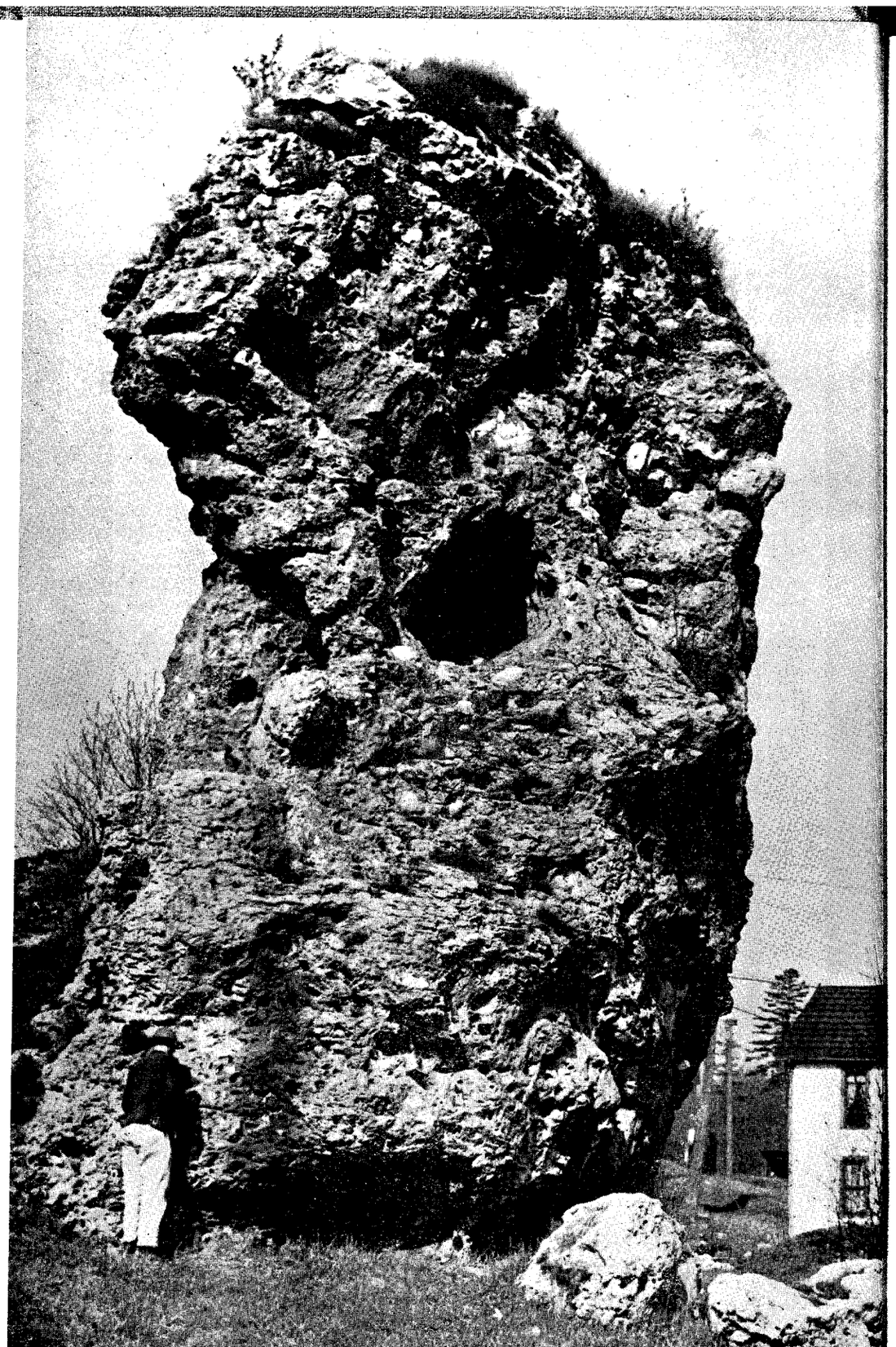
# GEOLOGY OF THE MACKINAC STRAITS REGION

# GEOLOGY
## *of the*
# MACKINAC STRAITS REGION



STATE OF MICHIGAN

DEPARTMENT OF CONSERVATION

P. J. Hoffmaster, Director

GEOLOGICAL SURVEY DIVISION

R. A. Smith, State Geologist

**Publication 44, Geological Series 37**

# GEOLOGY
## *of the*
# MACKINAC STRAITS REGION

*and*

# SUB-SURFACE GEOLOGY
## *of*
# NORTHERN SOUTHERN PENINSULA

*by*

KENNETH K. LANDES, GEORGE M. EHLERS and
GEORGE M. STANLEY

*University of Michigan*

PREPARED UNDER THE DIRECTION OF R. A. SMITH, STATE GEOLOGIST, AND IN COOPERATION WITH THE DEPARTMENT OF GEOLOGY, UNIVERSITY OF MICHIGAN
PUBLISHED AS A PART OF THE BIENNIAL REPORT OF THE GEOLOGICAL SURVEY DIVISION IN 1944

LANSING, MICHIGAN

1945

Printed in United States of America
Franklin DeKleine Printing Co.
Lansing, Michigan

# FOREWORD

To the Commissioners and Director of the Department of Conservation

Gentlemen:

Ever since the rock formations of Michigan have been studied by geologists the peculiar brecciated limestone formations of the Mackinac Straits region have been a puzzle. The effects of weathering on them, creating the famous Arch Rock, Sugar Loaf, Rabbits Back, Castle Rock, Big Crack of Mackinac Island, and many other features, have enhanced the scenic value of the region. Such features are readily explained, but although several hypotheses had been advanced, the causes of the brecciation remained unexplained, and the position of the formation in the geological column, its areal extent, and subsurface extension were incompletely known.

In the early days of our State's history the limestones had some economic value. They contained masses of gypsum which were quarried and burned for plaster and ground for fertilizer. Some of the limestone was used for building purposes, some was calcined for mortar and plaster. Those industries are almost forgotten. When the war made it necessary to find new sources of petroleum every exploration tool geologists know had to be put to work; new tools and means of study had to be devised; every sort of oil trap had to be searched for and explored. We have long known the rock traps that hold oil—the anticlines, "pinch-outs," and others. In Michigan "pinch-outs" of rock formations received little consideration until the war need arose, because such conditions exist around the rims of our Michigan Basin under the Lake Huron and Lake Michigan basins, and particularly in the northern third of the Southern Peninsula, where exploration for petroleum was not active.

Earlier studies made during the agitation for the Mackinac Straits bridge and the discovery by the late O. F. Poindexter of large faults

or rock slips in the rock exposed in the cut on U.S. Highway 2, west of St. Ignace, had shown that it is highly advisable that more detailed studies of the breccia and clay shales be made before construction of the bridge be undertaken. Also the rock cuts made in excavating for the causeway and ferry mole uncovered and exposed fresh sections of the rock that afforded new clues that could be studied to advantage before being destroyed by weathering.

For these reasons a contract was undertaken in 1943 between the Department of Conservation and the University of Michigan to make a detailed study under the direction of the Geological Survey Division of the surface exposures of the limestones and shales of the Straits area and the rims of the immediately over-lying rocks in the northern part of the Southern Peninsula, and to carry the study of the subsurface extension of the rocks under the Southern Peninsula to the oil-bearing areas to the south insofar as information is available from boreholes drilled for limestone, oil, gas, and water exploration.

Dr. Kenneth K. Landes and Dr. George M. Ehlers of the Geological Department of the University accepted assignment to make the study. The terms of the contract were carried out; the field work and subsurface studies were completed and reports written. Professor Landes wrote all the report excepting the discussion of the stratigraphy of the bedded rocks, which was written by Professor Ehlers and the chapter on the glacial geology which was written by Professor George M. Stanley also of the Department of Geology of the University. Fossils and rock samples collected during the study, the property of the Geological Survey Division of the Michigan Department of Conservation, are deposited with the Museum of Paleontology of the University of Michigan where they are available for study.

I have the honor to present herewith this report and recommend that it be published as Publication 44, Geological Series 37 of the Geological Survey Division of the Department of Conservation.

Respectfully submitted,

State Geologist,
August, 1945.

## CONTENTS



## ILLUSTRATIONS

### PLATES

## FIGURES



# GEOLOGY

*of the*

# MACKINAC STRAITS REGION

**and**

# SUBSURFACE GEOLOGY

*of the*

# NORTHERN PART OF THE SOUTHERN PENINSULA

*by*

KENNETH K. LANDES, GEORGE M. EHLERS

*and*

GEORGE M. STANLEY

# INTRODUCTION

The objectives of the project reported upon in this bulletin were three-fold: (1) to determine the rock formations and their distribution in the Straits area; (2) to correlate these formations with formations penetrated in deep wells drilled in the central part of the Southern Peninsula; and (3) to determine the possibilities for stratigraphic oil "traps" on the northern flank of the Michigan Basin. The following chapters contain the information assembled by the writers in their attempts to attain these objectives.

The rock formations from the base of the Salina to the top of the Detroit River were studied at their outcrop on the north rim of the Michigan Basin, and by means of well cuttings from their subsurface extension to the south. To complete the study the outcrops of the same formations on the south rim of the Basin, in southeastern Michigan, northern Ohio, and southwestern Ontario are to be studied and the rocks correlated with the subsurface section in southern Michigan. When that work is completed and the results published the Salina-Detroit River rocks should be known entirely across the Michigan Basin where exposed at the surface and also where buried under a thick section of younger rocks. It is to be hoped that these bulletins will assist in the discovery of more oil deposits and also provide research information necessary for such construction projects as the Straits bridge and ferry docks, and provide information for further study of the structure and stratigraphy of Michigan rock formations.

## Previous Work

In the one hundred and twenty-five years that have elapsed since Dr. John J. Bigsby, British Army surgeon and writer of geological narratives, visited the Straits area, many geologists have passed through this region and have written of what they found. The first were geological explorers; those who followed were primarily interested in either the stratigraphy (including the breccia) or the Pleistocene history of the region. Few spent very much time in the district, and all of the work was reconnaissance in scope. As the more important contributions of these men are described in subsequent chapters, only a brief sketch of their visits to the Straits is given here.

Bigsby visited Mackinac Island and the north shore of Lake Huron in 1819 and in 1820.[1] During 1820 Henry Rowe Schoolcraft also visited the area and described the rocks in a book published in 1821.[2] Twenty years later the rocks of the Straits area were described by Michigan's first State Geologist, Douglass Houghton, and C. C. Douglass, Assistant Geologist. These men were at Mackinac Island and St. Ignace in August, 1839, and their reports were published in 1841.[3] James Hall, famous State Geologist of New York, was employed on the Foster and Whitney survey of the Lake Superior Land District to study the stratigraphy. His description of the rocks of the Straits area appeared in print in 1851.[4] In 1860 the second State Geologist, Alexander Winchell, visited Mackinac Island and wrote of what he saw.[5] Nine years later his brother, N. H. Winchell, made a reconnaissance trip through Presque Isle, Cheboygan, and Emmet counties, paying particular attention to the economic possibilities of the rocks. His report was not published until 1875.[6]

Dr. Carl Rominger opened a new era in geological studies of the Straits area with the first detailed stratigraphic investigation. In 1873 his report on the Paleozoic rocks of the Upper Peninsula was published[7] and was followed three years later by his monograph on the Lower Peninsula.[8] These two reports contain descriptions of the stratigraphy and paleontology of the rocks on both sides of the Straits and on the various islands in the region. About 40 years ago another geologist, Dr. G. P. Grimsley, visited the Straits region and reported on the gypsum deposits.[9] Prof. A. W. Grabau published abstracts concerning the Mill Creek section,[10] and the Mackinac breccia[11] in 1906 and 1907, and a more complete discussion of the breccia in 1913.[12]

[1]Bigsby, John J., Geological and Mineralogical Observations on the Northwest Portion of Lake Huron; Am. Jour. Sci., Vol. 3, 254-272, 1821. Notes on the Geography and Geology of Lake Huron. Geol. Soc. London, Tr. (2) 1:175-209 (1824).
[2]Schoolcraft, Henry Rowe. Narrative journals of travel through the northwestern regions of the United States, 419 pp., Albany, 1821.
[3]Houghton, Douglass, Michigan Senate Documents, 1841, Vol. 1, p. 486 and p. 548.
[4]Hall, James, Upper Silurian and Devonian Series: Geology of the Lake Superior Land District, Pt. II, U. S. 32 Cong. Spec. Sess. Ex. Doc. 4, pp. 140-166, 1851.
[5]Winchell, Alexander, First biennial report of the progress of the Geological Survey of Michigan, Lansing, pp. 57-69, 1861.
[6]Winchell, Newton Horace. The Economical Geology of the region of Cheboygan and old Mackinac, in the counties of Presque Isle, Cheboygan, and Emmet, State of Michigan: Mich. St. Bd. of Agric., 12th Ann. Rept., 1873, pp. 103-107, 1875.
[7]Rominger, C. L. Paleozoic rocks (Upper Peninsula): Michigan Geol. Surv., Vol. I, pt. 3, 1873.
[8]_____ Geology of the Lower Peninsula, Michigan Geol. Surv., Vol. III, 1876.
[9]Grimsley, G. P., The gypsum of Michigan and the plaster industry: Michigan Geol. Surv., Vol. IX, pt. 2, 1904.
[10]Grabau, A. W., Discovery of the Schoharie fauna in Michigan; Science, n. s. 23, 467, 1906.
[11]_____ Subareal erosion cliffs and talus in the lower Devonian of Michigan: Science, n. s. 25, 295-296, 1907.
[12]_____ Principles of Stratigraphy, New York, 1913, 547-548.



For many years Henry H. Hindshaw roamed northern Michigan in search of commercial stone deposits. His views on the origin of the breccia were quoted by R. A. Smith in 1914.[13] A year later Dr. Smith brought out his report on Michigan Limestones, in which the rocks of the Straits area are described.[14] W. H. Norton, after visiting and studying the type locality, included a discussion of the Mackinac breccia in his classification of breccias published in 1917.[15] In 1939 O. F. Poindexter reported on the breccia at the faulted section along U.S. Highway 2, and made detailed studies of the rock cores from test holes drilled by the Mackinac Straits Bridge Commission,[16, 17] and in 1940 mapped and described the lithology of many of the breccia out-crops in the St. Ignace Peninsula.

The prominent raised beaches of Mackinac Island, and other glacial and post-glacial features of the Straits region, have long interested physiographers. Taylor, beginning in 1892, and later Leverett, published a series of papers and reports on the Pleistocene and Recent History of this area.[18-26]

Professor I. C. Russell also contributed to this branch of the science, and at the same time paid some attention to the bed rock geology.[27] In recent years Dr. G. M. Stanley has published reports on the raised beaches[28] and on the valley submerged beneath the waters of the Straits.[29] S. G. Bergquist studied the drumlins in the counties of Presque Isle, Cheboygan, and Emmet, and elsewhere.[30]

[13]Smith, R. A., The occurrence of oil and gas in Michigan: Michigan Geol. Surv., Pub. 14, 206-207, 1914.
[14]_____ Limestones of Michigan; Michigan Geol. Surv., Pub. 21, 103-311, 1916.
[15]Norton, W. H., A classification of breccias; Jour. of Geol., Vol. 25, pp. 192-193, 1917.
[16]Poindexter, O. F., A Geologic Section Across the Straits of Mackinac, Report Mich. Acad. of Sci., 1940. Unpublished.
[17]_____ and others—Preliminary Report on Straits of Mackinac drilling, Dec. 1939. Unpublished report.
[18]Taylor, F. B., The highest old shore line on Mackinac Island: Amer. Jour. Sc. (3), 43, 210-218, 1892.
[19]_____ The Muniscong Islands; Amer. Geol., Vol. 15, 24-33, 1895.
[20]_____ The second Lake Algonquin; Amer. Geol., Vol. 15, 100-120, 162-179, 394-395, 1935.
[21]_____ Niagara and the Great Lakes; Amer. Jour. Sc. (3), Vol. 49, 249-270, 1895.
[22]_____ Old shore lines of Mackinac Island and their relations to the lake history (abst): Geol. Soc. Amer., Bull. 26, 68-70. 1915.
[23]Leverett, Frank, and Taylor, F. B., The Pleistocene of Indiana and Michigan, and the history of the Great Lakes, U. S. Geol. Survey Mon. 53, 1915.
[24]Leverett, Frank, Surface geology of the Northern Peninsula of Michigan, Michigan Geol. Survey, Pub. 7, 1910.
[25]_____ Surface geology of the Southern Peninsula of Michigan, Michigan Geol. Survey, Pub. 9, 1911.
[26]_____ Surface geology and agricultural conditions of Michigan: Michigan Geol. Survey, Pub. 25, 1917.
[27]Russell, I. C., A geological reconnaissance along the north shore of Lakes Huron and Michigan; Michigan Geol. Survey, Rept. 1904, 1905.
[28]Stanley, G. M., Lower Algonquin beaches of the Upper Great Lakes, (abst): Geol. Soc. Amer. Proc. 1935, 107, 1936.
[29]_____ The submerged valley through Mackinac Straits: Jour. of Geol., vol. 46, No. 7, 966-974, 1938.
[30]Bergquist, S. G., The distribution of drumlins in Michigan: Mich. Acad. Sci., Arts, and Letters, Vol. 27, 451-464, 1942.

The stratigraphy and physiography of the Straits region are described in the guidebooks issued for the 8th and 11th annual excursions of the Section of Geology and Mineralogy of the Michigan Academy of Science, Arts, and Letters. The 8th Annual Excursion Guidebook was for Charlevoix, Emmet, and Cheboygan counties; the physiographic part of the guide was prepared by S. G. Bergquist, and the stratigraphic discussion was prepared by G. M. Ehlers. The 11th Excursion guidebook, prepared by O. F. Poindexter, G. M. Ehlers, George Stanley, and W. A. Kelly, describes the St. Ignace peninsula and Mackinac Island.

### Field Work

The field work on which this report is based was carried on during the summer and early fall of 1943. The writers, assisted by Walter Landes, rodman, surveyed the Straits area from the outcrop of the Engadine dolomite on St. Ignace peninsula southward to the areas where the bedrock disappears beneath the glacial drift near the northern end of the Southern Peninsula. North Fox Island and all the Beaver Islands, including Isle Le Galet in Lake Michigan, between the Beaver Group and the mainland, and Bois Blanc, Round, Mackinac, Goose, and the St. Martin Islands in Lake Huron were visited.

### Office Work

Subsurface stratigraphic studies were carried on from November, 1943, to October, 1944. In this investigation cuttings from drilled wells were glued to graphic log cardboard strips, scale 20 feet to the inch, and thus by means of actual graphic "rocklog" strips the character of the rocks, changes in lithology, and the regional structure were studied. Particular attention was paid to the stratigraphic section from the base of the Salina group to the base of the Dundee limestone throughout the entire north half of the Southern Peninsula. In other words, the series of rocks which was surveyed in the outcrop was followed underground by means of well records down the north flank of the Michigan Basin. In this cooperative project of the Michigan Geological Survey a large amount of data on both surface and subsurface were available, and detailed surface and subsurface studies could be combined. The benefits derived from this combination to the study of both surface and subsurface stratigraphy are considerable. Unfortunately in this as in earlier studies the conditions are not ideal; the scarcity of well records in the northern part of the peninsula at this time makes an excessive amount of interpolation necessary.



### Acknowledgments

This report is the result of a cooperative project between the Geological Survey Division of the Michigan Department of Conservation and the Department of Geology of the University of Michigan. Thanks are due to both of these organizations for their financial support and to the Horace H. Rackham School of Graduate Studies, University of Michigan, for a research grant which aided in meeting the University's share of the obligation.

The writers enjoyed and appreciated the encouragement, assistance, and advice readily given by the members of the staff of the Michigan Geological Survey, especially Dr. R. A. Smith, State Geologist, Miss Helen Martin (who first suggested the Straits area for study), Mrs. Lucille Esch, Mr. O. F. Poindexter, and Mr. Rex P. Grant. Professor George M. Stanley accompanied one of the writers (Landes) in a trip to the Mackinac Straits region in 1942. During this trip progress was made on the development of the breccia origin theory given in this report. Many discussions on the geological problems were held with another colleague, Professor A. J. Eardley. Dr. George V. Cohee of the Geological Survey, U. S. Department of the Interior, while engaged on a cooperative project between the Federal and State Geological Surveys and the Department of Geology, University of Michigan, read a part of the manuscript and supplied new data of value. Miss Marie Tharp, graduate student at the University of Michigan, prepared and contributed maps and cross sections of the Detroit River group. Mr. Raymond Hunt, consulting geologist of Mount Pleasant, kindly supplied data on the "Trenton" well on Drummond Island. Thanks are due Prof. W. A. Kelly of Michigan State College for his courtesy in contributing samples from wells drilled in northern Michigan. Some of the photographs used in this report were taken by Mr. Walter Hastings, official photographer for the Michigan Department of Conservation.

Similarities between the Mackinac breccia and the breccias of the Tri-State Zinc district were called to our attention by Mr. Carl Addison of the Pure Oil Company, who at one time worked on a Federal geological investigation of the zinc ores in the Tri-State district. Mr. Charles Mueller, late geologist for the United States Steel Corporation, brought to our attention the analogy between the collapse which we believe formed the Mackinac breccia and collapses which occur during and following mining operations.

The writers appreciate and express thanks to Mr. Walter Russell for his thoughtful kindness in bringing our work to the attention of the Mackinac Island Commission, and the kindness and hospitality of the Commission in furnishing quarters in Fort Mackinac during the 1942 and the 1943 field seasons. Thanks are also given to the officers of the Michigan Limestone and Chemical Company of Rogers City for many kindnesses.

The writers also desire to express thanks to Mr. Frank Laway for the use of his boat and other valuable assistance in the island studies, and to various other citizens of the Straits area for their hospitality and their aid in finding outcrops.

# PLEISTOCENE GEOLOGY
*of the*
# MACKINAC STRAITS REGION

GEORGE M. STANLEY

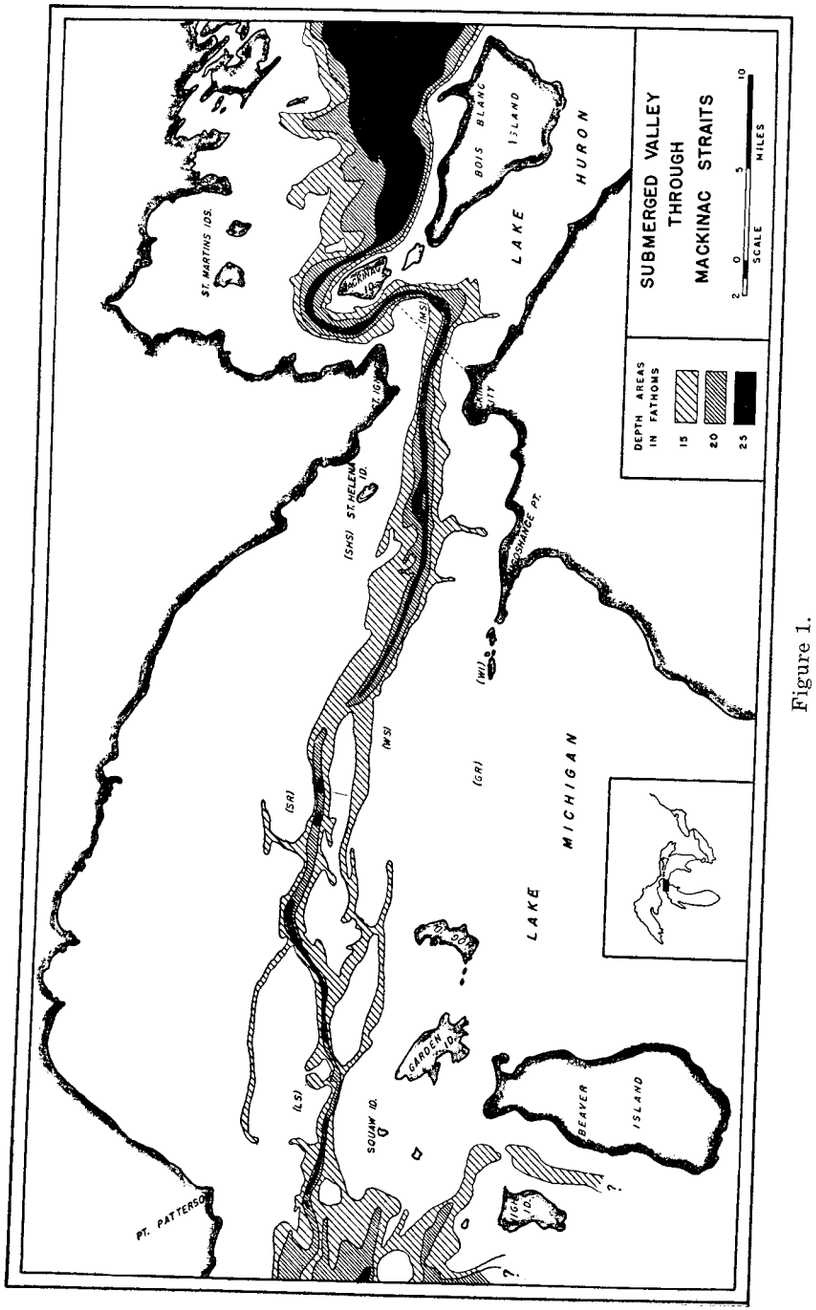



Figure 1.

CHAPTER I

# Pleistocene Geology

The area surrounding the Straits of Mackinac was heavily glaciated during the last or Wisconsin stage of the great Ice Age and undoubtedly also in all or most of the preceding glacial stages of the Pleistocene. However, no deposits of pre-Wisconsin ice have been recognized anywhere within the area, and any earlier deposits were presumably removed by ice scour of the last stage, unless preserved in a few places under a cover of the latest drift.

## Submerged Valley Through Mackinac Straits

However, one feature seems to date from pre-Wisconsin time—a submerged channel in the Straits. Soundings have shown a deeply submerged channel extending through Mackinac Straits from a little north of the Beaver Islands to a deep part of the Lake Huron basin east of Mackinac Island and north of Bois Blanc Island. The channel bottom is over 150 feet below lake level in much of its western part, and is more than 200 feet below lake level in its passage through the narrows of the Straits as well as throughout its semicircular sweep about the north end of Mackinac Island east of the narrows.

That this channel was formed by a river draining eastward is obvious from the general easterly slope of its floor. Consideration of the ultimate escape of drainage toward the sea leads to the same conclusion inasmuch as no place for discharge from the Lake Michigan basin is found elsewhere at so low a level. On the other hand the Lake Huron basin must have offered low passages leading to the Atlantic during the waning of the last ice and prior to the great uplift in the northeast which followed the final retreat of the ice. Very likely such occasions obtained also at the close of the pre-Wisconsin glacial stages and perhaps also in pre-glacial time.

The submerged valley has been described previously and in more detail by the writer.[1] The original incision into the rock floor of the Straits was probably made before the Wisconsin stage and reoccupied by an eastward flowing river between the stages of the

[1]Stanley, G. M.: The submerged valley through Mackinac Straits, Jour. Geol., Vol. 46, pp. 966-974, 1938.

Algonquin and Nipissing Great Lakes. The existence of this valley is an added problem to the construction of a highway bridge to span the Straits.

## Deposits From The Wisconsin Ice

Glacial drift is scanty on the St. Ignace peninsula, on the islands of the Straits and in eastern Presque Isle County, but over large areas north of Little Traverse Bay and toward Mackinaw City the drift attains considerable thickness. The hilly features of the moraine lack significant trends over most of the region and interpretation of successive positions of the ice border is not as feasible as in southern Michigan. Leverett considered this an interlobate tract between the Michigan and the Huron ice lobes, formed after the main Port Huron moraine was laid down and perhaps simultaneously with the building of Manistee moraine.[2]

Laminated clays of reddish color are found in many places buried beneath the surface till as far south as Frankfort, Benzie County. These clays definitely ante-date the latest stand of the ice front thereabouts and were formed in glacial waters, but the exact time and circumstances of their origin are not yet understood.

Small morainic areas have been noted on Beaver Island and on South Fox Island but they are too fragmentary to afford much information as to time of origin by correlation with other moraines. The latest moraine in the Southern Peninsula of Michigan seems to be the one known as the Cheboygan moraine which extends northwest-southeast and parallels the shore from Mackinaw City to Cheboygan. It was formed by ice retreating northeastward with slight readvances toward the southwest.

Such a movement of ice presents somewhat of a problem when compared with the indicated directions of movement outside of and beyond the moraine. Several clusters of drumlins between Alpena and Cheboygan trend northwest to southeast and prove glacial motion along a southeastward course or almost at right angles to the movement which formed the Cheboygan moraine. Some of the drumlins east of Mullet Lake are only six miles distant from the moraine. Drumlin-like flutings in the till surface near Onaway at the west edge of Presque Isle County, well illustrated on aerial photographs, have nearly the same direction. They appear to be a result of the same ice movements that produced the drumlins. The drumlins of Les Cheneaux Islands have similar trends and

[2]Leverett, Frank, and Taylor, F. B.: The Pleistocene of Indiana and Michigan and the history of the Great Lakes, U. S. Geol. Surv., Mon. 53, pp. 302-315, 1915.



though they are much farther north across the Straits region, they may also have been caused by the same ice movements.

Only a small part of the large sand and gravel plains of northern Emmet and Cheboygan counties is outwash; the outwash is along the headwaters of the west branch of Maple River in Center and Pleasantview townships north of Petoskey. Most of the plain areas were the bed of glacial Lake Algonquin which covered much of the area after the ice had abandoned the region.

## The Ancient Shorelines

The transition from the melting away of glacial ice to the period of submergence of most of the Straits region by lake waters is not distinctly marked. There are good reasons for believing that the spreading lake waters which advanced on the land as the ice front retreated belonged to an early phase of Lake Algonquin and that the highest level reached by this early lake was not as high as the strong shoreline built by the later Lake Algonquin. The beaches formed by the early lake were probably destroyed during the time when they were submerged and washed over by waves at the higher level that made the Algonquin beach, which in Michigan is the highest and oldest of the several ancient shorelines.

### THE ALGONQUIN SHORELINE

The Algonquin shoreline is perhaps the most important physiographic feature and boundary in the Straits region as well as throughout the northern Great Lakes area. In Michigan the Algonquin shoreline was made by a rising lake which like all rising lake levels had particular ability to develop a strong shoreline. The shore is especially conspicuous as it is the highest of the ancient strands and generally marks the change from a gently sloping plain or terrace to more rugged upland. In most places the boundary is a steep, wave-cut slope in the higher moraine or a line of rock cliffs, as on Mackinac Island, but elsewhere, especially at embayments, a broad, gravel ridge marks the upper limit of the ancient surf.

The outlet of Lake Algonquin was for a long time at Kirkfield, Ontario, with drainage eastward to the Ontario basin, but with the withdrawal of the ice sheet and consequent widespread northeastward uplift of the continent the outlet and the level of the lake were raised until the lake waters overflowed to the south by way of Port Huron and Chicago creating a three outlet stage of Lake Algonquin which endured for a long time. The Port Huron and

Chicago outlet areas were not affected by the uplift, as they were south of the "hinge line"—that is, south of the southern edge of the uptilted area and in the area of horizontality. Consequently as uplift continued, lake level remained stabilized on the outlets at Port Huron and Chicago while the northern shores emerged from water and the Kirkfield outlet was eventually abandoned. The Algonquin beach was formed during, or in a pause within, the slow transitional period when drainage shifted to the southern outlets, that is during a three-outlet stage, a time of rising lake waters when their working, cutting, building power was at a maximum. Over the Mackinac Straits region the waters of Lake Algonquin gradually rose and encroached on the land to the position where the lake built the great Algonquin beach and then as the uplift continued, the lake waters gradually receded to a lower level. Meanwhile erosion along the Port Huron outlet seems to have lowered the lake sufficiently to cause abandonment of the Chicago outlet, because a broad rock floor prevented similar cutting down of that outlet, and to divert all the waters of the lake eastward past Port Huron to the lower Great Lakes.

Lake Algonquin was the most expanded body of water in Great Lakes history during the stage when the Algonquin beach was formed. The northern parts of Emmet, Cheboygan and Presque Isle counties were an archipelago of islands. The largest island covered about five townships of Emmet County north of Little Traverse Bay. Wide arms of water stretched from Petoskey to Mackinaw City and to Cheboygan. Most of the present day islands of Mackinac Straits region were entirely submerged but small parts of Mackinac, Beaver and South Fox Islands were high enough to stand above the lake. Northward from the present Straits, Lake Algonquin covered the entire St. Ignace peninsula and nearly all of the eastern four counties of the Northern Peninsula. The geography of Algonquin time was indeed a contrast to that of the present day.

One of the most interesting facts connected with the Algonquin shoreline is its deformation. The shoreline is horizontal around southern lakes Huron and Michigan and only 27 feet above present water level, but its elevation increases northward from the "hinge-line" which extends from Grand Bend, Ontario, across Lake Huron, and Saginaw Bay, past Standish, Arenac County, Michigan and northwestward (about N. 68° W.). Although the altitude of the shore is 607 feet above sea level south of the hinge-line, it rises to 709 feet at Harbor Springs, Emmet County (at the south edge of the area of this report), to 813 feet at Mackinac Island, to 863 feet at Hessel, Mackinac County and to a much greater altitude at Sault Ste. Marie. These differences in a once horizontal beach illustrate the large upwarp of the land in the northeast which took place in response to removal of the glacier's weight.



Around embayments and wherever a gravel ridge marks the Algonquin shore, a series of successively lower ridges are generally found down to 40 or 50 feet which are known as the "upper group" of Algonquin beaches. They are excellently displayed on the short target range and on the western slopes of Mackinac Island, and also north of Bliss and south of Cross Village in Emmet County. They appear to be the result of continued uplift of the land which elevated this area with consequent change of water level after the Kirkfield outlet of Lake Algonquin had been abandoned. Below the lowest of these beaches, none are found for some distance and the lake is presumed to have discovered a newly ice-freed outlet eastward across Ontario and to have drained down rapidly so that its waves were unable to form distinctive shorelines until a relatively stable level was again established.

## LOWER ALGONQUIN SHORELINES

The procedure just described was apparently repeated a number of times; that is, periods of fixed outlet which lasted for sufficient time to develop marked beaches were followed by quick lowerings of lake level as the retreating ice front released new and lower drain-ways. Below the upper group of Algonquin beaches are several intervals quite devoid of good beaches, interspaced with shorelines which are fairly strong though not at all comparable to the Algonquin beach itself. These several shorelines are known collectively as "lower Algonquin". The discontinuity in spacing of these lower beaches is in striking contrast with the regular beach successions of the upper Algonquin group, or of the post-Nipissing group. A conspicuous beach of this lower group, having an elevation of 718 feet is in northern Mackinac Island on the "Battlefield" of August 4, 1814. Other good examples are at a corresponding level on the hills behind St. Ignace. A number of lower and later beaches are some distance below the Battlefield Beach on Mackinac Island,[3] in the St. Ignace area and on the mainland south of Mackinac Straits. The summit of Round Island, opposite Mackinac Island Village, is a broad pattern of shoal ridges associated with one of these shorelines.

[3]Stanley, G. M.: Pre-Historic Mackinac. Michigan Dept. Cons. Geol. Surv. Div. Pub. 43, Geol, Ser. 36, 1945.

From relationships of all these shorelines with later shorelines seen only much farther northeast, the conclusion is warranted that the lake continued to fall intermittently to still lower levels, even far below the level of the modern lake in Mackinac Straits. It seems likely that lowering proceeded to such an extent that the submerged valley of the Straits (fig. 1) was used by a river flowing into the Huron basin from a separate lake in the Lake Michigan area. The geography of this period was wholly different from the geography during formation of the Algonquin beach. Most of the modern islands in Mackinac Straits area were then joined with the mainland; Mackinac Island was a headland reaching out from Cheboygan County by way of Bois Blanc and Round islands.

The sequence of falling lake levels terminated when the lowest outlet from the Huron basin, the channel of the Mattawa valley east of North Bay, Ontario, was freed of ice and permitted unobstructed flow of glacial and lake drainage eastward into the Ottawa River. Glacial obstruction of outflow had then performed its last role in the development of the Great Lakes and continental uplift remained the only factor for later change. Only about 20 per cent of the total upwarp of the Algonquin beach had taken place by this time. Much the greater part of the uplift came later with great effect on the geography of the lakes region. The Mattawa-Ottawa outlet eastward from Georgian Bay was located in the most northeasterly part of the lake whose level it now controlled. Here continental uplifting was at a maximum, therefore lake level rose steadily higher and lake waters flooded over the shores to the south and west. Thus a period of intermittently subsiding lake levels, with a total drop of a few hundred feet, was followed by a period of steadily rising lake levels until the lake once again overflowed to the south.

## THE NIPISSING SHORELINE

The return of southward discharge past Port Huron brought another culminating lake level known as the Nipissing stage and the formation of the Nipissing beach. This beach is directly analogous to the highest Algonquin beach in strength of development and in being the product of a two-outlet lake stage after a period of rising water. About 85 per cent of the uplift of the Algonquin beach had by now taken place and the lakes had reached more nearly their modern outline in contrast to their wide extent in Algonquin times. Consequently the Nipissing beach was affected by only the last small fraction of postglacial uplift. It is only

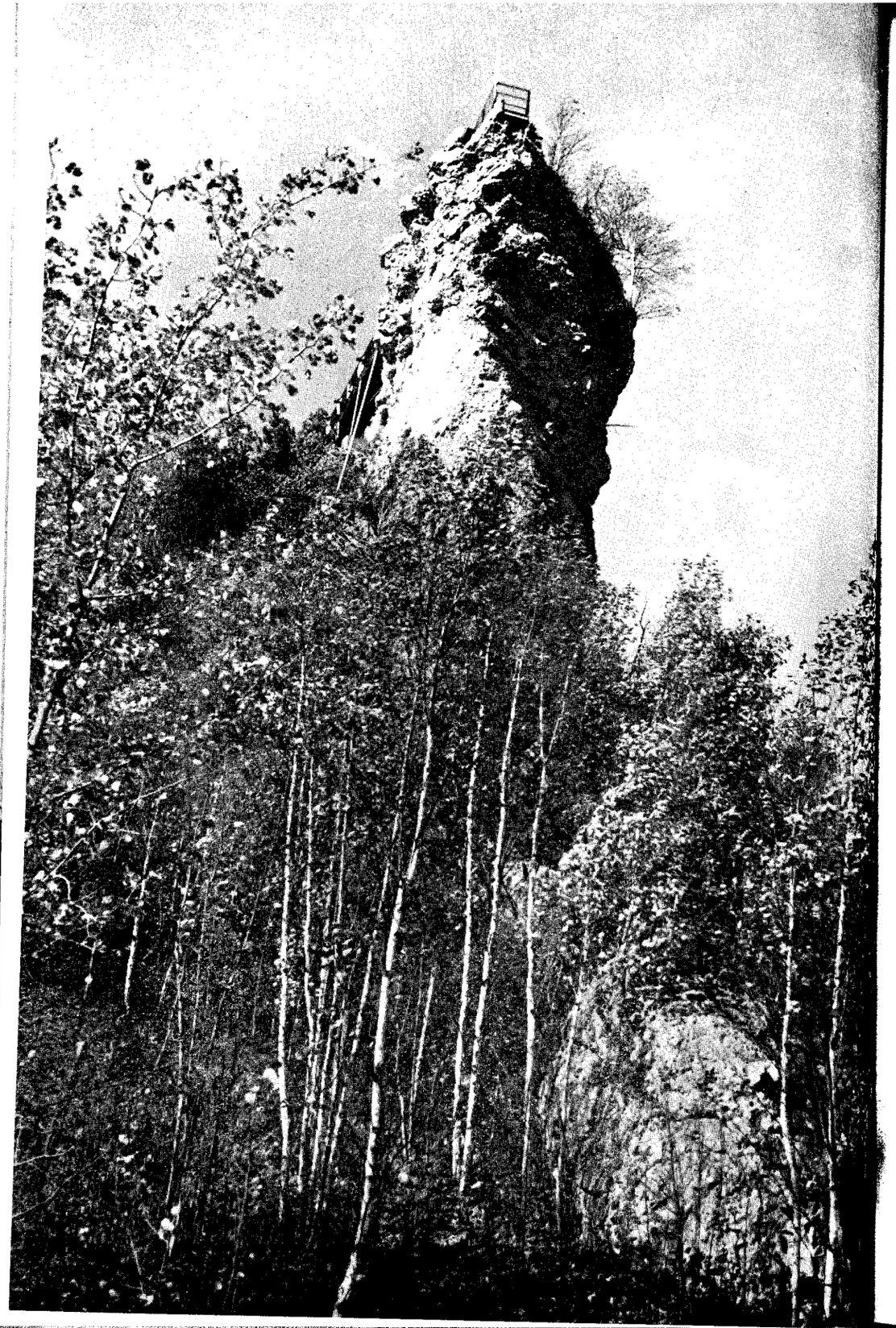


slightly tilted and is generally close to the modern shore. Lake Superior was not yet separated from the lower lakes but was connected by a narrow strait through the St. Mary's valley.

In the area covered by this report, the Nipissing beach rises 23 feet from 615 feet at Harbor Springs, Emmet County in the south to 638 feet at Hessel, Mackinac County in the north, but in the same distance the Algonquin beach rises 154 feet. This difference in differential rise of the two beaches demonstrates that the Nipissing shoreline was affected by only a minor amount of the movement of continental uplift. The Nipissing beach is well shown on Mackinac,[3] Round, Bois Blanc islands, the Fox islands, and the Beaver islands. In most places it is a terrace at the foot of a sharp wave eroded bluff or is a conspicuous gravel bar. The wave cut bluff is well shown on the fairway of the Mackinaw City golf course and about one mile south of Mackinaw City where the highway to Petoskey crosses the beach; at intervals along the highway from Mackinaw City to Cheboygan especially about the outskirts of Cheboygan where the bluff extends up the river and encircles Mullet Lake. A magnificent Nipissing gravel spit is just north of the St. Ignace airport. Well developed bars are on Mackinac Island: one near British Landing; another immediately southwest of the lower entrance to Fort Mackinac has a church on it. At each of these places, a significantly deep trough like depression is behind the gravel ridge which was built by rising waters and surf that heaped gravelly materials up the general off-shore slope.

## POST-NIPISSING SHORELINES

The abandonment, due to continued uplift, of the eastward North Bay (Mattawa) outlet of the post glacial Nipissing lakes was the last major drainage change in Great Lakes history, and was followed by total discharge southward past Port Huron. Post-Nipissing uplift has gradually raised the Mackinac Straits region out of water and in favorable places, regular successions of post-Nipissing beaches have been formed. North of British Landing on Mackinac Island, twenty-eight successive gravel ridges were counted, well distributed between the Nipissing (elevation 630 feet above sea level) and modern shores (at 583 feet above sea level), with an average difference in level between any two consecutive beaches of less than two feet. The number of beaches in this series varies in different places and is not significant except that the number generally increases northeastward due to widening out in that direction of the vertical interval in which they occur. In some places





no good beaches may be recognized below the Nipissing, and in most places the succession is incomplete. Only where materials accumulated abundantly from along shore drifting is a full series of these beaches found. The separation of Lake Superior and appearance of the "Sault" (St. Marie) was accomplished by uplift about midway in post-Nipissing time. Since studies of Niagara gorge and the rate of retreat of Niagara falls have shown this total interval to be about 4000 years, St. Mary's rapids probably came into being at about the time of Christ. Thereafter Lake Superior's level was controlled by its own outlet at the Sault on which it pivoted during subsequent tilting. Around the northeast coast of Lake Superior, the Nipissing shoreline is more than 100 feet above Lake Superior, but at Duluth it has been submerged by the rising water.

## STACKS AND SEA-CAVES

Wave erosion in the bedrock about St. Ignace and Mackinac Island has left a number of striking features such as stacks, frequently known also as skerries and chimney rocks, and some sea-caves. Most of the stacks and caves are associated with either the Algonquin or Nipissing shorelines and are developed in the brecciated limestones. Where the breccias offered superior resistance to erosion, stacks were developed.

On the St. Ignace peninsula several mesa-like plateaus of bedded rock rise from 100 to 200 feet above the lake. They are surrounded by lowlands, generally less than 50 feet above the lake, dotted with inland lakes and swamps. The Nipissing shoreline skirts these plateaus and connects some of them with large gravel bars which enclosed large bays or lagoons. Wave erosion cut back the more exposed fronts of the plateaus into sharp cliffs, stripping the stratified limestones and shales from the scattered plugs of more resistant breccia.

St. Anthony's Rock (frontispiece) in the central part of St. Ignace is a splendid example of a stack, situated several yards in front of the Nipissing cut cliff. Castle Rock, (pl. I) though not a true stack, is a more conspicuous feature overlooking the main highway north of town; it stands up boldly, buttressing a sharp Nipissing headland from which it was not quite isolated by the waves. Also along the cliffs in the north part of St. Ignace and at Gros Cap to the west, columns of breccia mark out distinctive promontories of the Nipissing shore (pls. XVIII, XX).

← PLATE I
Castle Rock, St. Ignace.

On Mackinac Island[3] the breccias are shown in the same fashion and in greater abundance. The most prominent stack is Sugarloaf Rock which stands 75 feet above the surrounding flat and 300 feet east of the Algonquin shore cliff with which it is associated. A smaller stack protected the southwest corner of the Mackinac Island of Algonquin time and wave erosion removed some of the weaker material from it, producing Skull Cave. Scott's Cave in the northeast part of the island was formed at the Nipissing stage of the lake and clearly exhibits the effects of wave erosion on its smoothed and rounded floor. About 500 feet northwest of the cave a small stack is on the Nipissing terrace, and a larger stack at the same level, known as Friendship's Altar, is about 600 feet north of British Landing Road. Robinson's Folly, Lover's Leap, Sunset Rock and many others including the cliff near the South Sally Port of Fort Mackinac, are conspicuous pinnacles of breccia projecting from the Nipissing cliffs. Devil's Kitchen, Fairy Arch and the eminence at Arch Rock are related in the same way to the Nipissing shore.

All these features are evidence of the erosional activities of the waves but each one has a considerable vertical elevation and indicates only roughly the level of the lake which formed it. The altitudes of the ancient strand lines are much better obtained from the gravel beach ridges or eroded terraces.

# STRATIGRAPHY OF THE SURFACE FORMATIONS

*of the*

# MACKINAC STRAITS REGION

*by*

GEORGE M. EHLERS

Chapter II

# STRATIGRAPHY OF SURFACE FORMATIONS

## CLASSIFICATION OF ROCKS

### Previous Classifications

Dr. J. J. Bigsby, a British Army surgeon and author of numerous papers on the geology of Canada and the United States, probably made the earliest study of the rocks of the region bordering the northern part of Lake Huron. Dr. Bigsby (1821, pp. 266, 268-269 and 1824, pp. 193-195)[1] briefly described the brecciated rocks of Michilimackinac, now known as Mackinac Island, but presented no classification showing the stratigraphic relationship of the breccia to other rocks of the Mackinac Straits region.

Douglass Houghton, the first State Geologist of Michigan, divided (1840a, pp. 214-220 and 1840b, pp. 74-82)[2] the sedimentary rocks of the Northern Peninsula into the "Lake Superior Sandstone", "Lower Limerock and Shales" and the "Upper Limerocks." The Lake Superior sandstone contains strata most of which are of Upper Cambrian age. The Lower Limerock and Shales include formations now assigned to the Middle and Upper Ordovician. The Upper Limerocks comprise strata of Silurian and Devonian ages.

Houghton (1840a, p. 218 and 1840b, p. 78)[2] stated that the Upper Limerocks may be divided into a "lower, or Pentamerus portion", a "middle, or Polypyferous portion" and an "upper, or Mackinac and Manitoulin portion." The lower and middle portions contain strata which are now placed in the Niagaran series of the Middle Silurian. Strata on Manitoulin Island, which Houghton probably had in mind when defining "the upper, or Mackinac and Manitoulin portion", are older than any rocks on Mackinac Island and also are of Middle Silurian age. According to Houghton (1840a, p. 218 and 1840b, p. 78)[2] the "upper portion of the rocks (Upper Limerocks) form the base of that group of islands, east from Mackinac, known as the

[1]Bigsby, J. J., Geological and Mineralogical Observation on the Northwest Portion of Lake Huron, Amer. Jour. Sci., Vol. 3, 1821.
Notes on Geography and Geology of Lake Huron, Trans. Geol. Soc. London, 2nd ser., Vol. 1, 1824.

[2]Houghton, Douglass, Third Annual Report of the State Geologist. Documents accompanying Jour., House of Representatives, State of Michigan, Vol. 2, no. 27, 1840.
Third Annual Report of the State Geologist accompanying the Journal of the Senate, State of Michigan, Vol. 2, No. 2, pp. 74-82.

Cheneaux, as well as the island of Mackinac and the range of hills extending westward on the mainland, commencing with the bare point of rock, known as the Sitting rabbit" (now known as Rabbit's Back). Les Cheneaux Islands are now thought to be underlain by the Engadine dolomite, the highest formation of the Niagaran series in the Northern Peninsula. Mackinac Island and the "range of hills" on the St. Ignace peninsula of the mainland west of Mackinac Island are composed chiefly of a Middle Devonian formed breccia, the Mackinac breccia, in which the blocks of dolomite, limestone and shale of Upper Silurian and Middle Devonian ages.

Houghton (1840, p. 222 and p. 82)[2] noted that the "middle and upper portions of the upper group of limestones" (apparently Houghton's Upper Limerocks) contain veinlets of gypsum in the bed of Lake Huron near St. Martin's Island and at several points on the coasts west of Mackinac. The strata having this gypsum belong to the Salina group of the Upper Silurian and on later pages of the present report are assigned to the Pointe aux Chenes formation.

Houghton (1840a, p. 221 and 1840b, p. 81)[2] briefly mentioned the "shattered condition" of the rocks on Mackinac Island, their "vesiculated structure" and susceptibility to disintegration. The rocks to which his remarks apply belong to the Mackinac breccia described in detail in Chapter III.

In his Fourth Anual Report to the Senate and House of Representatives, Houghton, (1841, p. 486)[3] presented a table to illustrate the order of super-position of the rocks of the Northern Peninsula. Examination of this table and Houghton's description of the strata listed therein (pp. 480-486)[3] show that Houghton had recognized several additional lithologic units since his work of the previous year. The division of the "Upper Limerock Group", which undoubtedly is the same as "the Upper Limerocks", into two parts "the Drummond Island and Mackinaw Limestones" is of interest because he recognized that these limestones were different and perhaps realized that the "Mackinaw limestone" was younger than the "Drummond Island limestone." Houghton did not intend to use the terms for exact stratigraphic units because he stated (1841, p. 484, foot-note)[3] that "the names which have been affixed to the several sand and lime rocks are regarded as merely temporary, and are introduced, for the present, barely to facilitate description."

C. C. Douglass, Assistant Geologist working with Douglass Houghton, gave additional information on the rocks of the Straits

[3]Houghton, Douglass, Annual Report (Fourth) of the State Geologist. Documents accompanying Jour. Sen. State of Michigan, Vol. 1, Senate and House, Dec. 11, 1841.



area in a paper which is incorporated as a part of the State Geologist's Fourth Annual Report to the Senate and House of Repretatives. In this paper Douglass (1841, p. 545)[3] presented tables showing a classification of the rocks along the shores of Lakes Michigan and Huron. He (p. 548)[3] described the "Mackinac limestone" in considerable detail and noted the occurrences of this rock on Mackinac, Round and Bois Blanc Island, on "Sleeping Rabit" (=Rabbit's Back) and in the bed of the lake west of old Fort Mackinac as far as "point Wabachance" (=Waugoshance Point). It is evident from his description that Douglass observed the brecciated rocks of the Mackinac Straits region and noted sections of strata, which are now in this report assigned to the Upper Silurian **St. Ignace formation** (new formation name) and the Middle Devonian **Bois Blanc formation** (new formation name). The St. Ignace and Bois Blanc rocks seen by Douglass are present as large blocks within his "Mackinac limestone", which is now designated the **Mackinac breccia.**

Douglass (p. 545–table and p. 550)[3] reported the occurrence of "Corniferous limestone" in T. 33 N. in his classification of the rocks of Lake Michigan. Douglass' Corniferous limestone is not the Corniferous limestone of Ontario and New York, which is now known as the Onondaga limestone. The Corniferous limestone, which Douglass noted, with little doubt is a very cherty limestone of the Middle Devonian Traverse group exposed on the shore of Lake Michigan about one mile north of Norwood in T. 13 N. of Charlevoix County.

James Hall (1843, pp. 118, 512, 519, 682 and map)[4] in his classic monograph on the geology of the fourth geological district of New York, gave information which contributed much to the knowledge of Michigan geology. In his discussion of the Onondaga salt group, which is typically exposed in New York, he (1843, p. 118)[4] noted that strata of the upper part of this group are present as far west as Mackinac Island. In chapter 23 dealing with a discussion of the rocks of states west of New York, Hall (p. 512)[4] again noted that "the upper part of the Onondaga salt group, and possibly a small portion of the Waterlime group" were observed at Mackinac Island. In the same chapter he (p. 512)[4] stated that "the limestone of the Helderberg series, principally the Corniferous and Onondaga masses, form the rocks of many of the bays and harbors; characteristic fossils of the masses being recognizable in those examined." On page 519 of his monograph, Hall presented a table to show which

[4]Hall, James, Geology of New York, Pt. IV, Survey Fourth Geological District: Nat. Hist. New York, Pt. IV, Geology 1843.

strata of various states were equivalent to formations of the New York section. A heading, "Michigan Survey," at the top of the column of Michigan rock terms indicates that Hall attempted to coordinate his findings with those of Douglass Houghton and C. C. Douglass of the Michigan Geological Survey. In the table Hall showed the Mackinac limestone as equivalent to the Onondaga salt group. He correlated the "Little Traverse bay limestone", "Black bituminous limestone," and "Blue limestone in thick regular layers" with New York formations occupying positions between the Onondaga salt group and the Onondaga limestone. The three Michigan limestones noted by Hall and the "Thunder bay limestone," which he doubtfully correlated with the same New York formations, are younger than the Onondaga limestone of New York and are now included in the Traverse group of Michigan. In the table of formations Hall correlated the "Corniferous" of Michigan with the Corniferous and Onondaga limestones of New York.

The colored geological map of the middle and western states, which appears at the back of Hall's monograph, is of considerable geologic interest. On this map the northern, southeastern and southwestern parts of the Southern Peninsula are shown as being underlain by Helderberg rocks. Belts of color representing progressively younger strata towards the central area of the Southern Peninsula indicate the existence of a basin structure. The recognition of the Michigan Basin should be credited to Douglass Houghton since as Hall stated (1843, p. 682)[4] Houghton supplied him with the geological map of Michigan.

An important contribution to the classification of the rocks of the Mackinac Straits area was made by James Hall in J. W. Foster and J. D. Whitney's "Report on the geology of the Lake Superior Land District", published by the United States government in 1851. Hall (1851, pp. 161-162)[5] assigned the marls, gypsum and vesicular and gashed limestones of Mackinac Island, the St. Martin islands and the mainland north of St. Ignace to the Onondaga Salt group, which is typically exposed in the state of New York. Most of the strata of the Onondaga Salt group are now included in what is known as the Salina group. As explained later in this report, the marls, chiefly green and red shales, and gypsum noted by Hall are included in the newly named **Pointe aux Chenes formation** (new formation name) of the Salina group. The vesicular and gashed limestones observed by Hall are now included in the St.

[5]Hall, James, Geological Reports published in Pt. V of Foster and Whitney report on Geology of the Lake Superior Land District, U. S. Senate, Spec. Ses., March, 1851, Ex. Doc. No. 4.



Ignace formation of this report. The St. Ignace formation is assigned to the Bass Islands[6] group, which is believed to be younger than the Salina group. Hall (1851, p. 162)[5] recognized that the fossiliferous "lower Helderberg series" of New York, now known as the Helderberg group, was not in the Straits region. He noted (p. 162)[5] the breccia of Mackinac Island and stated: "I cannot but regard the brecciated mass as terminating the Onondaga salt group, or perhaps more properly, as marking the era of the commencement of the succeeding group, which, as will be shown, corresponds with the upper Helderberg limestones of New York." He also recognized (pp. 162-163)[5] that the "lower Helderberg series" of New York, essentially the Helderberg group of present day terminology, is absent in the region and that the "upper Helderberg series," embracing the Schoharie grit and Onondaga and Corniferous limestones of Hall's time, rests directly on the "Onondaga Salt group."

With little doubt Hall (1851, pp. 163-166)[5] believed that the breccia of the Straits area, designated the "Mackinaw limestone" by Houghton and the "Mackinac limestone" by Douglass, belonged to the "upper Helderberg series." The basis for this belief was Hall's recognition of fossils in blocks of the breccia which are identical with fossils found in the Schoharie grit and Onondaga limestones of New York. It is most significant that Hall (pp. 166, 224-225, 228)[5] reported the occurrence of the trilobite *Phacops anchiops* in the cliff of Arched Rock on Mackinac Island. This trilobite, now known as *Anchiopsis anchiops* (Green), is as stated by Hall (p. 166)[5] characteristic of the Schoharie grit of New York. Hall undoubtedly obtained the trilobite from blocks of limestone within the Mackinac breccia. The blocks belong to a formation which in this report is designated the Bois Blanc formation. The rocks of this stratigraphic unit contain not only *Anchiopsis anchiops* (Green) but many other fossils diagnostic of the Schoharie grit and Onondaga limestone.

Hall (1851, p. 165)[5] stated that the upper beds of the upper Helderberg series come to the level of the water "in the neighborhood of Presqu'ile, on the western shore of Lake Huron." The strata at this locality, which is about 70 miles southeast of Mackinaw City, belong to the Dundee limestone and are younger than beds of the upper Helderberg series exposed in the vicinity of the Straits of Mackinac.

[6]See footnote 19.

Alexander Winchell, the second State Geologist of Michigan, (1860, pp. 57-69)[7] used the terms "Onondaga Salt group" and "Upper Helderberg group" for the rocks of the Straits area in much the same manner as James Hall. Winchell (1860, pp. 58-59)[7] assigned to the Onondaga Salt group certain rocks of Monroe County which are now placed in the Upper Silurian Bass Island group and Middle Devonian Detroit River group. He included in the Upper Helderberg group the strata of Crawford's quarry, the site of the present Michigan Limestone and Chemical Company's quarry at Rogers City, the strata of Middle Island about 28 miles southeast of Rogers City, and of Thunder Bay Island about 40 miles southeast of the city. The rocks at these three places are younger than typical upper Helderberg deposits and are now included respectively in the Dundee and Rogers City limestones, Rogers City limestone, and the Traverse group. The Dundee strata of the Judge Christiancy quarry at Dundee, Monroe County and at Mongaugon (=Sibley, two miles north of Trenton), Wayne County, and apparently beds of the Traverse group of Little Traverse Bay were placed in the Upper Helderberg group by Winchell (pp. 64-65)[7].

Winchell (p. 60)[7] reported the occurrence of a "cherty and agatiferous conglomerate" on Mackinac Island and the mainland west of this island which he believed occupied the position of the Oriskany sandstone of New York and "may not improbably be regarded as representing that formation." This conglomerate most likely is a broken or weathered block or cherty dolomite or limestone of the Bois Blanc formation and is in the Mackinac breccia.

The geological map of southeastern Canada and the northeastern part of the United States, published in the "Atlas of Maps and Sections" in 1865 and intended to accompany the "Report on the Geology of Canada by W. E. Logan and others (1863, 983 pages)[8] gives information on the classification and distribution of the rocks of Michigan. On this map (1865, pl. I)[9] the region adjacent to St. Ignace and Mackinac Island is shown as being underlain by "Onondaga" strata, which as indicated by Logan (p. 345)[8] are equivalent to the Onondaga salt group of New York. The Beaver Island group in Lake Michigan and the northern, southeastern and southwestern parts of the Southern Peninsula are shown as being

[7]Winchell, Alexander, First Biennial Report of the Progress of the Geological Survey of Michigan, Embracing Observations on the Geology, Zoology and Botany of the Lower Peninsula, 1860, Lansing, Michigan, 1861.
[8]Logan, W. E. and others, Report on the Geology of Canada: Geol. Surv. Canada, Rept. Prog. to 1863, 1863.
[9]Logan, W. E., and others, Maps and Sections to accompany Report on Geology of Canada: Geol. Surv. Canada, Rep't. Prog. 4 maps, sections 4 and 15, 1865.



occupied by "Corniferous & Oriskany." Since the "Corniferous & Oriskany" of the entire region covered by the map were indicated by one color, it is impossible to tell whether only one or both of these formations are at a particular locality. The classification and distribution of the strata of Michigan as shown on the map was obtained, as Logan stated (1865, p. 16)[9], from information given him by Alexander Winchell and James Hall and from the results of studies by Houghton and others.

In 1875 N. H. Winchell (1875, pp. 103-107)[10] adopted the views of his brother Alexander Winchell in classifying the rocks of the Mackinac Straits area. He stated (p. 103)[10] that the strata which "constitute the base of Mackinac Island," are a part of the Waterlime Group and "belong to the lower part of the *Lower Helderberg*" and those of the elevated part of this island belong to the "*Upper Helderberg.*" The two sets of strata, according to N. H. Winchell (p. 103)[10], "are separated by an 'agatiferous conglomerate' supposed to be equivalent to the *Oriskany Sandstone*, which at Crawford's Quarry appears near the bottom of the outcrop as a 'brown calcareous sandstone,' and in Southern Michigan and Northern Ohio as a 'white saccharoidal sandstone.'" N. H. Winchell, like his brother, was mistaken in believing that the "agatiferous conglomerate" and "brown calcareous sandstone" are equivalent to the Oriskany sandstone. The "white saccharoidal standstone" of Southern Michigan and Northern Ohio, mentioned by Winchell, is now known as the Sylvania sandstone, a formation which is younger than the Oriskany sandstone.

N. H. Winchell (pp. 103-106)[10] incorrectly assigned rocks of several particular localities in the Southern Peninsula to positions in his stratigraphic classification. Most of these errors have been recognized by later students of Michigan stratigraphy. Evidence given in this report indicates the correct stratigraphic assignment of the rocks of the Straits area noted by Winchell.

In 1873 Carl Rominger (1873, pp. 14, 29-31)[11] used the term "Onondaga Salt group" for dolomite and green and red variegated shale with some gypsum overlying the Middle Silurian "Niagara group" (=Niagaran series) of the Northern Peninsula of Michigan. In this usage he followed the terminology of James Hall. Now, in this report, the strata of Rominger's "Onondaga Salt group" are assigned to the Pointe aux Chenes formation of the Salina group.

[10]Winchell, N. H., The Economical Geology of the Region of Cheboygan and Old Mackinac in the counties of Presque Isle, Cheboygan and Emmet, State of Michigan: 12th Ann. Rep't. Sec'y. State Bd. Ag. Michigan for 1873, 1875.
[11]Rominger, C. L., Geology of the Upper Peninsula: Geol. Surv. Michigan, Vol. 1, pt. 3, 1873.

Rominger (1873, pp. 14, 22-29)[11] used the term "Helderberg group" for the rocks of the Northern Peninsula which are above the "Onondaga Salt group." On two pages of his report he (pp. 22-23)[11] pointed out that in New York and other states the Helderberg group has two divisions and that only the upper division is represented in Michigan. On later pages (pp. 26-28)[11] he noted the occurrence of thin, even-bedded, light-colored dolomites at the base of the breccia, which composes most of the Helderberg group of Mackinac Island and vicinity, and stated that these dolomites occupy an intermediate position between the rocks of the Onondaga Salt group and "well-characterized upper Helderberg strata." The finding of a few supposed lower Helderberg types of fossils in the dolomites led Rominger (p. 28)[11] to state that "we may safely take the intermediate beds as contemporaneous with the lower Helderberg group." The results of the study made by the writers in 1942-43, however, indicate that the thin, even-bedded, light-colored dolomites, which are now included in the St. Ignace formation, are older than any strata of the "lower Helderberg group" of Rominger's time. Rominger (p. 24)[11] described the "upper division" of the Helderberg group in the Northern Peninsula as consisting of "uneven-bedded limestones, and by cherty and argillaceous layers" and stated that blocks of these strata had become undermined by weathering and had "tumbled down-hill into open clefts between the breccia rocks." The uneven-bedded, cherty and argillaceous limestones noted by Rominger undoubtedly belong to the Bois Blanc formation defined and described in later pages of this chapter. Although some blocks of these limestones may have fallen into fissures of the breccia as stated by Rominger, most of the blocks undoubtedly were incorporated in the breccia at the time of its formation. The fact that Rominger (p. 24)[11] stated that "fossils are very abundant in this upper division and in the subjacent terminal strata of the brecciated limestone" indicates that Rominger himself was aware of the incorporation of blocks of the fossiliferous, cherty limestones in the breccia. The numerous species of fossils from the Helderberg group listed by Rominger (pp. 25-26)[11] prove that he was correct in correlating the fossiliferous, cherty limestones with the "corniferous" (=Onondaga) limestone of "Canada West" (=Ontario).

In his "Geology of the Lower Peninsula" Rominger (1876, pp. 23-24)[12] used the term Helderberg group for several exposures in the Mackinac Straits area. He correctly recognized that the strata

[12]Rominger, C. L., Geology of the Lower Peninsula. Geol. Surv. Michigan, Vol. 3, pt. 1, 1876.



at McGulpin's Point and at the top of Mackinac Island belonged to the very fossiliferous upper division of the Helderberg. He was successful in tracing these strata, composing the Bois Blanc formation of this report, to the Beaver Islands by means of drift material. He assigned ledges on the lake bottom adjacent to Whiskey Island in Lake Michigan and on Round and Bois Blanc Islands in Lake Huron to the lower part of the Helderberg group. These ledges are older than the fossiliferous cherty limestones and are included in the St. Ignace formation defined and described later in this chapter.

Rominger (pp. 24-35)[12] correlated the Helderberg strata of the Straits region with certain rocks of southeastern Michigan. He stated that dolomites in Lenawee, Monroe and Wayne counties, which many years later were placed in the "Monroe formation," were equivalent to the lower division of the Helderberg group of Mackinac Island. He correlated strata exposed in quarries near Trenton, Wayne County, and the Judge Christiancy quarries on Macon Creek with the upper division of the Helderberg group. The strata of all these quarries belong to the Dundee limestone, a formation which occupies a stratigraphic position above the highest rocks of the Helderberg group.

In his report as State Geologist for the years 1891-1892, M. E. Wadsworth (1892, pp. 84-86)[13] published tables showing the classification of the rocks of Michigan. In the table classifying the rocks of the Upper Peninsula he (p. 84)[13] followed Hall, Winchell, and Rominger in applying the new York terms "Onondaga (=Onondaga salt group)," "Lower Helderberg," and "Upper Helderberg" to strata of this region. In the table of the deposits of the Lower Peninsula he (pp. 85-86)[13] used the term "Upper Helderberg" for strata, which now are included in the Dundee limestone and the underlying Detroit River group. Below the "Upper Helderberg" he recognized a sand, which he doubtfully designated "Oriskany." This "sand" may be the Sylvania sandstone of present terminology. Below the doubtful Oriskany Wadsworth noted "Silurian limestones," which unquestionably include strata of Middle and Upper Silurian ages.

In Wadsworth's report (p. 66)[13] for the years 1891-1892, A. C. Lane presented a classification of Michigan rocks in which appear the formation names "Dundee limestone" and "Monroe Beds." In 1895 the Dundee limestone was described by Lane (1895, pp. 25-

[13]Wadsworth, M. E., Report of the State Geologist for 1891-1892: Rept. Bd. Geol. Surv. Michigan for 1891 and 1892, 1893.

26)[14] who stated that the name Dundee "is nearly equivalent to Corniferous or Upper Helderberg." At the same time Lane (pp. 26-28)[14] described the "Monroe Beds," noting that "the period of the Monroe beds is that of the Salina and Lower Helderberg."

In two papers Lane (1899a, p. 88 and 1899b, pl. 2)[15] [16] noted the occurrence in southeastern Michigan of the Sylvania sandstone, which is typically exposed in northwestern Ohio. He (pl. 2)[16] referred to the Monroe strata as "Monroe above Sylvania sandstone" and "Monroe below Sylvania sandstone."

W. H. Sherzer (1900, pp. 35-40, 43-100, pl. 1)[17] in his report on the geology of Monroe County, Michigan, described the Monroe beds and Dundee limestone in much detail. He followed Lane in differentiating the Monroe rocks above and below the Sylvania sandstone.

In 1909, A. C. Lane, C. R. Prosser, W. H. Sherzer and A. W. Grabau (1909, pp. 553-556)[18] presented a detailed classification of the Monroe strata. In this classification the strata were divided into the "Lower Monroe or Bass Islands[19] Series," the middle Monroe, consisting of the Sylvania sandstone, and the "Upper Monroe or Detroit River series." All of the Monroe strata were considered by these geologists as being of Upper Silurian age.

Many years later, C. R. Stauffer (1916, pp. 72-77)[20], M. Y. Williams (1919, pp. 18-22)[21] and J. E. Carman (1927, pp. 481-506 and 1936, pp. 253-266)[22] [23] published papers which show that the Lower Monroe or Bass Island series is of Upper Silurian age but that the Sylvania sandstone and Upper Monroe or Detroit River series are of Devonian age. The opinions of these geologists and other references pertaining to the classification of the Monroe strata are given in later pages of this chapter, particularly in the discussion of the nomenclature of the Detroit River rocks.

[14]Lane, A. C., The Geology of the Lower Peninsula with references to Deep Borings: Geol. Surv. Michigan, Vol. V, pt. 2, 1895.

[15]Lane, A. C., Water resources of the Lower Peninsula of Michigan: U. S. Geol. Survey, Water Supply Paper 30, 1899a.

[16]Lane, A. C., Lower Michigan Mineral Waters: U. S. Geol. Survey, Water Supply Paper 31, 1899b.

[17]Sherzer, W. H., Geological report on Monroe County, Michigan: Geol. Surv. Michigan, Vol. 7, pt. 1, 1900.

[18]Lane, A. C., Prosser, C. R., Sherzer, W. H., and Grabau, A. W., Nomenclature and subdivision of the upper Siluric strata of Michigan, Ohio and Western New York. Bull. Geol. Soc. Amer., Vol. 19, 1909.

[19]Although the original name of the group was "Bass Islands," the singular "Bass Island" was also used by Lane, Sherzer and Grabau and by M. Y. Williams in his reclassification of the "Monroe". Bass Island has been in use almost exclusively since 1910 and is therefore considered by the Michigan Geological Survey to be not only more euphonious but also to be "in use" according to the rules of nomenclature. G. M. Ehlers is not in accord with this decision and protested the change from "Islands" to "Island" in his manuscript. *Editor.*

[20]Stauffer, C. R., Relative age of the Detroit River Series; Geol. Soc. Amer. Vol. 27, 1916.

[21]Williams, M. Y., The Silurian Geology and faunas of Ontario Peninsula, Manitoulin and adjacent islands: Canada Dept. Mines and Geol. Survey, Mem. 111.

[22]Carman, J. E., The Monroe Division of rocks in Ohio: Jour. Geol., Vol. 35, No. 6, 1929.

[23]Carman, J. E., Sylvania Sandstone of Northwestern Ohio: Bull. Geol. Soc. Amer., Vol. 47, 1 pl., 5 figs., 1936.



The extensive use of the names Monroe and Dundee for strata in southeastern Michigan resulted in the application of these names to rocks of the Mackinac Straits area. Lane (1895, p. 28 and pl. 63)[14] as early as 1895 included gypsum and salt beds of this area in the Monroe Beds, noting in the legend of the record of a deep well at St. Ignace that the Monroe Beds were equivalent to the "Lower Helderberg and Salina." At the same time he (p. 26)[14] stated that the Dundee limestone was at the "northern end of the Lower Peninsula to Mackinaw City." In the record of a second deep well at St. Ignace, Lane (1902, pp. 227-228)[23] again included beds of gypsum, red and blue shale and some dolomite in the "Monroe" which now are known to belong to the Salina group. On a geological map of Michigan, Lane (map opposite p. 224)[23] shows the distribution of the Monroe and Dundee strata in the Straits region. In the legend of the map the Dundee is indicated as being equivalent to the "Corniferous, Upper Helderberg" and the Monroe as including "Waterlime, Salina, Onondaga." G. P. Grimsley (1904, pp. 80-83, 97)[24] in a discussion of the gypsum deposits of St. Ignace followed Lane in the usage of the term Monroe. I. C. Russell (1905, pp. 44-45)[25] used the term "Monroe formation" for strata which he stated are "about the equivalent in age of the Manlius and Salina." Russell noted the Mackinac breccia and several other beds of the Straits area which Hall had described and assigned to the Helderberg group. He described the breccia of the region and apparently included it in the "Monroe formation." A geological map by A. C. Lane inserted opposite page 40 of Russell's report shows a small area at the northern end of the Southern Peninsula, the St. Ignace Peninsula, some islands of the Beaver Island group, and all of Mackinac and Bois Blanc Islands as being underlain by the Monroe. All of Beaver Island and a northwest-southeast trending belt of land south of Mackinaw City are shown as being occupied by the Dundee limestone. In 1909 A. C. Lane published a detailed description of the geologic section of Michigan. In a table to illustrate the geologic column of Michigan, Lane (1909, table opposite p. 42)[26] assigned the "Salina" and "Lower Monroe or Bass Island"[19] strata to the "Upper Silurian or Ontarian," the "Middle Monroe, Sylvania"

[23]Lane, A. C., Deep wells and prospects for oil and gas. Geol. Surv. Michigan. 3rd Ann. Rep't. St. Geologist to Bd., Geol. Surv. 1902.

[24]Grimsley, G. P., The gypsum of Michigan and the plaster industry: Geol. Surv. Michigan, Vol. 9, pt. 2, 1904.

[25]Russell, I. C., A geological reconnaissance along the north shore of lakes Michigan and Huron: Geol. Surv. Michigan, Ann. Rep't 1904, map 1905.

[26]Lane, A. C., Notes on the geological section of Michigan. Pt. II from the St. Peter Up.: Geol. Surv. Michigan, 10th Ann. Rep't. State Geologist for 1908. 1909.

sandstone and "Upper Monroe or Detroit River" rocks to the "latest Ontarian, possibly Eo-Devonian," and the "Dundee" limestone to the "Meso-Devonian." Lane (pp. 60-61, 63, 67, 69-70)[26] referred the rocks of several localities in the Straits area to these stratigraphic divisions. He (p. 70) noted that A. W. Grabau (see Grabau, 1906, p. 467; 1907, pp. 718-719; 1908. p. 267)[27] had reported the discovery of a typical Schoharie fauna in the Dundee limestone of Mill Creek, four miles southeast of Mackinaw City. The occurrence of Schoharie fossils in the rocks of the Straits area was, as Lane stated (1909, p. 70)[26], known to James Hall. The strata containing Schoharie fossils do not belong to the Dundee limestone but to an older formation, the Bois Blanc formation of this report. R. A. Smith in his report on the occurrence of oil and gas in Michigan (1914, pp. 25-27, 242-243, and figs. 2-3)[28] and his paper on limestones of Michigan (1916, pp. 156-159, 198, 203-205, 235, 242 and figs. 7 and 9)[29] adopted Lane's classification and mapping of the rocks of Straits area and described in detail the lithology of several outcrops. R. B. Newcombe (1933, p. 38-39, 44-45, figs. 1-2)[30] and other workers followed Lane in the application of the names Salina, Monroe and Dundee to the rocks of the Straits region.

A. W. Grabau was an exception to most students of Michigan geology in that he recognized the need for the term "Mackinac limestone." In his discussion of the fauna of the Dundee limestone published in W. H. Sherzer's geological report on Wayne County, Michigan he (1913, pp. 365-366)[31] noted that the Mackinac limestone probably was older than "the Dundee limestone of Northern Michigan" and "for this reason and because the faunas are to a certain extent distinct, it is well to use a distinctive name for this formation." He (p. 365)[31] furthermore stated that "on the view that the Mackinac limestone (the so-called Dundee of the Mackinac region) is the approximate equivalent of the Onondaga and Schoharie of New York, the succeeding Bell shales of Northern Michigan represent in part the horizon of the Marcellus, but with a different type of sedimentation." From this statement it seems

[27]Grabau, A. W., Discovery of the Schoharie fauna in Michigan Science new ser., Vol. 23, No. 586, 1906; Bull. Geol. Soc. Amer., Vol. 17, 1907, and Am. New York Acad. Sci., Vol. 18, No. 7, Pt. 2, 1908.
[28]Smith, R. A., The occurrence of oil and gas in Michigan. Michigan Geol. and Biol. Surv., Pub. 14, G. S. 11, 1914.
[29]Smith, R. A., Limestones of Michigan. Michigan Geol. and Biol. Surv., Pub. 21, G. S. 17, 1916.
[30]Newcombe, R. B., Oil and gas fields of Michigan, a discussion of depositional and structural features of the Michigan Basin—Michigan Dept. Cons., Geol., Surv. Div., Pub. 38, G. S. 32, 1932.
[31]Grabau, A. W., Preliminary Report on the Dundee limestone of Southern Michigan in Sherzer Geology of Wayne County, Michigan Geol. and Biol. Survey, Pub. 12, G. S. 9, Ch. 10, 1913.



that Grabau included the Dundee limestone of the northern part of the Southern Peninsula in the Mackinac limestone.

In recent years a few changes were made in the nomenclature of the rocks of the Mackinac Straits area as proposed by Lane and adopted by others. On the centennial geological map[32] of Michigan compiled by Helen M. Martin and published in 1936, much of the Straits area previously mapped as Monroe was indicated as being underlain by the Mackinac limestone. The term Mackinac limestone, proposed by Houghton and Douglass of Michigan's first geological survey, was used because beds within this limestone, which is a breccia, were known to contain Onondaga and possibly younger faunas. In 1938 G. M. Ehlers and R. E. Radabaugh (1938, p. 444)[33] showed that the lower part of the previously designated Dundee limestone of the northern part of the Southern Peninsula contains a typical Dundee fauna but that the upper part, which they named the Rogers City limestone, contains a different fauna. They also noted that the Dundee limestone was younger than the Mackinac limestone.

## Proposed Classification

The rocks of the Mackinac Straits region occupy a position between the Engadine dolomite at the top of the Middle Silurian Niagaran series and the Dundee limestone of the Middle Devonian Erian series.

The proposed classification of these strata, the Engadine dolomite and the Dundee limestone is shown in table 1. The series terms and most of the group terms in this table are in common use and are noted in the recent correlation papers by C. K. Swartz et al (1942)[34] and G. Arthur Cooper et al (1942)[35]. The present paper proposes to use Bass Island and Detroit River as terms for groups, which hitherto have been designated as "beds," "formations," and "series."

**Pointe aux Chenes** is proposed for strata which in recent reports have been designated by the group term Salina. Further study may show that the Salina group of the Straits area contains several formations and that the Point aux Chenes formation is its uppermost division.

[32]Michigan Dept. Cons., Geol. Surv. Div., Pub. 39, Geol. Ser. 33, 1936.
[33]Ehlers, G. M., and Radabaugh, R. E. The Rogers City limestone, and a new Middle Devonian formation in Michigan. Michigan Acad. Sci., Papers, Vol. 23.
[34]Swartz, C. K., and others, Correlation of the Silurian formations of North America. Bull. Geol. Soc. Amer., Vol. 53, Chart 3, 1942.
[35]Cooper, G. A., and others, Correlation of Devonian Sedimentary formations of North America. Bull. Geol. Soc. Amer., Vol. 53, Chart 4, 1942.

**St. Ignace** is used for light-colored, even-bedded dolomites and few thin shales which the early geologists placed in the Onondaga salt group or Helderberg and which later workers assigned to the Salina or Monroe. The few, poorly preserved fossils collected from these dolomites suggest the inclusion of the dolomites in the Bass Island group.

**Garden Island** is proposed for a thin formation consisting of dolomite and dolomitic sandstone. This formation, which is exposed only on Garden Island in Lake Michigan, contains an Oriskany fauna and is the oldest Devonian unit in the Straits area.

**Bois Blanc** is proposed for strata composed chiefly of cherty limestones and dolomites with numerous fossils characteristic of of the lower Onondaga fauna of New York and Ontario. Further study of the fossils in the beds of the upper part of the formation may show that the upper beds should be separated from the rest of the stratigraphic unit.

Formations of the Detroit River group have not been differentiated in the Straits area. Outcrops are very few and have not yielded fossils which might aid in the recognition of formations composing the group in southeastern Michigan. The identification of the group in the Straits region is based on lithology, stratigraphic position and especially on the study of logs and rock samples of many deep wells.

Strata occupying a position between the lower part of the Pointe aux Chenes formation and the base of the Dundee limestone are involved in the brecciation of the region. The term **Mackinac breccia,** rather than the older term Mackinac limestone, is used to show the extent of this brecciation and the true character of the rock. The Mackinac breccia is described in detail in Chapter III.



**Table 1. Classification of the rocks of the Straits of Mackinac region.**

| System | Series | Group | Formation | |
|---|---|---|---|---|
| Devonian | Erian | Cazenovia | Dundee limestone | |
| Devonian | Ulsterian | Detroit River | Formations not differentiated—largely unexposed | Mackinac breccia |
| Devonian | Ulsterian | Onesquethaw | Bois Blanc | Mackinac breccia |
| Devonian | Ulsterian | Deerpark | Garden Island | Mackinac breccia |
| Silurian | Cayugan | Bass Is. | St. Ignace | Mackinac breccia |
| Silurian | Cayugan | Salina | Pointe aux Chenes | Mackinac breccia |
| Silurian | Niagaran | Lockport | Engadine dolomite | |

## POINTE AUX CHENES FORMATION

NOMENCLATURE: The name Pointe aux Chenes is proposed for the Upper Silurian formation occupying a position between the Middle Silurian Engadine dolomite and the overlying Upper Silurian St. Ignace formation defined on later pages of this report. The name is chosen for the reason that several exposures of the

stratigraphic unit are in the area near Pointe aux Chenes, a headland on Lake Michigan about nine miles northwest of the city of St. Ignace.

DISTRIBUTION: The formation underlies most of the large St. Ignace peninsula north of the Straits of Mackinac; narrow areas on the western, northern, and eastern sides of Mackinac Island; the St. Martins Islands north of Mackinac Island; and St. Martins Point east of St. Martins Islands (see map fig. 2 in pocket). It is possible that some of the drift-covered Cheneaux Islands located east of St. Martins Point and now believed to be underlain by the Engadine dolomite, may prove to be based on Pointe aux Chenes strata when the drilling of deep wells reveals the type of rock beneath the glacial deposits.

Outcrops of the formation are few in number largely because the shales, which compose most of the unit, were carved into a lowland by pre-glacial streams and subsequently were covered by glacial, glacial-lake, and dune deposits; and also because exposures caused by recent erosion or by human excavation quickly weather into soil and become covered by vegetation.

LITHOLOGIC AND PALEONTOLOGIC CHARACTERS: As a result of its lack of resistance to erosion and its cover by drift, soil, and vegetation, the formation exhibits exposures of very small thicknesses from which only an incomplete knowledge of the lithology and superposition of the strata may be obtained. Fortunately the known outcrops and the records of a few deep wells show that the formation consists of green and red shale with thin beds of dolomite of varied lithologic character and small irregular masses and thin beds of gypsum.

Strata occupying a position near the base of the formation are exposed on the right or south bank of the Carp River about half a mile above its mouth on St. Martins Bay approximately 11 miles north of St. Ignace. They consist of very fine-grained, ash-gray dolomites, mottled and shaded with pink; and a few thin layers of indurated shale. Only two feet of rock were visible above the mid-summer high water level of 1943. Dr. Carl Rominger, who had opportunity to study the outcrop at a very low stage of the river stated (1873, p. 30)[11] that the dolomites are in "uneven rugose layers of six to eight inches in thickness, and are interstratified with thin seams of shaly and marly substances; numerous cellular cavities, filled with calc-spar and occasionally with sulphate of baryta, are seen in the rock, which has a fine-grained, somewhat earthy fracture. The strata, of which six feet are exposed, have



a gentle dip to the southeast, which would bring them under the variegated marls of St. Martins Island. In the opposite direction, the first rocks met with are the Niagara limestones. The immediate contact of the two formation is, however, nowhere to be seen." (Onondaga Salt Group of Rominger = Salina group, and the Niagara limestones = Niagaran series with Engadine dolomite at the top).

About two and a half miles northwest of the Carp River outcrop and south of the center of sec. 12, T. 42 N., R. 4 W., two very small outcrops of green shale are in a Forest Service road at the crossings of two minor tributaries entering the Carp River from the north. The shale may occupy a position below the dolomites near the mouth of the Carp River. This stratigraphic relationship, however, cannot be substantiated until detailed information relative to the super-position of the shales and dolomites of the formation becomes known.

About four miles northwest of the two outcrops of shale and about one and a half miles north of the intersection of the Forest Service road with a road extending from Moran to East Lake is a point close to the boundary between the Engadine dolomite and Pointe aux Chenes formations. South of this point the road descends to the lowland and marshes of the Carp River which with little doubt are underlain by Pointe aux Chenes strata. A short distance north of the point numerous blocks of Engadine dolomite indicate that ledges of this formation are near to the surface. About one mile north of the mapped formational boundary the Engadine dolomite is exposed in the ditches of the Moran-East Lake road at several places between the center of sec. 27, T. 43 N., R. 4 W., and a road leading eastward about a quarter of a mile south of the center of the section.

Extensive pavement-like exposures of the Engadine dolomite are on both sides of a road leading westward to Kenneth between points one and two miles northwest of the center of sec. 27. The dolomite blasted from the bed of the road along the north lines of secs. 28 and 29, and piled around telephone poles, contains very poorly-preserved remains of a large pelecypod which seems to be *Megalomus canadensis* Hall. This characteristic Guelph species indicates the occurrence of the Guelph fauna in the upper part of the Engadine dolomite, and aids in locating the Engadine-Pointe aux Chenes contact, which must be between the northern parts of secs. 28 and 29, and the lowland along the Carp River.

Pointe aux Chenes dolomites which may not be far above the Engadine-Pointe aux Chenes contact, are exposed along the shore of St. Martins Bay in the NE¼ sec. 34, T. 42 N., R. 2 W., about one and three-quarters miles north of St. Martins Point. Their lithologic character and thickness are noted in the following description of the section:

Section of strata exposed along shore of St. Martins Bay, Lake Huron, about one and three-quarters miles north of St. Martins Point

| | Thickness Feet |
|---|---|
| Pointe aux Chenes formation: | |
| 3. Dolomite, light-buff to cream-colored, with bands of very small oolites | 1 |
| 2. Dolomite, oolitic, buff to brown, weathered joint-faces showing cross-bedding of oolites | 2 |
| 1. Dolomite, light buff gray to cream-colored, fine-grained, some layers apparently with very small oolites. Exposed along shore and on lake bottom | 5 |
| Total | 8 |

The dolomites at this locality somewhat resemble buff, thick-bedded, oolitic dolomites in the upper part of the St. Ignace formation, which overlies the Pointe aux Chenes. They differ from the St. Ignace dolomites in having well defined oolites rather than oolites which are difficult to discern because they have been modified by dolomitization. Their position in the Pointe aux Chenes formation is low, possibly below the dolomites exposed along the Carp River about eight miles to the west.

Big and Little St. Martins Islands located four and two miles west of St. Martins Point are underlain by Pointe aux Chenes strata with a covering of glacial drift. Green shale and a few thin beds of ash-gray, fine-grained dolomites, some of which have a pink tinge and resemble the dolomites of the Carp River, are at the surface of the low land adjacent to the south shore of Big St. Martins Island in the southern part of sec. 12, T. 41 N., R. 3 W. Undoubtedly the abundant fragments of red and green shale along the northwest shore of the island in the NE¼ sec. 2, T. 41 N., R. 3 W., were cast on the shore by storm waves and ice from ledges beneath the water. Rominger (1873, p. 30)[11] noted that informants had observed gypsum in place on Big St. Martins Island and in blocks along the shores of both Big and Little St. Martins Islands. Although gypsum was not found by Rominger or the writers, it is very likely that gypsum is on the islands but is covered by drift. The shale, dolomite, and gypsum of the two islands doubtless occupy a position in the formation above the dolomites



exposed along the shore one and three-quarters miles north of St. Martins Point and on the south bank of the Carp River.

Pointe aux Chenes strata are at or relatively near the surface of the upland south of the lower course of the Carp River in parts of secs. 29, 30, 31, and 32, T. 42 N., R. 3 W. Numerous exposures of green and red shale with some thin beds of gray, fine-grained dolomite are in the ditches along U. S. Highway 2 in secs. 30 and 31, where this highway crosses a ridge between one and two miles south of the Carp River. Red and green shale is encountered when excavating basements for some of the houses adjacent to this part of the highway and is exposed in the ditches of the road on the south line of sec. 30 about half a mile west of Highway 2. The highest strata visible along Highway 2 probably are 100 to 150 feet above the dolomites exposed on the Carp River.

Thin-bedded to laminated, green and red, dolomitic shale can be seen in many of the ditches of the roads in the vicinity of Allenville on the Duluth, South Shore, and Atlantic Railway about four miles west and one mile south of sec. 30, T. 42 N., R. 3 W. Some of the best exposures of the shale, which doubtless occupies a higher stratigraphic position than the strata along U. S. Highway 2, are in the ditches of the road on the south line of sec. 32, T. 42 N., R. 4 W., between Allenville and a point a third of a mile to the west.

A very small exposure of the formation is about 100 yards east of Massey's Hotel, located on the southern shore of Brevort Lake three and a half miles west of Allenville. The outcrop, which is in a path leading to a small wharf, shows six inches of green shale about two and a half feet above the lake, and an over-lying thin-bedded gray dolomite one and a half feet in thickness.

About five feet of green and red shale are exhibited in a pit at the abandoned Round Lake C.C.C. Camp located three and a half miles south of Massey's Hotel and slightly less than a quarter of a mile west of the center of sec. 23, T. 41 N., R. 5 W. (pl. IIA). Much of the shale in the pit, which is only three-fourths of a mile northeast of Pointe aux Chenes and a half mile north of U. S. Highway 2, has weathered to a clayey mass since excavation ceased about five years ago.

Slabs of thin-bedded to laminated, grayish-green, dolomitic shale are in numerous low piles that average five feet in diameter just beyond the shoulders of U. S. Highway 2 in the SE¼ sec. 23, T. 41 N., R. 5 W. (pl. IIB). The slabs of shale evidently were

A

B

PLATE II

A. Weathered green and red shale of Pte. aux Chenes formation in pit at Round Lake C.C.C. Camp.

B. Slabs of fossiliferous, dolomitic shale of Pte. aux Chenes formation beside U.S. Highway 2 in the SE¼ sec. 23, T. 41 N., R. 5 W., about 1 mile E. of Pte. aux Chenes.



picked up by a power shovel from the road bed and dumped beyond the sides of the highway. The ledges beneath the highway from which the slabs were taken probably occupy a stratigraphic position above the softer shales of the C.C.C. Camp pit.

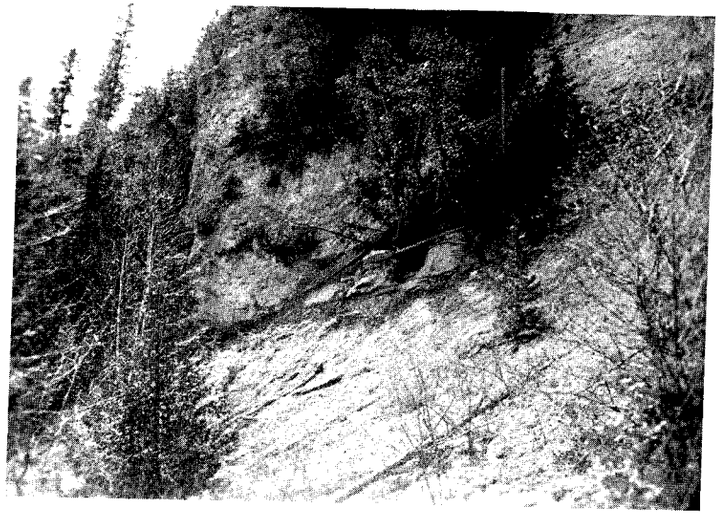
A very few irregularly shaped masses of mottled white and gray gypsum with some accompanying brownish-tinged selenite are in a pile with various kinds of rock on the south side of the highway. The gypsum was associated with some of the shale beneath the bed of the highway or was transported from some other ledge of the formation by the Pleistocene ice.

About half of a mile farther west small and large slabs of the same thin-bedded, grayish-green, dolomitic shale are on the sides of U. S. Highway 2 in the SW¼ sec. 23, approximately a third of a mile north of Pointe aux Chenes, and a few hundred yards west of a road leading northward to the C.C.C. Camp. This rock probably was derived from the highway bed at this place, but may have been hauled from the roadbed in the SE¼ sec. 23.

The slabs at both places contain *Medusaegraptus graminiformis* (Pohlman), *Lingula media* Ruedemann, *Orbiculoidea bertiensis* Ruedemann, *Whitfieldella* sp. cf. *W. subsulcata* Grabau, *Rhytimya buffaloensis* Ruedemann, *Modiolopsis* sp.—possibly new, *Leperditia scalaris* (Jones), fragments of eurypterids and excrementa of worms or other invertebrates (pls. IV, V). Most of these fossil species are characteristic of the fauna of the Bertie formation constituting the uppermost division of the Salina group of New York.

Green shale, which probably is stratigraphically higher than the dolomitic shale noted above, is at the shore of Lake Michigan in the SE¼ sec. 36, T. 41 N., R. 5 W., about two and a quarter miles southeast of Pointe aux Chenes. Slightly less than a mile to the southwest a similar shale is on the beach in the SW¼ SE¼ sec. 31, T. 41 N., R. 4 W.

Numerous pits, from which gypsum was taken many years ago, are in the SW¼ and the NW¼ SE¼ sec 31, T. 41 N., R. 4 W. These old workings probably are those noted by Alexander Winchell (1861, pp. 57-58)[10] as occurring "in the vicinity of Little Pt. aux Chene" and by Carl Rominger (1873, p. 30)[11] as having been "opened near Point aux Chenes." Many of the pits having a depth of 10 to 15 feet may be clearly recognized immediately south of U. S. Highway 2. Soil, bushes, and trees now cover the dolomite, shale, and gypsum which once must have been visible in the excavations. A few blocks of white gypsum with roughly spherical and irregular bands of brownish-tinged crystals are in



A

B

PLATE III

A. Contact of Pte. aux Chenes and St. Ignace formations in cliff at Dwightwood Spring, Mackinac Island. Contact present just below ledge of dolomite shown at center of view. Indurated breccia composes vertical cliff above and to left of dolomite.

B. Faulted strata in upper part of Pte. aux Chenes formation along U.S. Highway 2, 4 miles W. of St. Ignace. Man stands on down-thrown side of fault. Unit 1 of described section is shown above auto; unit 6 is highest, light-colored band at right side of view.



the remains of an old dump which is crossed by a path leading to the lake shore from Mr. Manville's cottage on the south side of U. S. Highway 2.

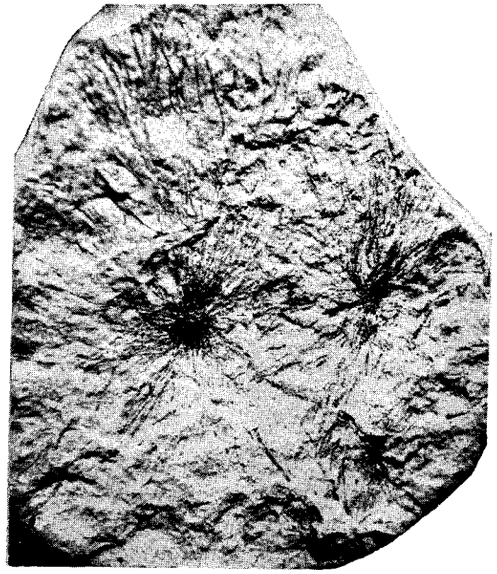
The shales at the Round Lake C.C.C. Camp, along U. S. Highway 2 and on the Lake Michigan shore, and the gypsum of the abandoned pits are in the type area of the Pointe aux Chenes formation and are characteristic of the material comprising the upper third of the formation.

Strata near the top of the formation are exposed in a cut along U. S. Highway 2 in the eastern part of the SW¼ sec. 9, T. 40 N., R. 4 W., about four miles west of the business section of St. Ignace. Their lithological character, thickness and fossils are indicated in the following description of the section.

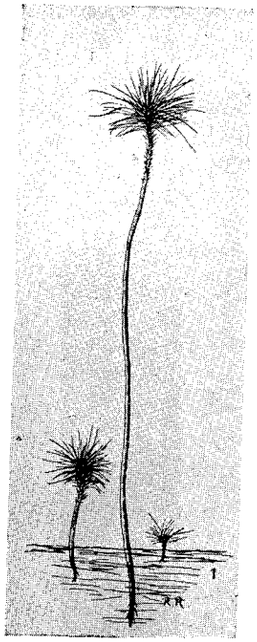
Section of strata exposed in cut along U.S. Highway 2 in eastern part of SW¼ sec. 9, T. 40 N., R. 4 W., about four miles west of St. Ignace

| | Thickness Feet | Inches |
|---|---|---|
| Pointe aux Chenes formation: | | |
| 6. Shale, slightly calcareous, light-green, weathering into angular fragments | 9 | |
| 5. Dolomite, light-gray to light brownish gray, thin- and even-bedded, with few specimens of *Leperditia alta* (Conrad) var. near base | 2 | 8 |
| 4. Dolomite, brown, uneven-bedded, and in layers one-half to two inches in thickness, with numerous veinlets of calcite in irregular fractures and well-developed crystals of calcite along joints; *Leperditia alta* (Conrad) var. present in some layers | 11 | |
| 3. Dolomite, brown, uneven-bedded, weathering into layers about six inches in thickness with numerous veinlets of calcite in irregular fractures and well-developed crystals of calcite along joints | 2 | |
| 2. Shale, dolomitic, greenish-gray to buff greenish gray, very thin-bedded to fissile, with minute crystals of gypsum abundant in some layers. Rock contains many specimens of *Leperditia scalaris* (Jones) and *Modiolopsis* sp.—close to *M. dubius* (Hall) and less numerous remains of *Lingula media* Ruedemann, *Whitfieldella* sp. cf. *W. subsulcata* Grabau, *Modiolopsis* sp. — possibly new, and fragments of eurypterids. Fossils more abundant in upper part of unit than in lower part | 1 | 4 |
| 1. Shale, slightly calcareous, dark bluish gray when wet and greenish-gray when dry. Uppermost three feet exposed by digging; remainder of unit covered with weathered shale and with little doubt consisting of the same type of shale | 7–8 | |
| Total | 34–35 | |

The beds noted in the section are in a faulted block on the north side of the road and at the eastern end of the cut (see Pl. IIIB). About 15 feet of green and red shale with some very thin layers

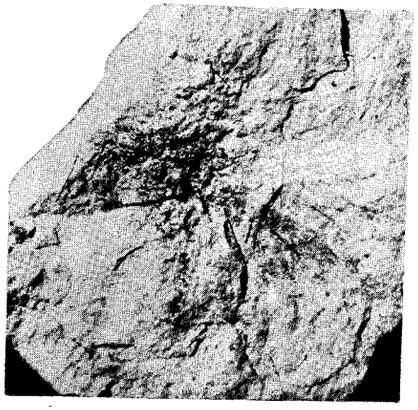


1



4

2



3

PLATE IV



## EXPLANATION OF PLATE IV

Fossils of Pte. aux Chenes formation

*Medusaegraptus graminiformis* (Pohlman)

1. Slab showing several "heads" with numerous, crowded, extremely fine, unbranched filaments, believed to be thecal tubes. Figured specimen (No. 23563, X 3). U.S. Highway 2, SE¼ sec. 23, T. 41 N., R. 5 W., 7 miles northwest of St. Ignace.
2. Slab showing a "head" with a part of the stipe just below the "head". Figured specimen (No. 23564, X 3). U.S. Highway 2, SW¼ sec. 23, T. 41 N., R. 5 W., 7½ miles northwest of St. Ignace.
3. Slab showing part of a rhabdosome with thread-like thecae of "head" and part of stipe below "head". Figured specimen (No. 23565, X 3). U.S. Highway 2, SE¼ sec. 23, T. 41 N., R. 5 W., 7 miles northwest of St. Ignace.
4. Restoration of three complete rhabdosomes. X ½. After Rudolf Ruedemann.

All fossils illustrated in this report have been placed in the collection of the Museum of Paleontology of the University of Michigan and catalogued under the numbers given in the explanations of plates.

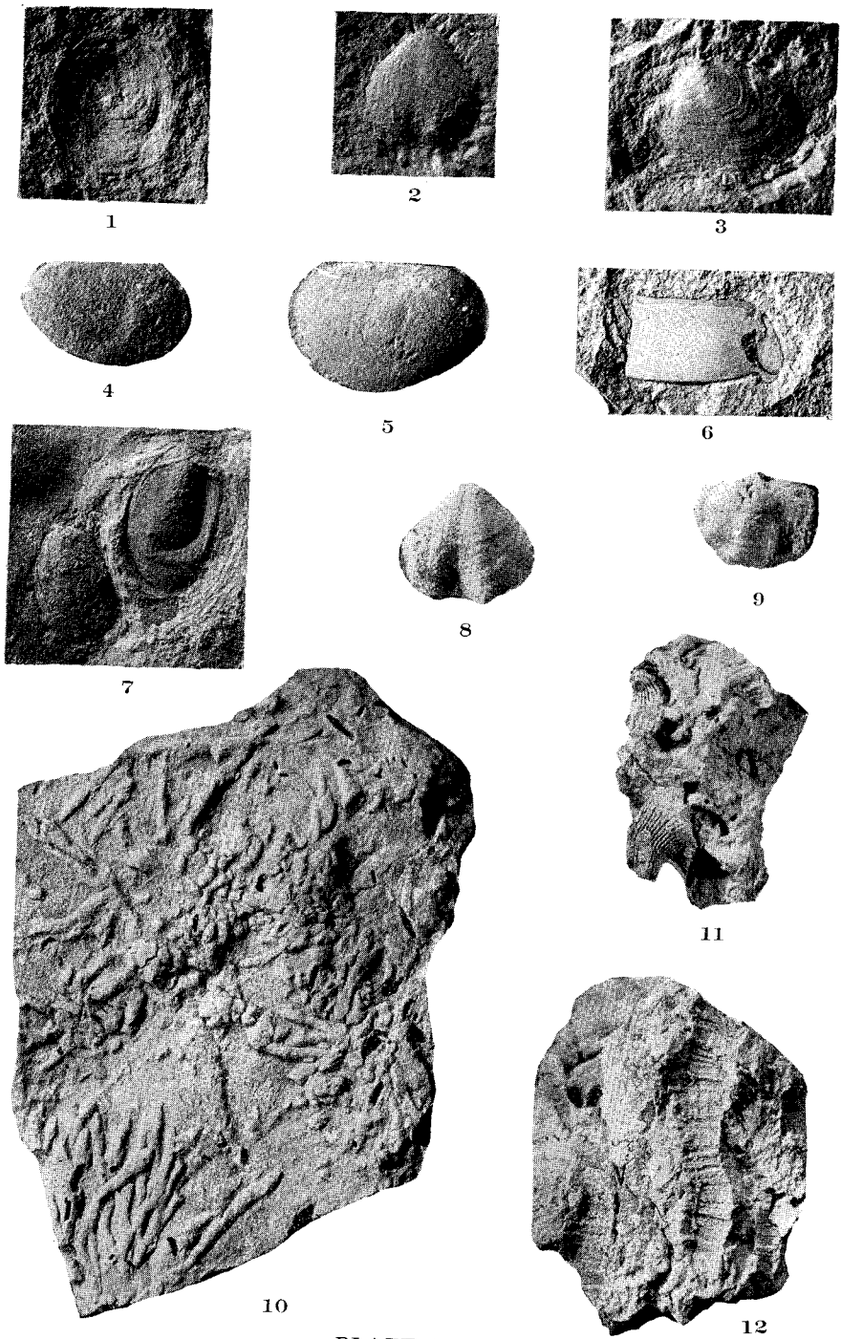


PLATE V



## EXPLANATION OF PLATE V

Fossils of Pte. aux Chenes and St. Ignace formations

*Orbiculoidea bertiensis* Ruedemann.

1. Dorsal valve. Figured specimen (No. 23566, X 3). Slab from Pte. aux Chenes formation beside U.S. Highway 2, SW¼ sec. 23, T. 41 N., R. 5 W., 7½ miles northwest of St. Ignace.

*Whitfieldella* sp. cf. *W. subsulcata* Grabau.

2. Mold of ventral valve. Figured specimen (No. 23567, X 2). Pte. aux Chenes formation beside U.S. Highway 2, SE¼ sec. 23, T. 41 N., R. 5 W., 7 miles northwest of St. Ignace.

*Rhytimya buffaloensis* Ruedemann.

3. Mold of left valve. Figured specimen (No. 23568, X 2). Same formation and locality as figure 2.

*Leperditia scalaris* (Jones)

4. Mold of left valve. Figured specimen (No. 23569, X 2). Pte. aux Chenes formation, unit 2 of section exposed in cut of U.S. Highway 2, SW¼ sec. 9, T. 40 N., R. 4 W., about 4 miles west of St. Ignace.
5. Mold of right valve. Figured specimen (No. 23570, X 2). Same stratum and locality as figure 4.

*Eurypterid*

6. One-half of a sternite. Figured specimen (No. 23571, X 1). Pte. aux Chenes formation, U.S. Highway 2, SW¼ sec. 23, T. 41 N., R. 5 W., 7½ miles northwest of St. Ignace.

*Lingula media* Ruedemann.

7. Two almost completely exfoliated valves. Figured specimens (No. 23572, X 2). Same bed and locality as figure 4.

*Spirifer (Delthyris)* sp. aff. *S. (D.) corallinensis* (Grabau)

8. Ventral valve. Figured specimen (No. 23573, X 3). Block from upper part of St. Ignace formation, enclosed in Mackinac breccia. About 500 feet west of Arch Rock on Arch Rock—Sugar Loaf road, Mackinac Island.
9. Dorsal valve. Figured specimen (No. 23574, X 3). Detached block from upper part of St. Ignace formation, probably unit 2 of section at northwest end of Hombach quarry, St. Ignace.

*Sphaerococcites? glomeratus* Grabau.

10. Slab with several specimens, doubtfully identified as algae. Figured specimen (No. 23575, X 1). St. Ignace formation, detached slab from unit 3 of section exposed in approach to proposed ferry terminal, 1 mile southwest of St. Ignace.

*"Cyathophyllum" hydraulicum* (Simpson Ms.) Grabau.

11. Molds of two calices shown at lower and upper left corners of figure. Figured specimen (No. 23576, X 1). Same stratigraphic position and locality as figure 8.
12. Molds of exteriors of corallites. Figured specimen (No. 23577, X 1). Highest bed of St. Ignace formation exposed at southeast end of Hombach quarry, St. Ignace.

and lenses of gray, fine-grained dolomite are exposed in another faulted block approximately 100 feet to the west. These strata apparently belong to unit 6, which elsewhere has a maximum thickness of 18½ feet, but may occupy a position below the shale of unit 1.

Rocks of the highway cut are shown at other places in the area. The shale of unit 6 crops out in the SE¼ sec 8, T. 40 N., R. 4 W., beside a little-used wagon road which ascends a cliff from a point an eighth of a mile northeast of the Catholic Church at Gros Cap village to U. S. Highway 2. At this place the shale is 18 feet thick and the uppermost one to two feet is greenish-buff, thus differing from the underlying part, which is green. It is underlain by two feet of dolomite of unit 5 exposed in the road ditch, and is overlain by 22 feet and seven inches of St. Ignace strata. Parts of units 1 to 6 that are faulted are poorly exposed in the eastern part of the NW¼ sec. 9, T. 40 N., R. 4 W., along a private road just east of Dr. Stewart's home. The beds of units 1 to 6 are recognizable also in several faulted blocks in a cut on U. S. Highway 2 near the center of the NW¼ sec 15, T. 40 N., R. 4 W. The upper layers of unit 5 are at the level of U. S. Highway 2 about 125 feet south of Mr. C. C. Eby's gift shop at Castle Rock three miles north of St. Ignace. Directly west of this outcrop, weathered green shale of unit 6 is exposed in patches along a road being built by Mr. Eby to provide automobile transportation to a point near the top of Castle Rock. A short distance south of the outcrop of unit 5, the much weathered shale of unit 6 is visible in low cuts on the west side of Highway 2.

A particularly fine exposure of the rocks in the upper part of the Pointe aux Chenes formation and the contact of this formation with the St. Ignace strata may be seen in a cliff just south of Dwightwood Spring on the east side of Mackinac Island (see pl. IIIA). In the following description of the section shown in the cliff, the rocks noted as units 1, 2, and 3 are the eastward continuation of units 4, 5, and 6 of the cut along U. S. Highway 2 about four miles west of St. Ignace.



Section of strata exposed in cliff just south of Dwightwood Spring on east side of Mackinac Island

| | Thickness Feet | Thickness Inches |
|---|---|---|
| St. Ignace formation: | | |
| 11. Dolomite, light-gray to light-buff, even-bedded; beds fractured and locally much brecciated | 24± | |
| 10. Shale, greenish-gray, hard, undoubtedly compressed in the course of regional brecciation | 0 | 10 |
| 9. Dolomite, buff-gray with some streaks of light buff gray, brecciated; fractured condition possibly due in part to sub-marine gliding and in part to regional brecciation | 1 | |
| 8. Dolomite, light-buff, fine grained, with few calcite crystals; weathers into layers 1 to 6 inches in thickness | 1 | 6 |
| 7. Dolomite, light-buff, very fine grained, massive, with numerous particles of calcite in rounded cavities 1/32 to 1/16 inch in diameter; much fractured, with fractures occupied by calcite | 1 | 8 |
| 6. Dolomite, light-buff, very fine grained with few rounded cavities having diameters of 1/32 to 1/16 inch and fillings of calcite; brecciated and cut with calcite-filled fractures | 3 | 6 |
| Total | 32± | 6 |

| | Thickness Feet | Thickness Inches |
|---|---|---|
| Pointe aux Chenes formation: | | |
| 5. Shale, buff, fairly hard | 4 | |
| 4. Shale, calcareous, greenish, with few calcareous grains, about 1/32 inch in diameter | 1 | |
| 3. Shale, light-green, with few bands of red; upper part bluish-green, difference in color possibly due to greater moisture content | 18 | 6 |
| 2. Dolomite, light buff gray to light-buff, thin- and even bedded | 2 | 6 |
| 1. Dolomite, brown, uneven-bedded and in layers a half to two inches in thickness, with many irregular veinlets of calcite and well developed crystals of calcite in cavities and along joints; *Leperditia alta* (Conrad) var. numerous in some layers. Base of unit is about 30 feet from carriage road along shore of island and 22 feet above Lake Huron | 8 | 6 |
| Total | 34 | 6 |

So far as known, the shale of units 4 and 5 are not well exposed elsewhere in the Mackinac Straits area. However, a part of unit 5 may be represented by the greenish-buff shale at the top of the 18 feet of green shale that crops out along the cliff road near the Catholic Church at Gros Cap village. The removal of a considerable covering of talus at this cliff road outcrop may reveal

unit 4 and all of unit 5 of the section at Dwightwood Spring, Mackinac Island. The contact between the Pointe aux Chenes and St. Ignace formations in the cliff at Dwightwood Spring shows no evidence of a period of erosion; the formations seem to be conformable.

About 800 feet north of Dwightwood Spring and 200 feet north of the base of Arch Rock, the beds of units 1, 2, and 3 of the Dwightwood Spring section are exposed below a copious spring which issues from, or from a short distance above, the contact of the Pointe aux Chenes and St. Ignace formations.

Green shale and buff dolomite are in a narrow bench beneath the lake from a point a few hundred feet south of Dwightwood Spring to a point approximately a half mile to the north. These strata, which may be seen best from the top of Arch Rock, are displaced blocks of rock of units 1, 2, and 3 to the Dwightwood Spring section, or occupy a position below the dolomite of unit one of this section.

Green shale, which probably occupies a lower stratigraphic position than the lowest rocks of the Dwightwood Spring section and the shale and dolomite of the shelf beneath the lake, constitute small areas of the lake bottom adjacent to the north end of Mackinac Island.

Brecciated green shale and dolomite of intervals 1, 2, and 3 of the Dwightwood Spring section are beside the road on the west side of Mackinac Island about a half mile south of British Landing.

The Pointe aux Chenes formation doubtless contains several beds of gypsum which are not shown in outcrop. Rominger (1873, p. 30)[11] reported the occurrence of "extensive patches of snow-white gypsum . . . . at the depth of eight to ten feet" in the bottom of Lake Huron adjacent to Goose Island, located nine and a half miles northeast of Mackinac Island. The "extensive patches" noted by Rominger may well indicate the existence of a distinct bed of gypsum rather than irregular masses of this mineral. Possibly two beds of gypsum were penetrated in a well drilled about two miles north of the business section of St. Ignace in sec. 31, T. 41 N., R. 3 W. In the record of this well the location of which is erroneously given as R. 1 W., instead of R. 3 W., A. C. Lane (1902, pp. 227-228)[23] noted the occurrence of 13 and 5 feet of gypsum at respective depths of 174 to 187 feet and 255 to 260 feet below the surface. In the record Lane also recorded the presence of "blue



shale with gypsum" and a "gypsiferous dolomite." He assigned the gypsum, gypsum-bearing strata and associated red and blue shales and dolomites to the Monroe formation.

Although no beds of salt have been found in outcrop or in the few deep wells of the area, it is of interest to note that salt water and a vein of salt were recorded by A. C. Lane (1895, pl. 63)[14] in the record of the Mackinac Lumber Company well at St. Ignace. In the record the salt water and vein and associated red and blue shales are assigned to the "Monroe, i. e. Lower Helderberg and Salina," whereas they are now assigned to the Pointe aux Chenes formation of this report.

THICKNESS: The thickness of the Pointe aux Chenes formation is indicated by the records of deep wells, which unfortunately are few in number and lacking in detail. Information gained from these records show that the thickness of the formation on the St. Ignace Peninsula is between 500 and 600 feet.

STRATIGRAPHIC RELATIONSHIP: The slabs of grayish-green dolomitic shale along U. S. Highway 2 at points a third of a mile north and nearly one mile northeast of Pointe aux Chenes, contain an assemblage of fossil species, which is indicative of the Upper Salina Bertie formation of New York and Ontario. The ledges from which these slabs were taken during the course of construction of the highway occupy a position in the upper third of the Pointe aux Chenes formation.

The dolomitic shale of unit 2 of the section exposed in the cut of U. S. Highway 2 about four miles west of St. Ignace has *Lingula media* Ruedemann, *Whitfieldella* sp. of *W. subsulcata* Grabau, *Modiolopsis* sp. close to *M. dubius* Hall and *Leperditia scalaris* (Jones), which suggest the fauna of the Bertie formation. The dolomites of units 4 and 5 of this section have a variation of *Leperditia alta* (Conrad), a species also reported in this formation. The strata of units 2, 4, and 5 are in the upper part of the Pointe aux Chenes formation, the base of unit 2 being 35 feet below its top.

Although the upper third of the Pointe aux Chenes formation can be correlated with Bertie, the stratigraphic relationship of the rest of the formation is unknown. However, the possible relationships of the lower two-thirds of the formation may be indicated by a comparison of the Salina strata of the Mackinac Straits area with the Salina of New York and Ontario. In a relatively recent paper dealing with the correlation of the Silurian formations of North America by C. K. Swartz and others (1942, pp. 533-538, ch. 3)[34] the Salina group of western New York is described as being

composed of five divisions, in ascending order as follows: The Pittsford shale, Vernon shale, Syracuse salt, Camillus shale, and Bertie waterlime. The Pittsford shale, which, with the higher divisions of the Salina group, has been described in detail by Winifred Goldring (1931, pp. 336-341)[36] and by D. H. Newland (1929, pp. 38-45)[37] is a thin formation having a lithology unlike any known Pointe aux Chenes strata. Although thin in New York and not reported in southwestern Ontario, the Pittsford shale may be represented by strata of equivalent age in the thick section of the Salina group of Michigan. The Vernon shale thins to the west of Syracuse, New York, where it has a thickness of 500 feet and its color changes from a deep red to green with some red. So far as known, the Vernon shale is not reported in Ontario. As the lithology of many of the Pointe aux Chenes shales is similar, some may prove to be of Vernon age. The Syracuse salt, according to Newland (1929, pp. 39-40)[7], does not represent a "horizon but a zone . . . . in which from one to five or six beds of salt occur at various levels associated with limestone, limey shale and some anhydrite." In the opinion of Newland (1929, pp. 40, 43)[7] the Syracuse salt or salt zone constitutes the lower part of the Camillus shale. The part of the Camillus above the salt zone consists of shale, thin magnesian and argillaceous limestones, gypsum, and anhydrite. The Camillus with beds of salt which probably represent the Syracuse salt zone, have been recognized in a few outcrops and many deep wells in Ontario by M. Y. Williams (1919, pp. 83-84).[21] Since the Camillus strata have been traced in deep borings to the borders of Michigan, it seems very likely that these beds may be present in the very thick Salina section of this State. The writers believe that salt beds of possible Camillus-Syracuse age were in the lower part of the Pointe aux Chenes but were leached out in the Straits area prior to the deposition of the Middle Devonian Dundee limestone.

From these criteria it seems probable that at least the upper third of the Pointe aux Chenes is a correlate of the Bertie formation and that its lower two-thirds may contain strata equivalent in age to New York Salina beds below the Bertie. A final decision in regard to the stratigraphic relationships of the lower Pointe aux Chenes beds awaits the finding of more fossils and a study of carefully taken samples from more deep borings.

[36]Goldring, Winifred, Handbook of paleontology for beginners and amateurs, pt. 2. New York State Museum Handbook 10, pp. 336-341, 384, 1931.
[37]Newland, D. H., The gypsum resources and gypsum industry of New York, New York State Mus. Bull. No. 283, pp. 38-45, 1929.



## ST. IGNACE FORMATION

NOMENCLATURE: The name St. Ignace is proposed for the youngest known Upper Silurian formation of the Northern Peninsula. It is chosen because large segments of this stratigraphic unit are well shown in an extensive breccia, the Mackinac breccia, of the St. Ignace area.

DISTRIBUTION: On the St. Ignace Peninsula and Mackinac Island the formation is represented by large masses of strata within the Mackinac breccia. Because it is impossible to delineate the boundaries of these masses as well as those of huge blocks of Devonian rocks also in this breccia, the St. Ignace deposits of these two places have been mapped with the Mackinac breccia (see map in pocket).

South of an east-west line passing between Mackinac and Round Islands and just north of Garden Island in Lake Michigan, the St. Ignace rocks have not been greatly displaced by brecciation and as a consequence their areal distribution can be recognized (see map). All of Round Island and the northern part of Bois Blanc Island, which are southwest of Mackinac Island, are underlain by St. Ignace deposits. The northern part of Garden Island, located in Lake Michigan about 35 miles west of St. Ignace, and all of Squaw and Whiskey Islands a few miles west of Garden Island have St. Ignace strata at or near the surface.

LITHOLOGIC AND PALEONTOLOGIC CHARACTERS: The formation, except for the upper part, consists of even-bedded, very light gray, cream-colored, and light-buff dolomites. Some of the dolomites contain slit-like gashes, probably resulting from the solution of celestite; and others, numerous small spherical cavities which originally may have been occupied by salt. Many beds exhibit both gashes and spherical cavities. Crystalline calcite and dolomite occupy the gashes and spherical cavities of some layers. Bluish to greenish-gray shale, in beds ranging from a few inches to a few feet in thickness, are an inconspicuous part of the formation. The upper part of the St. Ignace consists of thick-bedded buff dolomites overlying thick-bedded light-gray dolomites. Some of the buff dolomites are oolitic and present a sugary appearance on weathering. Some beds of both light-gray and buff dolomites contain frosted grains of quartz. The grains are larger and more abundant in the buff dolomites near the top of the formation than in lower beds. In the following paragraphs the descriptions of

certain outcrops will give more detailed information in regard to the lithology, super-position, and fossil content of the St. Ignace strata.

A section of the beds in the lower part of the formation is shown clearly along the little used wagon-road which ascends the cliff near the Catholic church at Gros Cap village about five miles west of the business district of St. Ignace.

Section of strata exposed beside the little used wagon road ascending the cliff from a point one-eighth of a mile northeast of the Catholic church at Gros Cap village to U.S. Highway 2

| | Thickness Feet | Inches |
|---|---|---|
| St. Ignace formation: | | |
| 9. Dolomite, light-buff to cream-colored and massive, containing minute spherical cavities and slit-like gashes | 1 | 3 |
| 8. Dolomite, cream-colored to buff and fine-grained, with an earthy feel | 3 | 9 |
| 7. Dolomite, very light buff to cream-colored, laminated and very fine grained, having an earthy feel; minute folds in laminae apparently due to submarine gliding; splits into layers an eighth to a half inch in thickness | 3 | 6 |
| 6. Dolomite, grading from light buff at top to buff at base, finely crystalline and gashed, gashes especially abundant near base; weathered surface buff, having earthy feel, and showing uneven-bedding | 2 | |
| 5. Dolomite, gray, and very fine grained, having numerous closely spaced joints and splitting into layers a fourth to a half inch in thickness; weathered surface bluish-gray; on weathering rock breaks into angular fragments | 2 | 6 |
| 4. Shale, buff-gray with greenish tinge | 4 | 7 |
| 3. Dolomite, light-buff to cream-colored, thick-bedded and with earthy feel | 5 | |
| Total | 22 | 7 |
| Pointe aux Chenes formation: | | |
| 2. Shale, green, except for greenish-buff in upper-most one to two feet, and red at base, with few layers or lenses of argillaceous dolomite two inches in thickness | 18 | |
| 1. Dolomite, light-gray to light brownish gray, exposed in ditch beside road | 2 | |
| Total | 20 | |

In the description of the stratigraphic section given above, 22 feet and seven inches of dolomite with little shale rest conformably on shale of the Pointe aux Chenes formation. A similar exposure of St. Ignace strata in contact with Pointe aux Chenes shale is shown in the cliff near Dwightwood Spring on Mackinac Island.



Either of these exposures may serve as a type section for beds in the lower part of the St. Ignace formation. The cliff at Dwightwood spring exhibits about 10 more feet of strata than the cliff near the Gros Cap church, but at least the upper 20 feet of rock at Dwightwood Spring are in a vertical cliff and inaccessible for close examination.

The exact succession of strata between the beds of the cliff near the Gros Cap church and Dwightwood Spring and rocks composing the upper part of the formation is not known. This lack of information is due to the fact that the super-position of the beds must be determined from blocks of the formation within the breccia of the area instead of from more extensive exposures of undisturbed strata. Any attempt to correlate the rocks of these blocks is very difficult because the various beds show few lithologic differences and are almost lacking in fossils which might serve as stratigraphic guide-markers. Fortunately, the approximate positions of sections of strata in the middle part of the formation were recognized in the course of the field study; these positions and the lithology of the rocks composing the sections are discussed in the following paragraphs.

Strata which probably occupy a position not far above the highest beds of the cliffs near the Gros Cap church and Dwightwood Spring are shown in the ditches along Church Street on the western boundary of the St. Ignace State Park.

Section of strata exposed in ditches along Church Street, St. Ignace between its intersection with Graham Street and a road entering St. Ignace State Park from the west

| | Thickness Feet | Inches |
|---|---|---|
| St. Ignace formation: | | |
| 5. Dolomite, light grayish buff to cream-colored, with some small slit-like gashes and numerous specimens of *Leperditia* sp. aff. *L. jonesi* Hall and *L. ohioensis* Bassler; on weathering breaks into layers an eighth to a half inch in thickness. Elevation of base of unit—638 feet | 0 | 10 |
| 4. Shale, dolomitic, gray, fissile | 2 | |
| 3. Dolomite, light-buff, weathering to dark-buff | 1 | |
| 2. Covered | 16 | |
| 1. Dolomite, light buff gray to buff, with gashes and many fractures filled with calcite crystals | 2 | 6 |
| Total | 22 | 4 |

Unit 1 is exposed in the ditch on the west side of Church Street just north of its intersection with Graham Street. Units 3, 4, and 5 are present in the ditch on the east side of Church Street at its juncture with the State Park road.

The dolomite of unit 5 with its numerous *Leperditia* may prove to be a stratigraphic marker and be helpful in the recognition of the super-position of the rocks of the middle part of the formation if it can be found in several outcrops. A special effort to locate this ostracodal dolomite should be made in any future attempt to determine the rock succession.

Numerous blocks of light-buff to cream-colored, fine-grained dolomite, containing numerous examples of the species of *Leperditia* found in unit 5, are along the shore of Lake Michigan about two and one-half miles west of the Church Street outcrop and about three-quarters of a mile northwest of Pte. la Barbe. Apparently the blocks were brought to the shore by storm waves and moving lake ice from a ledge which is now covered by the high water of the lake.

The *Leperditia*-bearing ledge, which has an elevation of only a few feet less than 581 feet, (the aproximate level of Lake Michigan during the summer of 1943) and unit 5 of the Church Street section, which has an elevation of 638 feet, very likely are part of the same stratum. The difference in elevation is due to the dropping of the segment of the formation containing the ostracodal layer northwest of Pte. la Barbe to a lower position than the level of the formation containing this layer along Church Street. Such differences in the elevation of beds of the formation, which were brought about by the collapse of the strata of the region, are of widespread occurrence and unless recognized may result in erroneous conclusions regarding the succession of the rocks of the St. Ignace formation.

Beds, which probably occupy a position not far above unit 5 of the Church Street section, are shown in a large block within a breccia exposed in the walls of the approach to the causeway intended for use as a ferry terminal about one mile southwest of the business district of St. Ignace and approximately a third of a mile west of the outcrop on Church Street. The beds of the block noted as units 3 to 11 in the following description are best exhibited in the east wall of the causeway approach and are illustrated in plate VI, B. The strata of units 1 and 2 can be seen by trenching beneath the base of unit 3 where it appears in the west wall.

A

B

PLATE VI

A. Ledge of dolomite near top of St. Ignace formation. Cherty dolomite of Bois Blanc formation occupies hill above ledge. Eastern part of NW¼ sec. 9, T. 40 N., R. 4 W., about 4 miles W. of St. Ignace.

B. Dolomite and shale of St. Ignace formation in east wall of approach to proposed ferry terminal, 1 mile west of St. Ignace. Units 3 to 11 of described section shown in illustration.

Section of strata of a large block of rock within a breccia exposed in the walls of the approach to a causeway intended for use as a ferry terminal, about 1 mile southwest of the business district of St. Ignace

| | Thickness Feet | Inches |
|---|---|---|
| St. Ignace formation: | | |
| 11. Dolomite, very light buff gray except for a few light-buff beds; upper 3 to 4 feet splits into layers about a quarter of an inch in thickness | 7 | 6 |
| 10. Shale, calcareous, buff | 1 | 4 |
| 9. Dolomite, light buff gray, finely crystalline, weathered surface white; lowest 6 inches with thin bands of secondary calcite | 2 | |
| 8. Dolomite, light buff gray, with few spherical cavities about a thirty-second of an inch in diameter and some dessication fissures; on weathering rock breaks into layers a quarter to a half inch in thickness and becomes brown at surface | 1 | 3 |
| 7. Shale, dark brownish gray, weathering into small angular fragments | 1 | 6 |
| 6. Dolomite, buff, even-bedded, in layers 1 to 3 inches in thickness, weathered surfaces brown; very thin seams of secondary calcite on bedding planes | 2 | 4 |
| 5. Dolomite, light-buff to buff, finely crystalline; some joints a half an inch in diameter, filled with breccia having calcareous brown matrix and some angular fragments of very light-gray dolomite | 3 | |
| 4. Shale, calcareous, bluish-gray, with some layers of buff limestone averaging 2 inches in thickness | 3 | 6 |
| 3. Dolomite, ranging from light-gray to light buff gray, finely crystalline, even-bedded in layers 2 to 15 inches in thickness; some beds with spherical cavities a thirty-second to a sixteenth of an inch in diameter, others with slit-like gashes a quarter to a half inch in length, resulting from solution of tabular crystals of celestite or other unknown mineral | 14 | |
| 2. Dolomite, argillaceous, dark bluish gray, uneven-bedded, breaking into angular fragments | 2 | 6 |
| 1. Dolomite, light-gray to cream-colored, with talcose feel. Elevation to base of unit 630 feet | 6 | 6 |
| Total | 45 | 5 |

Numerous other blocks showing most of the strata described above are exhibited in the breccia composing the vertical walls of the approach to the causeway. Separating some of these blocks are large masses of higher St. Ignace and lower Bois Blanc beds. These occurrences are discussed in the section of this report dealing with the Mackinac breccia.

In the course of the field work it seemed likely that the *Leperditia* of unit 5 of the Church Street section would be found in the strata of the causeway approach. This expectation was founded on the fact that the base of unit 3 has almost the same elevation



as unit 5 of the Church Street section and the probability that these units originally were on the same line of strike. Failure to find a single valve of *Leperditia* illustrates again that large segments of the St. Ignace formation have dropped different distances during the course of brecciation of the strata.

The writers believe that the beds in the block of the causeway approach occupy a position above unit 5 of the Church Street section. This belief is suggested by the occurrence of dolomites like those of the block in small exposures in the bed of Church Street within a few hundred yards north of the exposure of unit 5. The small exposures are in a rise of the street, the highest outcrop reaching an elevation of nearly 50 feet above the top of unit 5. Even though the elevations indicate that the beds of the causeway approach are above the *Leperditia*-bearing dolomite of unit 5, it must be recognized that this apparent stratigraphic relationship may have been brought about by the unequal dropping of segments of the St. Ignace formation at the time of regional brecciation.

Several exposures of strata, which are in large breccia blocks and apparently occupy positions in the middle part of the St. Ignace formation, are worth noting because they ultimately may supply information leading to the determination of the exact stratigraphic succession. One of these exposures is above an abandoned lime-kiln on the south side of Rabbits Back ridge about four miles north of St. Ignace. The lithological character of the rocks of this outcrop is given in the following description:

Section of strata shown above abandoned lime kiln on south side of narrow ridge about an eighth of a mile southeast of highest point on Rabbits Back, about four miles north of St. Ignace

| | Thickness Feet | Inches |
|---|---|---|
| St. Ignace formation: | | |
| 3. Covered—pieces of rock on surface are similar in lithology to strata of unit 2 and suggest that unit 3 may be composed of such material | 5 | |
| 2. Dolomite, cream-colored, and very fine grained, weathering into layers a fourth to one inch in thickness; on extensive weathering breaks into small angular chips | 14 | |
| 1. Dolomite, light-buff, very fine grained and thin-bedded; exposed by digging | 1 | 2 |
| Total | 20 | 2 |

A small though interesting outcrop is exhibited a short distance west of the Michigan State Police Substation in St. Ignace.

Section of strata shown in contact with indurated breccia of small hill about 200 feet west of the Michigan State Police Substation at St. Ignace

| | Thickness Feet | Inches |
|---|---|---|
| St. Ignace formation: | | |
| 5. Calcite, buff-gray and crystalline, evidently deposited from waters which had passed through adjacent breccia | | 2 |
| 4. Dolomite, light-gray and laminated | 1 | 6 |
| 3. Calcite, like unit 5 and similar in origin | | 2–6 |
| 2. Dolomite, light-buff gray to cream-colored and laminated; some layers brecciated | 8 | |
| 1. Dolomite, brown, massive but showing layers 1 inch in thickness on weathered surface | 1 | |
| Total | 10 | 10–14 |

The calcite of units 3 and 5, although a part of the section, is not of St. Ignace age; it was deposited after the brecciation of the rocks of the region.

The dolomites of this section are very similar in their lithology to those above the abandoned lime-kiln on the south side of Rabbits Back Ridge and may occupy about the same position in the formation. Their occurrence in a block within an indurated breccia is strikingly exhibited. A third small outcrop is a knoll several hundred yards southwest of the summer home of Dr. Kirk Stewart in the NW¼ sec. 9, T. 40 N., R. 4 W., about four miles west of St. Ignace. The lithological character of the beds at this place, which will be the site of a caretaker's house, is given in the following description of the section:

Section of strata on knoll several hundred yards southwest of Dr. Kirk Stewart's home in the NW¼, sec. 9, T. 40 N., R. 4 W., about 4 miles west of St. Ignace

| | Thickness Feet | Inches |
|---|---|---|
| St. Ignace formation: | | |
| 3. Dolomite, similar to unit 1, except that some layers become brown on weathering | 5 | 6 |
| 2. Shale or shaly dolomite, greenish-gray | 1 | 6 |
| 1. Dolomite, light-gray and laminated, with slit-like gashes, earthy feel and conchoidal fracture | 3 | |
| Total | 10 | |

Evidence that this section of strata exists as a block within a breccia is shown by outcrops of indurated and non-indurated breccia in the woods covering most of the knoll.

Beds which are higher in the formation are exhibited in a large block of westward-tilted strata adjacent to the indurated breccia



of Castle Rock. The lowest of these beds, which are described below, is in contact with the breccia beneath a board walk near the top of Castle Rock; successively higher strata are shown in a ridge extending westward from Castle Rock.

Section of strata exposed in a large block of westward-tilted strata adjacent to the indurated breccia of Castle Rock, three miles north of St. Ignace

| | Thickness Feet | Inches |
|---|---|---|
| St. Ignace formation: | | |
| 20. Dolomite, buff-gray to buff, with slit-like gashes | 0 | 11 |
| 19. Dolomite, light-gray, very fine grained, with slit-like gashes | 0 | 10 |
| 18. Shale, dolomitic, greenish-buff | 1 | |
| 17. Dolomite, light-gray, very fine grained with very small gashes and earthy feel | 1 | 5 |
| 16. Covered | 5–6 | |
| 15. Dolomite, similar to unit 14 but with very few gashes and cavities; laminations on weathered surfaces | 2 | 6 |
| 14. Dolomite, gray to light buff gray with spherical cavities and slit-like gashes coated with yellowish substance; spherical cavities more abundant in lower half | 2 | 6 |
| 13. Shale, dolomitic, greenish-buff, with some layers hard and more dolomitic than others; basal two inches red | 2 | 6 |
| 12. Dolomite, cream-colored, fine-grained, with large gashes; thick-bedded, upper one foot with laminae on weathered surfaces | 5 | |
| 11. Dolomite, gray, fine-grained, with few slit-like gashes and earthy feel; laminae on weathered surfaces | 1 | |
| 10. Dolomite, gray to buff-gray, with spherical cavities and slit-like gashes coated with yellowish substance | 2 | 4 |
| 9. Shale, gray, compressed at time of regional brecciation | 0 | 6 |
| 8. Dolomite, gray, very fine grained | 2 | |
| 7. Shale, gray, compressed at time of regional brecciation | 0 | 2 |
| 6. Dolomite, gray, very fine grained, with *Leperditia* sp. one foot above base | 2 | |
| 5. Shale, brownish-gray, with many angular fragments of gray dolomite; fragmentation due to regional brecciation | 0 | 6 |
| 4. Dolomite, very light buff gray, very fine grained with few slit-like gashes and earthy feel; thin-bedded with laminae on weathered surfaces; weathers into angular fragments | 1 | 10 |
| 3. Dolomite, darker gray than unit 2, with numerous spherical and small tabular cavities coated with yellowish substance; buff-gray on weathering | 0 | 10 |
| 2. Dolomite, light-gray, very fine grained, with earthy feel, and laminae on weathered surfaces | 1 | |
| 1. Shale, greenish-buff, exposed by digging | 4 | 7 |
| Total | 38–39 | 5 |