaney Junction, Schoolcraft County. Virgiana.
18. Numerous slabs on N shore of Manistique Lake adjoining SW$\frac{1}{4}$ sec. 29, T 45 N, R 12 W, Luce County.
19. Small exposure on E side of small brook in SE$\frac{1}{4}$ SE$\frac{1}{4}$ sec. 19, T 45 N, R 12 W, about 1 mi. NW of locality 18, Luce County. Brook now mapped as E. Branch Fox River.
20. Northward-facing bluff (Hendricks Member of Burnt Bluff) in NW$\frac{1}{4}$ sec. 6, T 44 N, R 8 W and NE$\frac{1}{4}$ sec. 1, T 44 N, R 9 W, about $\frac{1}{2}$ mi. N of Hendricks Quarry, Luce County. Drift immediately N of bluff contains Virgiana mayvillensis blocks.
21. Hendricks Quarry and vicinity, drift blocks

with molds of Virgiana mayvillensis, sec. 1, T 44 N, R 9 W, and sec. 6, T 44 N, R 8 W, in Mackinac County. Adjacent to locality 20 but in Mackinac County.

22. Headland on northwest side of Drummond Island, about 1 mi. N of Maxton, Chippewa County. Dolomite.

23. Scattered blocks just east of locality 22, in NE¼ SE¼ sec. 9, T 42 N, R 6 E, Chippwa County. Dolomite.

24. Bluff on S side of a marsh on northwest side of Drummond Island, N part of sec. 3, T 42 N, R 6 E, Chippewa County, about 1½ mi. N of locality 23. May be Manitoulin Dolomite, 40 to 45 feet thick.

25. Exposures at lake level on Walter Stevenson's farm, SW¼ sec. 3, T 42 N, R 6 E, Chippewa County. May be Manitoulin Dolomite, continuation of rocks at Locality 24.

26. Drift blocks beside abandoned railroad bed about 1 mi. S of Cordell, a station on the Minneapolis, St. Paul, & Sault Ste. Marie Railroad, about 10 mi. E of Trout Lake, NE¼ NE¼ sec. 29, T 44 N, R 4 W, Chippewa County.

27. Exposures on W side of Lime Island and small abandoned quarry on the shore less than ¼ mi. N of the coaling wharf of the Pittsburg Coal Company, Chippewa County. 7 feet of Virgiana beds. Contact with Burnt Bluff Dolomite.

28. Scattered blocks with Virgiana mayvillensis along shore at Glen Point on E side of Drummond Island, about 1/3 mi. N of center of sec. 26, T 42 N, R 7 E, Chippewa County.

29. Scattered blocks with Virgiana on shore about 3 mi. N of locality 28, S part of sec. 10, T 42 N, R 7 E, Chippewa County.

30. Exposure on S slope of Big Limestone Mountain, about 4 mi. N of Hazel, southern Houghton County.

BURNT BLUFF LIMESTONE AND DOLOMITE

31. Cliff along N and W shores of St. Martins Island, from NW¼ sec. 15 to SW¼ sec. 21, T 36 N, R 20 W, Delta County. Cliff rises about 60 feet above Green Bay. Dolomites of Hendricks Member.

32. Cliff on E shore of St. Martins Island a short distance S of the lighthouse, near the shore, NE¼ sec. 22, T 36 N, R 20 W. Contact with Manistique Formation. 9 feet of Hendricks Member, 44 feet of Manistique.

33. Low cliff on S shore of Little Summer Island just W of a small point of land in SE¼ sec. 18, T 37 N, R 19 W, Delta County. Contact with Manistique Formation. 20 feet of Hendricks Member.

34. Exposure on SW point of Little Summer Island, NW¼ sec. 18, T 37 N, R 19 W, Delta County. About 8 inches of Hendricks.

35. Shingle beaches on shore of Squaw Island, a very short distance W of Little Summer Island, Delta County. Ledges crop out on bottom of Lake Michigan on E side of island.

36. Burnt Bluff on Garden Peninsula, facing Big Bay de Noc, about 9½ mi. SW of Garden, NW¼ sec. 18, T 38 N, R 19 W, and NE¼ sec. 13, T 38 N, R 20 W, Delta County. Byron Member 117 feet thick, Hendricks Member 121 feet thick, Manistique Dolomite 10 feet thick.

37. Middle Bluff and abandoned quarry in the S end of the bluff near Fayette, facing Big Bay de Noc, SW¼ sec. 33, T 39 N, R 19 W, and NW¼ sec. 4, T 38 N, R 19 W, Delta County. 113 feet of Hendricks dolomite, 22 feet of Manistique with Pentamerus.

38. Wooded cliff extending N-S along E side of South River Bay, SW¼ sec. 23, T 39 N, R 19 W, Delta County. Hendricks strata from 40 to 125 feet above bay.

39. Garden Bluff, facing Big Bay de Noc, secs. 10, 11, and 15, T 39 N, R 19 W, Delta County. Hendricks Member.

40. Abandoned quarry about 3/4 mi. E of Garden Bluff, near shore of Goulley's Harbor, N part sec. 14, T 39 N, R 19 W, Delta County. Hendricks Member; lower Manistique Dolomite with Pentamerus a short distance back from bluff.

41. Cliff a short distance NW of Vans Harbor, which is 1 mi. NW of Garden, near center

sec. 7, T 39 N, R 18 W, Delta County. Contact with Manistique Dolomite.

42. Exposures along shore NW of Locality 41 for about 1 mile, past Ansel's Point, Garden Peninsula, Delta County. Lower part of Hendricks Member.

43. The "11-mile bluff," about 11 mi. NE of Burnt Bluff, facing Big Bay de Noc, about 3 mi. N of Garden, NW$\frac{1}{4}$ sec. 32, T 40 N, R 18 W, Delta County. 82 feet of Hendricks Member.

44. Very small quarry for road metal in side of low E-W ridge about 6 mi. N and 1$\frac{1}{2}$ mi. E of Cooks, SW$\frac{1}{4}$ sec. 28, T 42 N, R 17 W, Schoolcraft County. 5 to 6 feet of lowest Hendricks Member.

45. Along road and in nearby fields about 3$\frac{1}{4}$ mi. S of locality 44, SW corner sec. 9, T 41 N, R 17 W, and N of this corner, Schoolcraft County. Beds with Trimerella, Hendricks Member.

46. Small quarry for road metal in small hill about $\frac{1}{2}$ mi. E and 100 yds. N of SW corner sec. 9, T 41 N, R 17 W, on N side of E-W road, Schoolcraft County. About 16 feet of dolomites with Trimerella, Hendricks Member.

47. Low ridge crossing E-W road about 3/4 mi. W of SW corner sec. 9, T 41 N, R 17 W, Schoolcraft County. About 2$\frac{1}{2}$ mi. NNE of Cooks. About 3 feet of Hendricks dolomite.

48. Roadside exposures about $\frac{1}{4}$ mi. W of Locality 47, about 100 feet E of SW corner sec. 8, T 41 N, R 17 W, Schoolcraft County. 4 to 6 feet of Hendricks, may be dolomitized equivalent of Fiborn Limestone.

49. Escarpment N of Manistique, in T 42 N, R 16 W, extending from N central part of sec. 29 NW through W central part of sec. 22, thence NE into S parts of secs. 15 and 14 (there E-W-trending), thence SE into E central part of sec. 23 and S into NE$\frac{1}{4}$ sec. 26, thence ENE into S part of sec. 24 and continuing as a low and discontinuous cliff into NE$\frac{1}{4}$ sec. 25. Escarpment and cuesta between Indian Lake and valley of Manistique River, Schoolcraft County.

50. Cut for Highway 94 (old Manistique-Shingleton road) through cuesta and escarpment of locality 49, about $\frac{1}{4}$ mi. S of center sec. 14, T 42 N, R 16 W, Schoolcraft County. (Later roadside quarry at this locality known as the Sawheidle Quarry, now abandoned.) Over 58 feet of fossiliferous Hendricks dolomites.

51. Discontinuous exposures along NE shore of Indian Lake and in low cliff between outlet of lake into Indian River and point about 1 mi. NE, Schoolcraft County. Hendricks Member, dolomite at base, limestone above, lower than Fiborn Limestone.

52. Ledges on bottom of Indian River between Indian Lake and Highway 94 (old Manistique-Shingleton road), Schoolcraft County. Hendricks dolomite, stratigraphically higher than beds at Locality 51.

53. Surface exposure over 3 to 4 acres just N of Indian River and E of Highway 94, and a few small quarries excavated in this exposure for building stone, Schoolcraft County. Near top of Hendricks Member.

54. Escarpment facing N and NW, located $\frac{1}{4}$ to 3/4 mi. S and SE of Manistique River and from 6 to 12 miles NE of Manistique, from sec. 22, T 42 N, R 15 W, to sec. 34, T 43 N, R 14 W, Schoolcraft County. This includes Localities 55-57. Hendricks Member.

55. Escarpment about 9 mi. NE of Manistique, NE$\frac{1}{4}$ SW$\frac{1}{4}$ sec. 8, T 42 N, R 14 W, Schoolcraft County. Escarpment rises 80 feet above swamp bordering Manistique River, exposing about 48 feet of Hendricks dolomites at top.

56. Cliff facing NE in NE$\frac{1}{4}$ SE$\frac{1}{4}$ sec. 8, about 3/4 mi. E of Locality 55, and extending from NE$\frac{1}{4}$ sec. 17 to SW$\frac{1}{4}$ sec. 4, T 42 N, R 14 W, Schoolcraft County. About 45 feet of Hendricks, probably dolomitized equivalent of Fiborn.

57. Rock pavement over S$\frac{1}{2}$ sec. 8, T 42 N, R 14 W, Schoolcraft County.

58. Low ridge about 5 mi. NE of Manistique, NE$\frac{1}{4}$ SE$\frac{1}{4}$ sec. 27, T 42 N, R 15 W, along sides of "river road" crossing ridge, and in small abandoned quarry just S of road, Schoolcraft County. Dolomite with Trimerella.

59. Large area around Nicholsonville where limestones and dolomites are very near the surface or crop out as rock pavement, including the S halves of secs. 34-36 and SE¼ sec. 33, T 43 N, R 13 W; the N halves of secs. 1 and 2, all of sec. 3, the E and S parts of sec. 4, and the N halves of secs. 8 and 9, T 42 N, R 13 W, eastern Schoolcraft County. Fiborn Limestone. The following six localities lie within this area.

60. Nicholsonville Quarry ("Blaney Quarry" of local residents) at Nicholsonville (now Calspar), owned by the Manistique Lime Company, then by the Inland Lime & Stone Company, now abandoned, located on the Blaney & Southeastern Railroad (long abandoned), NE¼ SW¼ sec. 3, T 42 N, R 13 W, eastern Schoolcraft County, about 10 mi. N of Seul Choix Point. Not to be confused with the Inland Quarry of the Inland Lime & Stone Company located about 3 miles to the E in Mackinac County. 44 feet of Hendricks Member, mostly Fiborn Limestone.

61. Small bluff about 3/4 mi. N of Nicholsonville Quarry, S part of sec. 34, T 43 N, R 13 W, Schoolcraft County. Near Locality 17. 2 feet of dolomite, stratigraphically a little below Fiborn Limestone.

62. Test pits dug in N part of sec. 10, T 42 N, R 13 W, Schoolcraft County, S of road providing access to Nicholsonville Quarry. Fiborn Limestone.

63. Ditch about 2 mi. W of Nicholsonville Quarry, SE¼ SW¼ sec. 5, T 42 N, R 13 W, Schoolcraft County. 3 inches of dolomitized strata below 8 inches of highly calcareous Fiborn.

64. Exposures along N-S road extending S from center of N line of sec. 8, T 42 N, R 13 W, Schoolcraft County. Fiborn Limestone.

65. Roadside quarry in side of low W-facing bluff, less than ½ mi. W of locality 64, and field exposures just S of quarry, SW corner sec. 5, T 42 N, R 13 W, Schoolcraft County. 11½ feet of dolomite, stratigraphically below Fiborn Limestone.

66. Low ridge about 2¼ mi. SW of locality 63, crossing section line 1/8 mi. N of SE corner sec. 12 and extending WSW, Schoolcraft County. Dolomitized equivalent of Fiborn Limestone.

67. Small abandoned quarry at SW end of ridge of locality 66, Schoolcraft County. Dolomitized equivalent of Fiborn.

68. Roadside exposure on S½ of line between secs. 11 and 12, T 42 N, R 14 W, Schoolcraft County. 10 feet of dolomite with Trimerella.

69. Exposure along E-W road about 1 mi. NW of Locality 68, on S line near corner of sec. 2, T 42 N, R 14 W, Schoolcraft County. 2 feet of limestone, lower than Trimerella beds.

70. Quarry for road metal about 2 mi. N and 1½ mi. W of Nicholsonville Quarry, SW¼ NE¼ sec. 29, T 43 N, R 13 W, Schoolcraft County. 6 feet of limestone like that at Locality 69.

71. Roadside exposure about 1/8 mi. NE of Locality 70 on NE-SW section of old Manistique Highway (part now cut off by US 2), Schoolcraft County. Limestone like that at Locality 69.

72. Surface exposures over extensive area north of Hunt's Spur, covering most of sec. 6 and NE¼ sec. 5, T 42 N, R 12 W, and S½ sec. 31 and SW¼ sec. 32, T 43 N, R 12 W, Mackinac County. Area continuous with that of Locality 59 in Schoolcraft County. Fiborn Limestone.

73. Inland Quarry of Inland Lime & Stone Company, opened in SW¼ sec. 6 and expanded into secs. 5 and 6, T 42 N, R 12 W, about 7 mi. NNE of Port Inland, Mackinac County. Thickest known section of Fiborn Limestone, about 50 feet.

74. Surface exposures about ¼ mi. NW of Gould City in S parts secs. 19 and 20 and N parts secs. 29 and 30, T 43 N, R 11 W, Mackinac County. Fiborn Limestone and overlying magnesian-limestone.

75. Roadside exposure on road leading N from Gould City and about 4 mi. N of that community on line between secs. 4 and 5, T 43 N, R 11 W, Mackinac County. Limestone of Hendricks Member, may be Fiborn.

76. Drift blocks beside road, about 4½ mi. N

and 1 mi. E of Engadine, W line sec. 27, T 44 N, R 10 W, Mackinac County, magnesian-limestone, probably higher than Fiborn Limestone.

77. Near-surface limestone about 4½ mi. N of Engadine and 1½ mi. S of Donald, in sec. 29, T 44 N, R 10 W, Mackinac County. Probably upper part of Hendricks Member.

78. Hendricks Quarry, near N line of county, NW¼ sec. 6, T 44 N, R 8 W, and NE¼ sec. 1, T 44 N, R 9 W, Mackinac County. 81 feet of Hendricks Member, including 18 feet of Fiborn Limestone.

79. Escarpment about ½ mi. N of Hendricks Quarry, extending from SE¼ sec. 2 to NE¼ sec. 2, thence into Luce County in SW corner sec. 36, NE to center of E line of sec. 36, thence SE into SE¼ sec. 31, then re-entering Mackinac County and ending in E¼ sec. 6, T 44 N, R 8 W, thus forming roughly a semicircle. Escarpment 80 to 100 feet high, capped at most places by Fiborn Limestone.

80. Fiborn Quarry, about 4 mi. NE of Rexton, just S of center sec. 16, T 44 N, R 7 W, Mackinac County. Nearly along the strike and 9 mi. ESE of Hendricks Quarry. 32 feet of Hendricks limestone, including 28 feet of Fiborn.

81. Exposures beside N-S road about 7 mi. SE of Rudyard, about 1/8 mi. S of NE corner sec. 11, T 43 N, R 2 W, Mackinac County. Dolomite, probably Hendricks.

82. Exposure in road a short distance S of previous locality, Mackinac County. 6 feet of limestone, partly dolomitized; lower Pentamerus dolomite of basal Manistique exposed a short distance S of this locality on N side of low ridge crossing the road.

83. Escarpment capped by Hendricks strata about ½ mi. N of Hendricks Quarry; this is the part of Locality 79 situated in Luce County.

84. Bluff about 5 mi. E and ½ mi. N of Hendricks Quarry, extending from SW¼ sec. 36 to NE¼ sec. 35, T 45 N, R 8 W, Luce County. 6 feet of limestone and 3 feet of magnesian-limestone, Hendricks Member.

85. Limestone exposed in test-pit of Cheesbrough Lumber Company, about 4 mi. W of Trout Lake, S part sec. 18, T 44 N, R 6 W, Chippewa County. Fiborn Limestone, 10 feet of limestone overlain by 4½ feet of magnesian-limestone and 8 feet more of limestone.

86. Limestone exposed in small knoll about 100 feet S of pit in Locality 85, Chippewa County. Stratigraphically higher than strata at Locality 85.

87. Limestone exposure near edge of swamp, about 500 feet N of pit in Locality 85, Chippewa County. Stratigraphically below strata at Locality 85.

88. Small escarpment about 3/4 mi. S of Cordell and 9 mi. E of Trout Lake, its eastern part in NW¼ SE¼ sec. 29, T 44 N, R 4 W, Chippewa County. Escarpment faces N; this small outlier contains Scott Quarry (see Locality 124). Beds near top of Hendricks Member.

89. Escarpment facing NE, about 3/4 mi. S of Raber, extending SE across S½ sec. 33, T 43 N, R 3 E, NE¼ sec. 4, T 42 N, R 3 E, and into W½ sec. 3, T 42 N, R 3 E, Chippewa County. Escarpment continues but decreases in height to SE along shore of Potagannissing Bay. Near center of high escarpment nearly 100 feet of Manistique strata exposed. Lower Pentamerus dolomite exposed about 1/8 mi. S of NE corner sec. 4.

90. Abandoned quarry on NW shore and top of escarpment at N end of Lime Island in Potagannissing Bay. Quarry adjacent to Mayville Virgiana beds at Locality 27. 17 feet of dolomite in quarry's other strata exposed leading to top of escarpment 1/3 mi. NE of quarry.

91. Abandoned L. Seaman Quarry and natural exposures in vicinity of Drummond, Drummond Island, Chippewa County. 114 feet of fossiliferous Hendricks Member overlain by 8 feet of basal Manistique.

92. Abandoned quarry about 3/4 mi. SW of L. Seaman Quarry (Locality 91), Drummond Island, Chippewa County. 59 feet of fossiliferous Hendricks dolomites.

93. Abandoned lime kiln quarry about 1 mi. NE of Drummond, on shore of Potagannissing Bay, Drummond Island, Chippewa County.

80 feet of Hendricks dolomites overlain by 16 feet of lower and upper Pentamerus dolomites.

94. Thick exposures on Victor Hilden Ranch about 4½ mi. E of Drummond, NW¼ sec. 26, T 42 N, R 6 E, Drummond Island, Chippewa County. 56 feet of Burnt Bluff strata.

95. Along lake shore, in abandoned quarry, and in bluffs at Marblehead on E side of Drummond Island, Chippewa County. Over 172 feet of strata exposed in bluffs and nearby. 118 feet of Hendricks dolomites and limestones overlain by 55 feet of Manistique Dolomite.

96. Exposures along shore of Drummond Island between Pilot Harbor (= Pirate Harbor) and Glen Point about 1½ mi. to the NW. Pilot Harbor nearly 4 mi. NW of abandoned quarry at Marblehead. Dolomites, probably Byron Member.

MANISTIQUE DOLOMITE

97. Exposures along roads in and near Garden and in W½ sec. 18, T 39 N, R 18 W (about 1½ mi. W of Garden), Garden Peninsula, Delta County. Schoolcraft Member.

98. Outcrops in glacial-lake terraces in vicinity of Fairport, S end of Garden Peninsula, Delta County. Schoolcraft Member.

99. Exposures along and near shore between Fairport and Pt. Detour at SE tip of Garden Peninsula, Delta County. Low cliffs of Cordell Member on shore about 1½ mi. NW of Pt. Detour.

100. Cliffs on W side of Big Summer Island, about 9 feet high, Delta County. Dolomites of Cordell Member.

101. Surface of Little Gull Island, about 1½ mi. E of St. Martin's Island, Delta County. 6 feet of cherty Cordell dolomite.

102. Surface outcrops on Gull Island, about 3/4 mi. N of Little Gull Island, Delta County. 5 feet of Cordell dolomite.

103. Bluffs and field exposures about 2 mi. N of Cooks, in SW¼ sec. 17, SE¼ sec. 18, NE¼ sec. 19, and NW¼ sec. 20, T 41 N, R 17 W, Schoolcraft County. NE-SW bluff crosses road about 1/3 mi. N of SW corner sec. 18, exposing 6 feet of dolomite, probably basal Manistique.

104. Outcrops in town of Manistique E of Manistique River, along river from mouth to Charcoal Iron Company plant 1 mi. above mouth, and along lake shore, Schoolcraft County.

105. White Marble Quarry in Manistique, formerly operated by Inland Lime & Stone Company, and more elevated nearby sections of the town (as behind football field), Schoolcraft County. 56 feet of Schoolcraft Member starting with basal lower Pentamerus dolomite, overlain by 19 feet of Cordell Member.

106. Exposures along Highway 94 (Manistique-Shingleton highway) less than ¼ mi. S of the Indian River, near center W½ sec. 2, T 41 N, R 16 W, Schoolcraft County. Dolomite, probably lower Pentamerus dolomite.

107. Marblehead Quarry of Inland Lime & Stone Company (not the quarry at Marblehead on Drummond Island) about 5 mi. E of Manistique, SW¼ sec. 36, T 42 N, R 15 W, Schoolcraft County. 8 feet of massive dolomite, probably lower Pentamerus dolomite, and about 5 feet more in old test-pit.

108. Road cut of US 2 by-passing old corner in SW¼ sec. 36 near Marblehead Quarry, Schoolcraft County. Strata dipping steeply and faulted. Cordell and Schoolcraft Members.

109. Exposure on S side of road about ½ mi. E of Marblehead Quarry, SE¼ sec. 36, T 42 N, R 15 W, Schoolcraft County. Contact between Cordell and Schoolcraft Members.

110. Surface exposures about 1 3/4 mi. W of Gulliver (formerly Whitedale), E½ sec. 33 and W½ sec. 34, T 42 N, R 14 W, Schoolcraft County. Highly fossiliferous Cordell strata.

111. Exposures along N-S road from NE corner sec. 33, T 42 N, R 14 W, to NE¼ sec. 28, where low ridge crosses road, Schoolcraft County. Intersection of ridge and road nearly 2 mi. NW of Gulliver; upper Pentamerus dolomite.

112. Two outliers of Engadine Dolomite and surrounding exposures of Cordell strata at and near Gulliver, Schoolcraft County.

113. NW-SE ridge about 1 mi. SE of Gulliver, Schoolcraft County. Cordell dolomites.

114. Exposures on N, S, and SW shores of McDonald Lake, 2 mi. SE of Gulliver, Schoolcraft County. Cordell beds.

115. Field exposures near W line sec. 7, T 42 N, R 12 W, at points $\frac{1}{4}$ and $\frac{1}{2}$ mi. N of Hunt's Spur, Mackinac County. These are SW of Inland Quarry (Locality 73). Thin Cordell dolomites.

116. Low ridge about $\frac{1}{2}$ mi. SW of Gould City, $SE\frac{1}{4}$ sec. 29, T 43 N, R 11 W, continuing S through E part of sec. 32 and crossing road on E line of this sec. about $1\frac{1}{2}$ mi. S of Gould City, Mackinac County. Thin exposure of Cordell beds, at most 4 feet.

117. Exposures along road leading S from Gould City between SE corner sec. 29, T 43 N, R 11 W, and SE corner sec. 17, T 42 N, R 11 W, Mackinac County. Cordell strata. Contact with Engadine Dolomite crosses road near SE corner sec. 17.

118. Low bluff about 1 mi. N of Hazelmere (station on Minneapolis, St. Paul, & Sault Ste. Marie Railroad) and 3 mi. ENE of Gould City, $SW\frac{1}{4}$ sec. 13 and $NW\frac{1}{4}$ sec. 24, T 43 N, R 11 W, Mackinac County, and field exposures to the W. Bluff is Engadine Dolomite and field exposures are Cordell Member.

119. Near-surface dolomite and exposures 1 to 3 mi. N of Engadine, from about center E line sec. 8, T 43 N, R 10 W, to center E line sec. 32, T 44 N, R 10 W, Mackinac County.

120. Roadside exposures about 5 mi. S of Fibre (station on Minneapolis, St. Paul, & Sault Ste. Marie Railroad), secs. 8 and 9, T 43 N, R 3 W, Mackinac County. Lower and upper Pentamerus dolomites.

121. High N-facing escarpment about 6 mi. S and 2 mi. E of Rudyard, W part sec. 3, T 43 N, R 2 W, Mackinac County. Escarpment rises 225 feet above swamp in four distinct bluffs (probably wave-cut by glacial lakes), capped by 5 feet of Engadine Dolomite. Cordell Member at least 105 feet thick.

122. Escarpment $3\frac{1}{2}$ mi. E of Trout Lake, $SW\frac{1}{4}$ sec. 21 and $SE\frac{1}{4}$ sec. 20, T 44 N, R 5 W, Chippewa County. Exposures descend to Minneapolis, St. Paul, & Sault Ste. Marie Railroad to the N. Capped by Engadine Dolomite, 25 feet thick at N end of escarpment and 55 feet about $\frac{1}{2}$ mi. farther S. Contact with underlying Cordell Member dolomites.

123. Exposures 1 mi. W of top of escarpment (Locality 122), $SE\frac{1}{4}$ sec. 19, T 44 N, R 5 W, less than 100 feet N of road on S line of sec. Lower or upper Pentamerus dolomite.

124. Scott Quarry formerly operated by Inland Lime & Stone Company, about 3/4 mi. S of Cordell, $SW\frac{1}{4}$ sec. 29, T 44 N, R 4 W, Chippewa County. Hendricks Member of Burnt Bluff, 15 feet; Schoolcraft Member of Manistique, over 35 feet; Cordell Member of Manistique, over 77 feet.

125. Taylor's Mill, about 4 mi. SE of Pickford, sec. 20, T 43 N, R 1 E, Chippewa County. Lower and upper Pentamerus dolomites.

126. Escarpment 3/4 mi. S of Raber, Chippewa County. Exposure of 97 feet of Manistique strata, with lower Pentamerus dolomite at base; contact with Burnt Bluff Dolomite covered.

127. Exposures in N part of village of Detour ($NW\frac{1}{4}$ sec. 35, T 42 N, R 4 E) and in small abandoned quarry near NW corner sec. 35, Chippewa County. About 14 feet of Cordell Member below basal beds of Engadine Dolomite; contact about 48 feet above level of water in Detour Passage.

128. Exposure on E shore of prominent peninsula about 3/4 mi. N of Point St. Vital (about 4 mi. W of Point Detour at S entrance into Detour Passage), and on very small low islands just offshore about 1/3 mi. N of Point St. Vital. Uppermost Cordell Member.

129. Outcrops along SW shore of Drummond Island near N line sec. 30, T 42 N, R 5 E, Chippewa County. Lower and upper Pentamerus dolomites.

130. Outcrops along shore of Drummond Island

about 2 mi. S of Locality 129, E central part sec. 36, T 42 N, R 4 E, Chippewa County. Upper part Cordell Member.

131. Bluff about 1 mi. SE of Drummond village, SE¼ sec. 19, T 42 N, R 6 E, Chippewa County. 65 feet of Cordell dolomites.

132. Outcrops 3 mi. W of Marblehead, NW¼ sec. 3, T 41 N, R 7 E, Drummond Island, Chippewa County. Lower and upper Pentamerus dolomites, can be traced to Victor Hilden Ranch (Locality 94).

133. Various exposures along S shore of Drummond Island, Chippewa County. Cordell strata exposed where overlying Engadine Dolomite has been eroded from crests of small plunging anticlines.

ENGADINE DOLOMITE

134. Exposures on sides and tip of Point Detour Peninsula at SE tip of Garden Peninsula (not the Point Detour at Detour Passage in Chippewa County), Delta County.

135. Exposure on SW shore of peninsula about 1 mi. NW of Point Detour, Delta County.

136. Low cliffs along N, E, and S shores of Big Summer Island, Delta County.

137. Dolomite pavement in E part of Big Summer Island, central part sec. 35, T 37 N, R 19 W, Delta County. Dolomite contains Pentamerus molds.

138. Outcrops near SW point of Big Summer Island, SW¼ sec. 33, T 37 N, R 19 W, Delta County. Engadine-Manistique contact, adjacent to Locality 100.

139. Near-surface dolomite over most of Poverty Island (just SW of Big Summer Island) and continuous exposures on E, S, and W shores, Delta County. 12-feet vertical cliffs on W shore.

140. Exposures on both sides of Seul Choix Point peninsula, by their decided dips defining a distinct anticline. Engadine Dolomite on both shores, on one side dipping SW and on the opposite side of the peninsula dipping NE. Off the SW shore sharply dipping thick beds of dolomite stand above water as an interrupted chain of huge blocks. Cordell Member of Manistique Dolomite exposed on centerline of narrow peninsula near lighthouse.

141. Outcrops on beach and pavements in shallows near shore at places between Seul Choix Point and outlet of Bulldog Creek about 2 mi. to N, Schoolcraft County.

142. Near-surface dolomite and exposures about 5½ mi. S of Gould City, E½ sec. 20, W½ sec. 21, NW¼ sec. 28, and NE¼ sec. 29, T 42 N, R 11 W, Mackinac County.

143. Sinkholes in dolomite, SE¼ sec. 20, T 42 N, R 11 W, Mackinac County. Largest, 150 feet in diameter, located ¼ mi. W of SE corner sec. 20 and 500 feet N of S line of sec.; stream from NW disappears into sinkhole. Small sink opening into cave about 75 feet W of E line sec. 20 and 200 feet N of S line of sec.; cave contains S-flowing underground stream.

144. Surface exposures over area 3/4 mi. wide SE of Gould City, extending NE for 2 mi. from NE¼ sec. 22 to W part sec. 12, T 42 N, R 11 W, Mackinac County.

145. Along shore near Epoufette at East Epoufette Point, 1 mi. SE of village, sec. 10, T 42 N, R 7 W, Mackinac County.

146. West Epoufette Point (mapped as Epoufette Point), a little more than 1 mi. W of East Epoufette Point (Locality 145), sec. 8, T 42 N, R 7 W, Mackinac County.

147. Outcrop on E shore of Epoufette Point Island, just offshore from Locality 146, Mackinac County. Radial dip of beds indicates small dome in Engadine Dolomite of this island.

148. Quarry excavated in escarpment about 1/3 mi. NE of railroad depot at Ozark, sec. 8, T 43 N, R 5 W, Mackinac County. 22 feet of Engadine Dolomite.

149. Exposure in railroad cut about 1½ mi. S of depot at Ozark, Mackinac County. At S end of bluff, an S-facing bluff extends E and W; small quarry in bluff E of railroad exposes about 40 feet of dolomite.

150. Exposure in railroad cut near Murray (station about 2 mi. S of Ozark), Mackinac County.

151. Exposures in railroad cut just S of Kenneth and in small quarry just E of the cut, sec. 8, T 43 N, R 5 W, Mackinac County.

152. Surface exposures about 1 mi. W of Kenneth, sec. 29, T 43 N, R 5 W, Mackinac County. Also reported in secs. 19 and 30 and in banks of Carp River near small dam on S line sec. 30.

153. Low bluff along Lake Huron shore about 1 mi. SE of mouth of Pine River, extending SE from S central part sec. 11 to NW part sec. 13, T 42 N, R 3 W, Mackinac County.

154. Exposures along Highway 134 (St. Ignace-Detour highway) about 3 mi. E of Pine River bridge, sec. 6, T 42 N, R 2 W, Mackinac County.

155. Exposures along Highway 134 about 6 mi. E of Pine River bridge, sec. 3, T 42 N, R 2 W, Mackinac County.

156. Low S-facing bluff 3/4 mi. long, about 6 mi. SE of mouth of Pine River, sec. 15, T 42 N, R 2 W, Mackinac County.

157. Prominent E-W ridge about 3/4 mi. N of Hessel, secs. 21 and 22, T 42 N, R 1 W, Mackinac County.

158. Exposures over large area 2 mi. NE of Cedarville, secs. 20, 21, 28, and 29, T 42 N, R 1 E, Mackinac County.

159. Exposures over large area N of Locality 158, secs. 1, 2, 3, 4, 5, 10, and 11, T 42 N, R 1 E, Mackinac County.

160. Low discontinuous outcrops along shore of Lake Huron between Cedarville and E line of Mackinac County.

161. Escarpment at Rockview, a short distance E of Pickford-Cedarville road, Chippewa County. About 110 feet of Engadine; uppermost Cordell. Exposures over a large area SE from Rockview.

162. High ridge about 1/3 mi. E of Gatesville, Chippewa County. Perhaps 75 feet of dolomite.

163. Small outlier of Engadine Dolomite about 1 mi. N of Gatesville, a short distance W of NE corner sec. 6, T 42 N, R 3 E, Chippewa County.

164. Ridge about 4 mi. SE of Gatesville, $SE\frac{1}{4}$ sec. 23 and $SW\frac{1}{4}$ sec. 24, T 42 N, R 3 E, Chippewa County. About 50 feet of dolomite.

165. Numerous outcrops in S part of Drummond Island, Chippewa County. Good exposures in SW part of island in sec. 36, T 42 N, R 4 E, and secs. 1 and 12, T 41 N, R 4 E.

ADDENDA

166. Dam at Consolidated Lumber Mill, Manistique. This is part of Locality 104. Manistique Dolomite.

167. Drift beside road 1/8 mi. W of NE corner sec. 4, T 42 N, R 14 W, Schoolcraft County. Manistique Dolomite, Schoolcraft Member.

168. Rock piles from outcrop in field, $SW\frac{1}{4}$ sec. 34, T 43 N, R 14 W, Schoolcraft County. Burnt Bluff Dolomite, Hendricks Member.

169. About 100 yards NE of SW corner sec. 28, T 44 N, R 5 W, Chippewa County. Not far from Scott Quarry (Locality 124). Manistique Dolomite, Cordell Member.

170. Along N-S road about 1/8 mi. S of NE corner sec. 11, T 43 N, R 2 W, Mackinac County. Manistique Dolomite, Schoolcraft Member (lower Pentamerus dolomite).

171. Top of bluff above abandoned quarry, sec. 19, T 42 N, R 6 E, Drummond Island, Chippewa County. Apparently different from Locality 131. Manistique Dolomite, Schoolcraft Member (lower Pentamerus dolomite).

172. Along NE-SW road, $NE\frac{1}{4}$ sec. 32, T 43 N, R 3 E, Chippewa County. Probably Manistique Dolomite, Schoolcraft Member.

173. Road quarry on N-S road about 1/8 mi. N of SW corner sec. 19, T 42 N, R 14 W, Schoolcraft County. Possibly a small outlier. Manistique Dolomite, Schoolcraft Member (lower Pentamerus dolomite).

174. Along N-S road about $\frac{1}{4}$ mi. S of NE corner sec. 11, T 43 N, R 2 W, Mackinac County. Manistique Dolomite, Schoolcraft Member (upper Pentamerus dolomite).

175. Vicinity of center of W line sec. 10, T 43 N, R 10 W, Mackinac County. Manistique Dolomite, Cordell Member.

176. Material cast up from lake bottom onto point on Lake Michigan, sec. 27, T 41 N, R 16 W, Schoolcraft County. Manistique Dolomite, Schoolcraft Member (upper Pentamerus dolomite).

177. Immediately S of Marblehead-Blaney road, SW¼ SW¼ sec. 31, T 42 N, R 14 W, Schoolcraft County. Manistique Dolomite, probably Schoolcraft Member below upper Pentamerus dolomite.

178. Exposures in sec. 4, T 43 N, R 10 W, Mackinac County. Manistique Dolomite, Cordell Member.

179. Along road on W line sec. 3, T 43 N, R 10 W, Mackinac County. Manistique Dolomite, Cordell Member.

180. N-S road on W line sec. 34, T 44 N, R 10 W, Mackinac County. Manistique Dolomite, Cordell Member.

181. About ½ mi. N of SE corner sec. 8, T 42 N, R 11 W, Mackinac County. Within the general area of Locality 117. Manistique Dolomite, Cordell Member.

182. Near SE corner sec. 5, T 42 N, R 11 W, Mackinac County. Within the general area of Locality 117. Cordell Member.

183. About 1/8 mi. (300 paces) S of NE corner sec. 5, T 42 N, R 11 W, Mackinac County. Cordell Member.

184. Along N-S road about ¼ mi. S of NW corner sec. 24, T 43 N, R 11 W, Mackinac County. Cordell Member.

185. Field in SW¼ sec. 13, T 43 N, R 11 W, Mackinac County. Within the general area covered by Locality 118. Cordell Member.

186. About 1/8 mi. N of SW corner sec. 26, T 43 N, R 11 W, Mackinac County. Near areas of Localities 117 and 118. Cordell Member.

187. Hill in NW¼ sec. 13, T 42 N, R 3 E, Chippewa County. Manistique Dolomite, Cordell Member.

188. Abandoned quarry in NE¼ sec. 13, T 42 N, R 3 E, Chippewa County. Manistique Dolomite, Cordell Member.

189. Loose material along N-S road about ¼ mi. S of NE corner sec. 11, T 43 N, R 2 W, Mackinac County. Manistique Dolomite.

190. Lake Michigan shore 2½ mi. NW of Seul Choix Point, Schoolcraft County. Engadine Dolomite.

191. Exposure N of Hunts Spur, SW¼ sec. 7, T 42 N, R 12 W, Mackinac County. Near Localities 72 and 73. Probably Burnt Bluff Dolomite, Hendricks Member (Fiborn Limestone).

192. Pit on S side of Manistique Street, Manistique. Within the general area covered by Locality 104. Cordell Member.

193. Bluff about ¼ mi. N and 1/8 mi. E of SW corner sec. 8, T 42 N, R 14 W, Schoolcraft County. Near Locality 55. Burnt Bluff Dolomite.

194. Rock cut on NE-SW road in SW¼ sec. 17, T 42 N, R 14 W, Schoolcraft County. Near Locality 56. Burnt Bluff Dolomite, Hendricks Member.

195. N-S road in SE¼ sec. 33, T 43 N, R 14 W, Schoolcraft County. Burnt Bluff Dolomite Hendricks Member.

196. NE¼ NE¼ sec. 8, T 42 N, R 14 W, Schoolcraft County. Burnt Bluff Dolomite, Hendricks Member.

197. Spring in NW¼ NE¼ sec. 8, T 42 N, R 14 W, Schoolcraft County. Burnt Bluff Dolomite.

198. Road cut in SW¼ NW¼ sec. 20, T 42 N, R 15 W, Schoolcraft County. Burnt Bluff Dolomite.

199. Along N-S road about 1/8 mi. S of NE corner sec. 11, T 43 N, R 2 W, Mackinac County. Burnt Bluff Dolomite, top of Hendricks Member.

200. Rock cut in road near S line sec. 14, T 42 N, R 16 W, Schoolcraft County. Within general area covered by Locality 49. Burnt Bluff Dolomite, Hendricks Member.

201. Top of bluff at center of S line sec. 15, T 42 N, R 16 W, Schoolcraft County. Burnt Bluff Dolomite, Hendricks Member.

202. Road cut on Highway 94 (old Indian Lake road) about 1/8 mi. S of N line sec. 35, T 42 N, R 16 W, Schoolcraft County. Between Localities 50 and 53. Burnt Bluff, Hendricks Member.

203. Quarry in SE corner sec. 9, T 41 N, R 17 W, near Cooks, Schoolcraft County. Burnt Bluff, Trimerella zone of Hendricks Member.

204. Field on N side of road and about ½ mi. W

of SW corner sec. 8, T 41 N, R 17 W, Schoolcraft County. Near Locality 48. Burnt Bluff Dolomite.

205. Limestone sink in SW$\frac{1}{4}$ sec. 22, T 40 N, R 18 W, Delta County. Burnt Bluff, Hendricks Member.

206. Exposure in NE$\frac{1}{4}$ sec. 29, T 44 N, R 4 W, Chippewa County. Near Locality 88. Burnt Bluff, Hendricks Member.

207. High bluff in secs. 35 and 36, T 45 N, R 8 W, Luce County. Burnt Bluff, Hendricks Member.

208. Hill about 1/8 mi. W of Hendricks Quarry and 1/8 mi. S of Luce County line, Mackinac County. Burnt Bluff, upper part of Fiborn Limestone of Hendricks Member.

209. Along railroad $\frac{1}{2}$ mi. S of Blaney Quarry (Locality 60), Schoolcraft County. Presumably basal Manistique Dolomite.

210. Outcrop at Maxton, Drummond Island, sec. 9, T 42 N, R 6 E. Probably Manistique Dolomite.

211. Low S-facing escarpment about 100 yards S of NW corner sec. 30, T 42 N, R 14 W Schoolcraft County. Burnt Bluff, Trimerella zone of Hendricks Member.

212. Small abandoned quarry near NE corner sec. 23, T 42 N, R 5 E, Drummond Island, Chippewa County. Burnt Bluff Dolomite.

213. Small abandoned quarry near NW corner sec. 24, T 42 N, R 5 E, Drummond Island, not far from Locality 212. Burnt Bluff Dolomite, Hendricks Member.

214. West shore of Drummond Island near abandoned quarry, NW$\frac{1}{4}$ sec. 19, T 42 N, R 6 E, Chippewa County. Probably Burnt Bluff Dolomite.

PAPERS ON PALEONTOLOGY: No. 3

George Marion Ehlers: Niagaran Series of Michigan