POSSIBILITY OF DETERMINING RESTRICTED REEF CONDITIONS FROM THE AREAL DISTRIBUTION OF THE WIDELY DISTRIBUTED CONTEMPORANEOUS DETRITAL AND LAGUNAL FACIES

Thesis for the Degree of M. S.

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Cornelius Simon Verhoeven

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THESIS

This is to certify that the

thesis entitled

"Possibilities of Determining Restricted Reef Conditions from the Areal Distribution of Widely Distributed Contemporaneous Detrital and Lagunal Facies"
presented by

Cornelius S. Verhoeven

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W. A. Kelly
Major professor

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POSSIBILITY OF DETERMINING RESTRICTED REEF CONDITIONS FROM THE AREAL DISTRIBUTION OF THE WIDELY DISTRIBUTED CONTEMPORANEOUS DETRITAL AND LAGUNAL FACIES

By

Cornelius Simon Verhoeven

A THESIS

Submitted to the School of Graduate Studies of Michigan State College of Agriculture and Applied Science in partial fulfillment of the requirements for the degree of

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INTRODUCTION

NATURE OF THE PROBLEM

This thesis is a report of field studies and laboratory examination of the formations of the Traverse Group of the middle Devonian in western Presque Isle county, Michigan. The purpose of the study was to determine the areal distribution of the various formations and to map and attempt an explanation of the structures present. The identification of the Traverse formations was made almost entirely on lithologic characteristics. Faunal zones were used for determining the approximate positions of the outcrops in the stratigraphic column. Fossils are especially important in the Genshaw formation where the lithology is similar throughout the entire section. The thin Ferron Point member is recognized by both lithology and fauna. It is not within the scope of this paper to describe and classify these fossils, but some species described by G. W. Smith in the Afton-Onaway area and recognized in the region covered by this report are mentioned.

LOCATION OF BOUNDARIES OF THE AREA

The area described is located in Presque Isle county in the lower Peninsula of Michigan, and occupies approximately 50 square miles. A line drawn between the abandoned Onaway Stone Company quarry on the south shore of Black Lake to the Disappearing River is the northern boundary of the area. The southern boundary is the Detroit and Mackinac

INDEX MAP

Plate 1

Railroad between the towns of Onaway and Millersburg. The area is bounded on the west by highway M-211 and on the east by highway US-23. Location 15 is outside these boundaries, being three and one-half miles east and two miles south of Onaway.

PROCEDURE

Several trips into this area preliminary to the field work were made by the writer. An introduction to the Traverse Group was given by Dr. W. A. Kelly during a field stratigraphy course offered by the department of Geology at Michigan State College. Outcrops of the Traverse Group in other areas were also visited.

The field work was completed in seven weeks during the summer of 1948. Stream valleys were traversed on foot and the roads were traveled by auto. The field mapping was done largely on sketches made from aerial photos. A base map was constructed from aerial photos with a scale of one inch equals 2,000 feet. The radial line, steel template method was employed in preparing the map with horizontal control points being taken from the original survey of the area.

Elevations were obtained by the three base altimeter method with the high and low base elevations being carried from known elevations established by F. G. Dewell. Within a small area a single altimeter was used and rechecked at established points. Outcrops along the rivers were mapped in by spotting on the aerial photos. Speedometer readings were used in establishing locations along the highways of the area.

ACKNOWLEDGEMENTS

The writer expresses thanks to Dr. W. A. Kelly for his field and laboratory assistance, the aid in preparation of the base map and the wealth of information given on the subject. Dr. S. G. Bergquist's assistance in the preparation of the thesis, and arrangement of aid in the laboratory is deeply appreciated. To Dr. B. T. Sandefur, the writer expresses appreciation for laboratory assistance. The field work was accomplished with financial aid from the Michigan Geological Survey.

TOPOGRAPHY AND RELIEF

Glacial features appear to dominate the topography of the Onaway-Oequeoc region. The glacial drift is relatively thin but effectively covers most of the area. Relief is low, not exceeding 250 feet, although the glacial features are sufficiently sharp and well defined to be recognized easily. Drumlins are common in the area and may be observed on the aerial photos. One large belt of drumlins occurs just east of Onaway and a second group is found west of the Oequeoc River. The relief in the area is due in part to rock formations where erosion has exposed bedrock to form escarpments. The Ferron Point formation offers little resistance to erosion and is easily undermined, often leaving the overlying Genshaw Formation as a

well defined bluff.

DRAINAGE

Two major rivers cross the area. The Rainy River, the most westerly of the drainage ways, has its headwaters in southwestern Presque Isle county and flows northwest to Black Lake. The Ocqueoc River which parallels the Rainy, flows north from May Lake in southern Presque Isle county to Lake Huron. During the dry season these streams are shallow and have little velocity but in periods of heavy rainfall they have a sufficient volume to cut appreciably into bed rock. Rapids are common and each of the rivers has a small water fall which exposes a relatively thick section. Black Lake, the only lake in the area, is probably bottomed on the Bell shale. In the areas to the north and west where outcrops are lacking, sand plains seem to dominate the surface expression.

STRATIGRAPHY

The entire section of the Michigan Traverse Group of rocks is not found in this area. A. S. Warthin, Jr. and G. A. Cooper describe the Four Mile Dam, Norway Point, Thunder Bay and Squaw Bay members of the Traverse Group in the Thunder Bay region of eastern Michigan. These are not found in the Onaway-Ocqueoc region. The Traverse Group of the Onaway-Ocqueoc region includes the Bell shale, the Rockport Quarry lime-

stone, the Ferron Point shale, the Genshaw formation, the Koehler formation and the Gravel Point formation. The formations of the Traverse Group are here described in the order of ascending age.

BELL SHALE.--The Bell shale does not outcrop in this region, although it is probable that the floor of Black Lake is on this member. The Bell shale outcrops northwest of Black Lake on the banks of the Milligan River. The shale is reported as being present in two different wells that were drilled in this region. In the Lobdell-Emory Manufacturing Company well, which has an elevation of 775.0' above sea level, and located in the SE. ¼, SE. ¼, Sec. 26, T. 35 N., R. 2 E., in Allis township, the Bell shale was encountered 138 feet below the surface. In the Presque Isle Development Company well, with an elevation of 839.0' above sea level, located in the SE. ¼, NW. ¼, Sec. 5, T. 34 N., R 2 E., near the City of Onaway, the shale is recorded 250 feet below the surface.

ROCKPORT QUARRY LIMESTONE.--The type locality of this formation is the quarry at Rockport, Alpena county (Warthin and Cooper, 1943, P. 580). In the Onaway-Ocqueoc region, the Rockport Quarry formation is represented by two distinct facies, both of which are present in the abandoned quarry at Black Lake. The upper, and more extensive facies is a light gray, dense, even-bedded, stylolitic, sub-lithographic limestone with abundant secondary calcite fillings. Several flat-lying Favosites zones, together with thin shale partings, interrupt the otherwise continuous sub-lithographic texture of the limestone. The dark argillaceous facies which also has flat-lying Favosites zones is

represented by the lower five feet of section at Black Lake. A cup coral zone is found in the dark facies at the Disappearing River (loc. 32) and at the Ocqueoc Falls (loc. 31). The dark gray argillaceous limestone is of detrital origin and shows a characteristic wavy structure caused by dark streaks of organic matter. The greater part of the material is in the form of crinoid columns and shell fragments set in an argillaceous matrix. None of the dense sublithographic section is shown at the two latter locations. The facies change will be discussed later in this report.

SECTION AT OCQUEOC FALLS

Rockport Quarry limestone		Feet	Inches
10.	Limestone; shaly, black, detrital.	8	
9.	Limestone; massive, dark, detrital, wavy structure.	4	6
8.	Limestone; shaly, black, Favosites bed.		6
7.	Limestone; massive, brown detrital, Hexagonaria and Favosites.	2	
6.	Limestone; shaly, black, Favosites bed.	1	2
5.	Shale; black, thin-bedded, non-fossiliferous.		2
4.	Limestone; brown, detrital, wavy structure.	2	2
3.	Limestone; massive, brown, crystalline.	1	6
2.	Limestone; shaly, black, Favosites bed.	6	6
1.	Limestone; dark, detrital.	3	6

SECTION AT ONAWAY LIMESTONE COMPANY QUARRY

	Feet	Inches
Genshaw		
8. Limestone; massive, many Hexagonaria.	10	
Ferron Point formation		
7. Clay, shale.		
Rockport Quarry Limestone		
6. Limestone; gray, sub-lithographic, calcite fillings, stylolite zones.	16	
5. Limestone; gray, sub-lithographic, large calcite fillings.	1	
4. Limestone; shaly, black, Favosites bed.	1	
3. Limestone; gray, sub-lithographic, stylolitic, calcite fillings.	19	7
2. Limestone; shaly, black, Favosites bed.	4	
1. Limestone; detrital facies.		

FERRON POINT FORMATION.--The type locality of the Ferron Point formation is the same as that of the Rockport Quarry limestone. Outcrops of this formation are relatively scarce in the Onaway-Ocqueoc region. At no location is the entire section exposed, but the estimated thickness of the Ferron Point formation in this area is 10 feet. The Ferron Point usually is represented by a concealed interval with fossil evidence in the weathered zone to support its presence. At the Black Lake Quarry the lower foot of the Ferron Point formation, exposed by digging into the slump above the top of the Rockport Quarry limestone, is composed of gray, soft, fossiliferous clay shale. Ferron Point fossils are numerous in the slump both above and below the contact of the Ferron Point and

Rockport Quarry formations at Black Lake. At location 46, the Rainy River cuts through the Genshaw and Ferron Point formations but a portion of the Ferron Point is represented as a concealed interval. It is underlain at this location by the sub-lithographic facies of the Rockport Quarry limestone. Both the Rockport Quarry limestone and the lower Genshaw beds are exposed at locations 9 and 10 on the Rainy River. The vertical interval between these two formations is ten feet, which represents the apparent thickness of the Ferron Point formation in this region. This interval of ten feet is considerably less than the 37 feet of beds ascribed to the Ferron Point formation in the Thunder Bay region. It is possible that one or more of the lower fossiliferous shale zones that are placed by the writer in the lower Genshaw may have been included in the Ferron Point formation in the Thunder Bay region, described by Warthin and Cooper. A composite section of the Ferron Point formation in the Onaway-Ocqueoc region is as follows:

	Feet	Inches
Genshaw		
8. Limestone; dark gray, Hexagonaria.		
Ferron Point		
7. Limestone; shaly, blue.	?	
6. Concealed		
5. Limestone; massive, gray.	2	
4. Shale; blue, Chonetes Fragilis.	2	
3. Limestone; shaly, blue, blocky, no fossils.	1	
2. Concealed interval.		
Rockport Quarry limestone		
1. Limestone; light gray, sub-lithographic.		

COMPOSITE SECTION OF THE
GENSHAW FORMATION IN THE
ONAWAY-OCQUEOC AREA.

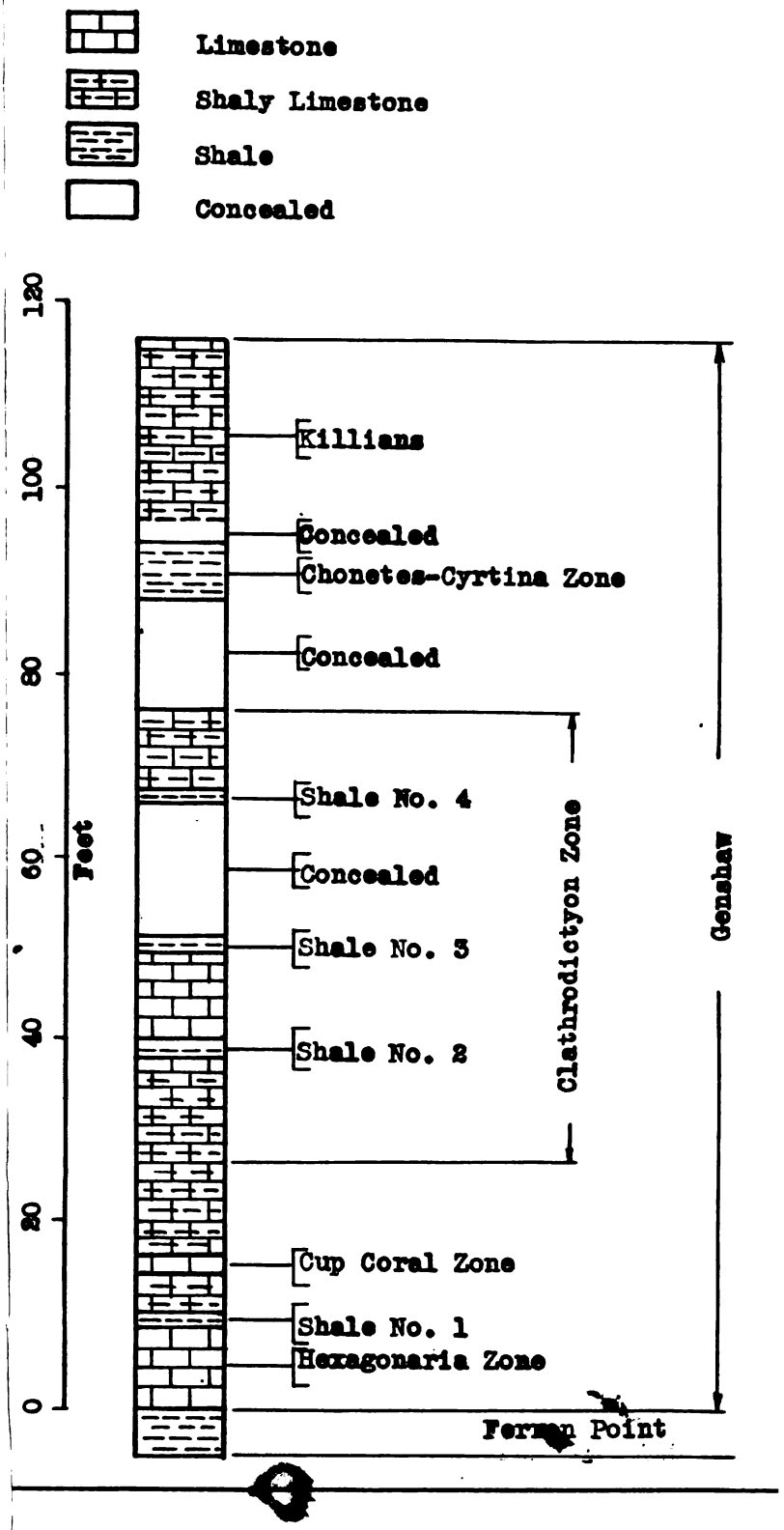
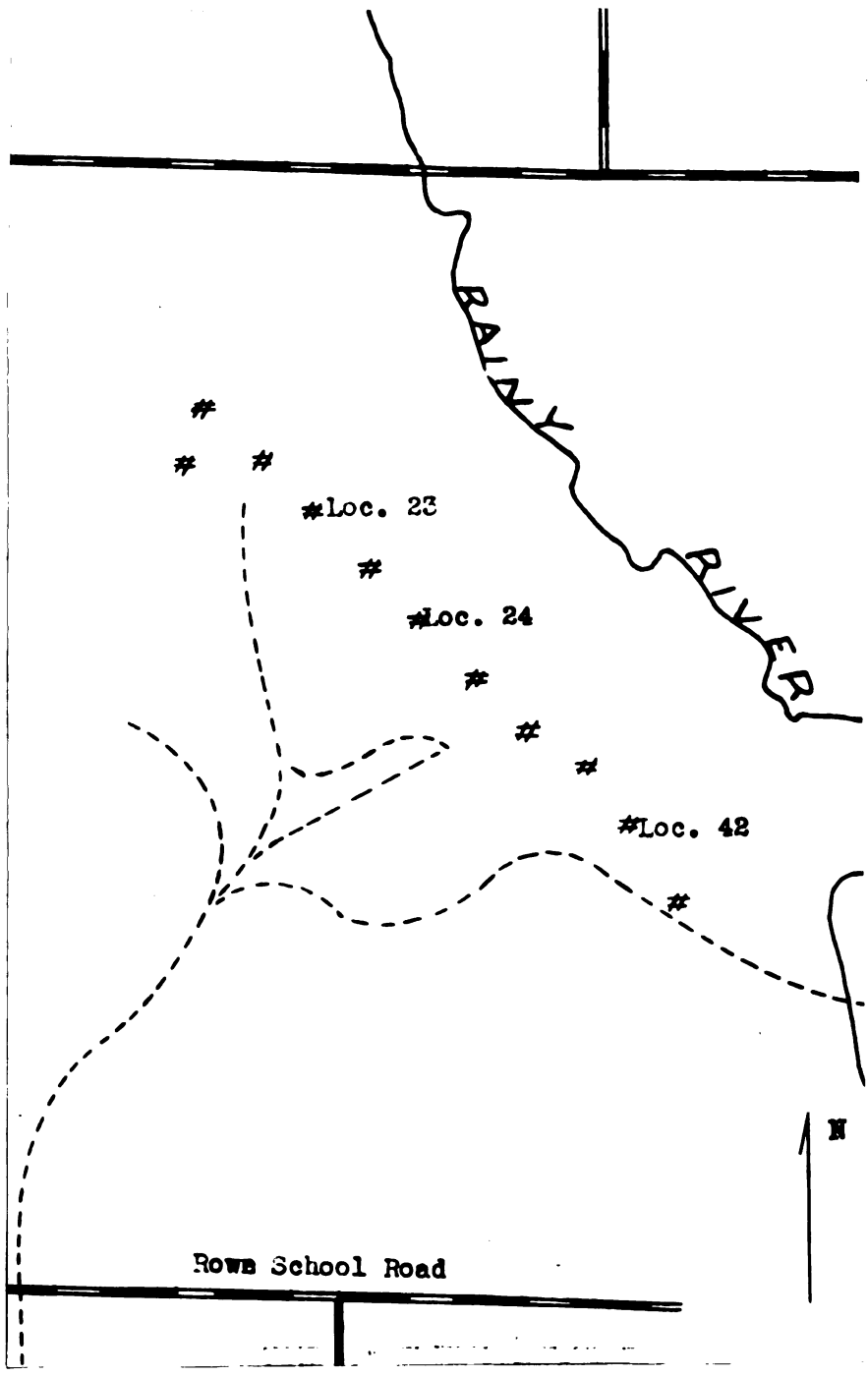


Plate 2

Bed 5 is highly fossiliferous and carries numerous remains of Atrypa, Brachyspirifer, Hexagonaria, Mucrospirifer, Trilobite, Cyrtina, Bryozoan, Crinoid columns, Cup Corals and Favosites. Bed 4 is a zone composed of Chonetes Fragilis together with a large species of Brachyspirifer. The Ferron Point type of Hexagonaria is one common to shale zones, with complete specimens ranging from two to eight inches in diameter.

GENSHAW FORMATION.--The Genshaw formation originally had its type locality in the NE. ¼, T. 32 N., R. 8 E., Alpena County. The amended section of Warthin and Cooper is a composite one with type localities at the Alpena Portland Cement Company shale quarry, on the Long Lake Road, along French Road, and in the Michigan Alkali Company quarry, respectively. Including 35 feet of beds above the Killians member, the entire section of the Genshaw formation measures 116 feet in the Thunder Bay region. In the Afton-Onaway area (W. A. Kelly and G. W. Smith) the Genshaw has a thickness of 150 feet with no beds higher than the Killians member. In the area included in this report, the Killians formation is probably overlain by a thin bed of upper Genshaw age. Locality 19 is the only outcrop in this area that could be ascribed to the Genshaw above the Killians member.

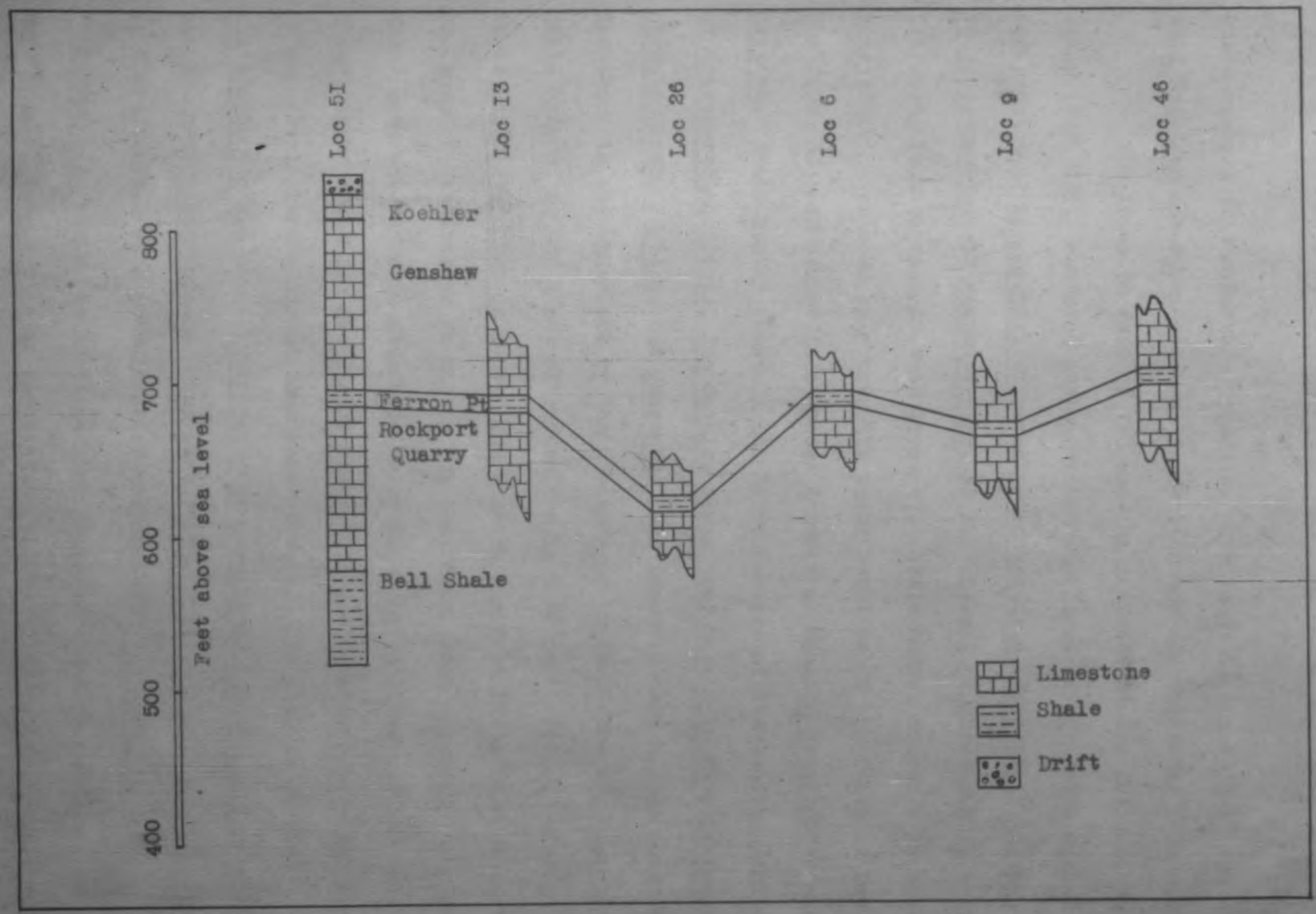
Shale members rich in fauna are common in the Genshaw. Because of the similarity of lithology below the Killians member, these shale members were used in ascribing the scattered outcrops to their correct position in the stratigraphic column. It is doubtful that all of the



Scale: 3 inches = 1 mile

MAP SHOWING RELATIONSHIP BETWEEN
RAINY RIVER CHANNEL AND GENSHAW OUTCROPS
IN SECTIONS 22 AND 27, NORTH ALLIS TOWNSHIP

Plate 3

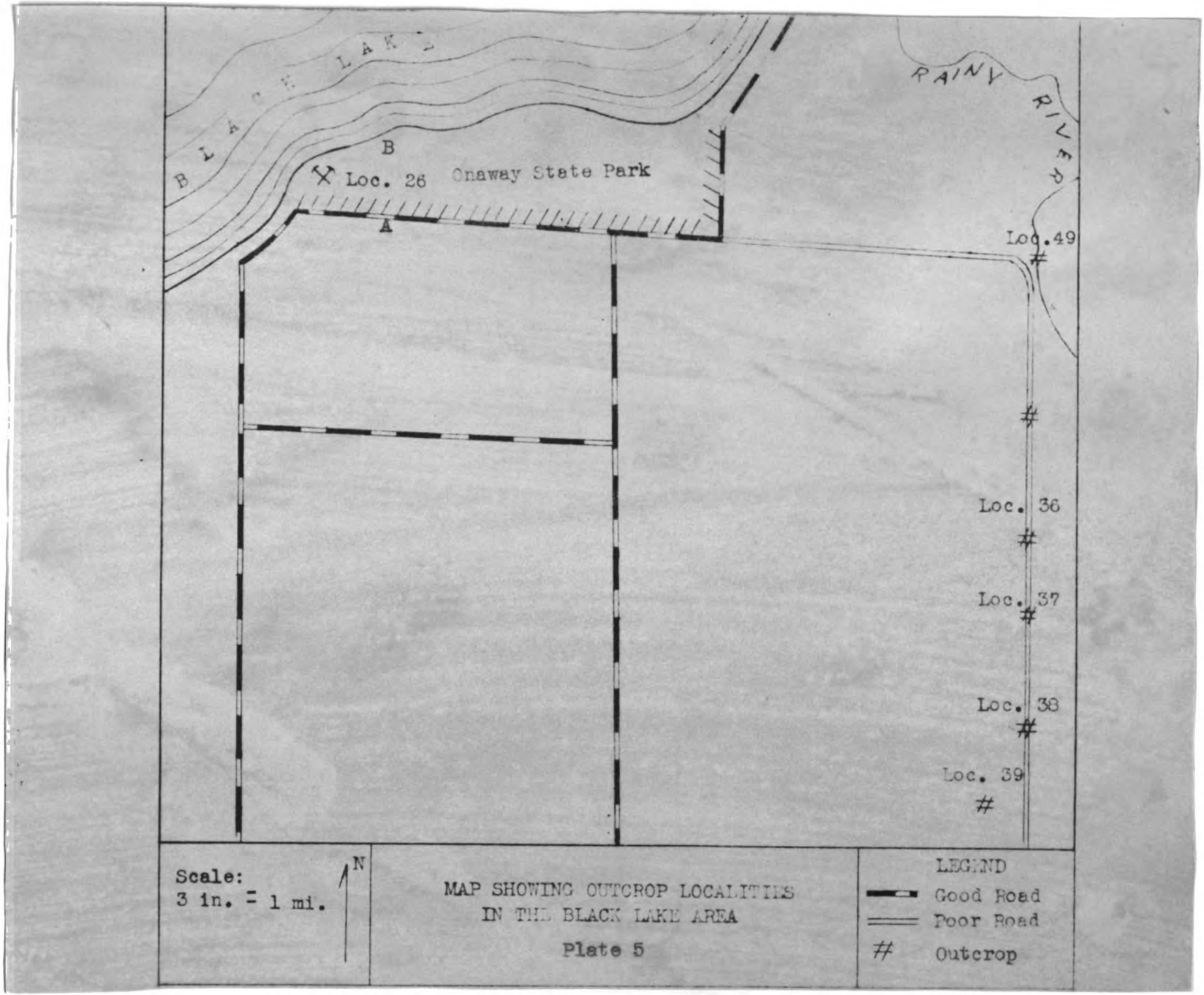


Correlation Of Geologic Sections In Onaway-Ocqueoc Area

Plate 4

shale members in the Genshaw formation were located, however, by use of well logs and outcrops, a composite section was constructed. (Plate 2).

The lower 56 feet of the section is found at the Rainy River Falls (loc. 13). Number 3 shale zone at the level of the falls containing species of Brachyspirifer, small Stropheodonta, Favosites, Atrypa, Pholidostrophia, and Mucrospirifer, is the highest of three shaly, fossiliferous beds exposed at this location. Shale member number 2 is a blue clay which is exposed only when the water level below the falls is low. The fauna of this member is composed largely of small Mucrospirifer and Cyrtina. Shale member number 1 has large numbers of the smooth umbo type of Pentamerella, Atrypa, Cup Corals, Favosites, Mucrospirifer, Schizophoria, Stropheodonta, Crytina, and Chonetes. The lower 10 feet of the Genshaw formation is characterized by the presence of an abundance of Hexagonaria. Shale beds 2, 3, and 4 are all contained in a 50 foot section referred to as the Clathrodictyon zone. The zone ranges from 25 to 75 feet above the base of the Genshaw formation but the fossil from which the zone is named does not occur in abundance below the massive limestone bed between shale layers 2 and 3. The Clathrodictyon is a stromotoporoid which grows in concentric layers around some other fossil. The centers of the Clathrodictyon are usually Atrypa, Pentamerella or Brachyspirifer, although several with Gastropods as cores were found. The upper Clathrodictyon zone is characterized by a prevalance of costate umbo Pentamerella and Brachyspirifer while the lower portion contains abundant specimens of a smooth umbo Pentamerella in association with Brachyspirifer. Shale member


BLACK LAKE
RAINY RIVER
B
Loc. 26
Onaway State Park
A
Loc. 49
Loc. 36
Loc. 37
Loc. 38
Loc. 39
Scale:
3 in. = 1 mi.
N
MAP SHOWING OUTCROP LOCALITIES
IN THE BLACK LAKE AREA
Plate 5
LEGEND
Good Road
Poor Road
Outcrop

4 is characterized by the presence of many specimens of Atrypa.

Chonetes, associated with Cyrtina, are abundant in shale zone 5 which is 12 feet above the top of the Clathrodictyon zone. This zone, with a thickness of about six feet, is exposed on a hillside at loc. 42 (Plate 3). The Genshaw above the Chonetes zone is concealed below the Killians, which has a thickness of approximately 20 feet in this region. Outcrops are few due to the ease in which this member is weathered. The Killians member is a black, detrital, shaly limestone with the most common fossils being Mucrospirifer, Gomphoceras, pygidia of the trilobite Proetus, and a coral, Favosites. The Favosites often show dark bituminous penetrations into the corallites. Except for the intercalated shale layers, the lithology of the Genshaw formation is similar throughout the entire section, being composed of detrital limestone ranging from light gray to dark gray in color. Black detrital beds occur both above and below the shale layer number 1.

NEWTON CREEK LIMESTONE.--The type locality of the Newton Creek limestone is in the quarry of the Michigan Alkali Company at Alpena, Michigan (Warthin and Cooper). This formation is described as a dark brown, crystalline limestone having an approximate thickness of 25 feet in the Thunder Bay region.

Large fragments of limestone, considered by the writer as possibly belonging to the Newton Creek formation, are found associated with the Killians member of the Genshaw formation in this area. These fragments

occur in large numbers in a field to the north of the Vilburn School (loc. 33). Similar fragments are also found in the bed of the Ocqueoc River (loc. 2) at the junction of highway M-211 and the Rowe School Road (loc. 19), and also at location 20 on the Rowe School Road. The thickness of the Newton Creek formation in this area is not known but it must be considerably less than 35 feet as determined at Alpena.

KOEHLER FORMATION.--In the Onaway Stone Company quarry south of the airport at Onaway, several beds are exposed which do not fit into the described section of the Traverse Group. These beds lie above the Newton Creek limestone and below the Gravel Point formation, and thus must be Koehler in age. This series of beds, with approximately four feet of vertical section exposed, is being quarried for building stone.

The following section shows the beds exposed at the Onaway Stone Company quarry:

		Feet	Inches
Overlying formation not exposed.			
5.	Limestone; dark gray, coarsely crystalline, detrital.		8
4.	Limestone; shaly to sandy, light gray, even-bedded.		
3.	Limestone; massive, dense, dark gray.	1	2
2.	Stylolite Zone.		1
1.	Limestone; gray, dense, thin-bedded.	1	6

The type locality of the Koehler formation in the Afton-Onaway area is the abandoned quarry of the Campbell Stone Company located one mile north of Afton in Koehler township (W. A. Kelly and G.

W. Smith). The Koehler is composed chiefly of gray, thin bedded, dense limestone of sub-lithographic textures.

Except for fragments, fossils in the detrital beds are absent in the Onaway member. It is probable that the four feet of section at the Onaway Stone Company quarry does not represent the entire thickness of the Koehler formation in this region. The Presque Isle Development Company well (log by R. A. Smith) located merely 50 feet north of the quarry, records 15 feet of gray limestone ascribed by the writer to the Koehler formation.

GRAVEL POINT FORMATION.--The Gravel Point is the youngest formation of the Traverse Group exposed in the Onaway-Ocqueoc region. Outcrops of the Gravel Point limestone are relatively few with the best exposures found on the Ocqueoc River, between Millersburg and the bridge over highway M-68 (loc. 1). Because of concealed intervals, the thickness of this section cannot be accurately determined. The beds exposed at location 1 are shown in the following section:

6. Limestone; crystalline, dark gray.

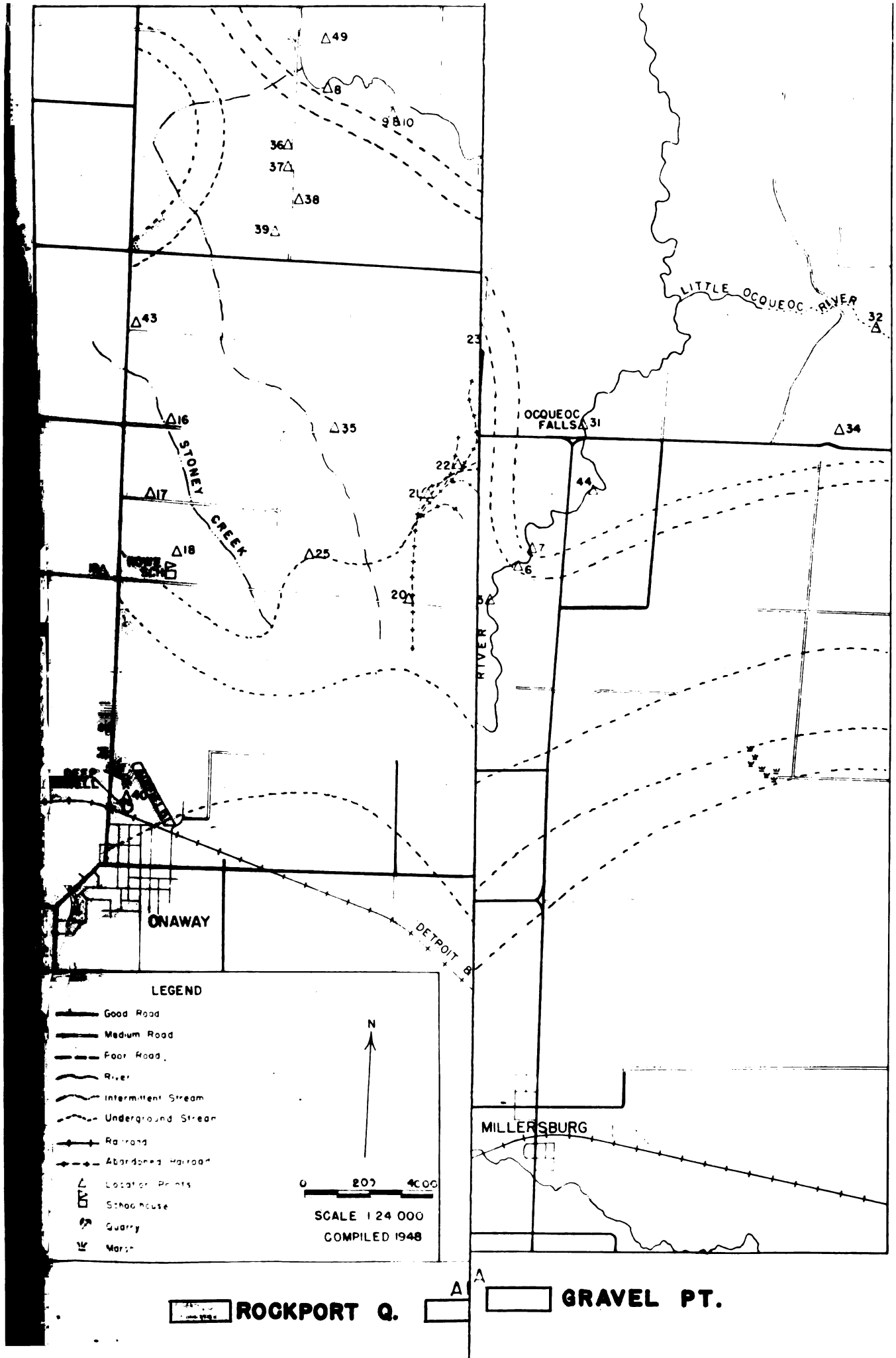
5. Limestone; coarsely crystalline, light gray to buff.

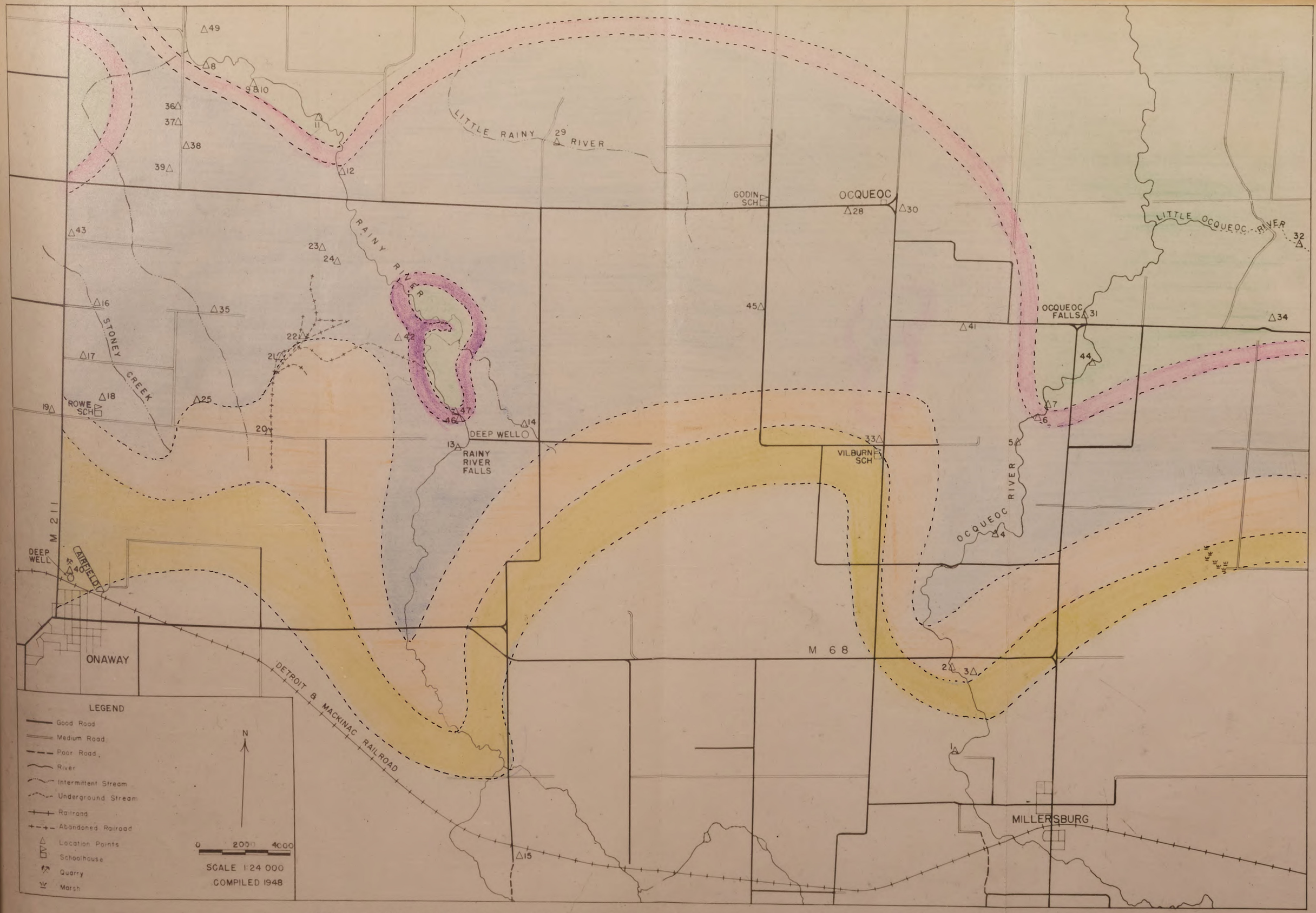
4. Limestone; finely crystalline, dark gray, massive detrital with conchoidal fracture.

3. Limestone; shaly black.

2. Limestone; dense, dark, detrital, very fossiliferous, contains Athyris and Mucrospirifer.

1. Limestone; sandy, but fossiliferous (probably Newton Creek limestone).


LITTLE OCQUEOC RIVER
OCQUEOC FALLS
STONEY CREEK
OCQUEOC RIVER
ONAWAY
DETROIT &
MILLERSBURG
LEGEND
Good Road
Medium Road
Poor Road
River
Intermittent Stream
Underground Stream
Railroad
Abandoned Railroad
Locator Points
School House
Quarry
Marsh
N
0 2000 4000
SCALE 1 24 000
COMPILED 1948
ROCKPORT Q.
GRAVEL PT.



AREAL DISTRIBUTION OF THE TRAVERSE GROUP IN THE ONAWAY - OCQUEOC AREA

ROCKPORT Q. | FERRON PT. | GENSHAW | KILLIANS | KOEHLER | GRAVEL PT.

PLATE 6

The Gravel Point formation is readily recognized by its lithology, being composed of light to dark gray, dense, thin-bedded limestone. It breaks with a conchoidal fracture and has a metallic ring when struck a blow with a hammer. Fragments of the Gravel Point are usually found to be sharp, angular and relatively thin. Fossils common to the Gravel Point in this area include relatively fine costate Stropheodonta, small Atrypa, Bryozoa and Mucrospirifer.

OUTCROP LOCALITIES

The outcrop localities spotted on the areal distribution map of the area included in this report with elevations above sea level wherever available are as follows:

Locality 1. Elevation of the highest exposure is 771.1'. The Gravel Point formation outcrops in the bed and in the banks of the Ocqueoc River (Sec. 7 of Case township). This is a discontinuous outcrop extending from approximately ¼ mile north of Millersburg on the river to a point 1/8 mile south of highway M-68 bridge.

Locality 2. Elevation - 739.0'. Rock approximately in place in the bed of the Ocqueoc River, 1/8 mile south of the bridge on highway M-68, N. ½, Sec. 9, Case township. Here the outcrop material is a mixture of fragments derived from the Killians, Newton Creek and Koehler.

Locality 3. Elevation - 741.0'. The Killians member of the

Genshaw formation is exposed in the field along the east side of the Ocqueoc River, just south of the bridge over highway M-68, N. ½, Sec. 9, Case township.

Locality 4. The Clathrodictyon zone of the middle Genshaw formation is represented by fragments not in place but sufficiently abundant to be near to the outcrop, SE. ¼, Sec. 33, Ocqueoc township.

Locality 5. Elevation - 698.2'. Lower Genshaw (cup coral zone) is exposed in the bed and in the banks of the Ocqueoc River, SE. ¼, Sec. 28, Ocqueoc township. Hexagonaria are abundant and place this locality in the lower 10 to 15 feet of the Genshaw. A small falls is formed on this outcrop.

Locality 6. Elevation - 698.2'. The Ferron Point-Genshaw contact is exposed in the bed and along the banks of the Ocqueoc River, SE. ¼, Sec. 28, Ocqueoc township.

Locality 7. Rockport Quarry limestone (sub-lithographic facies) is found as talus in a road cut on highway M-211, 1¼ miles south of the Onaway State Park.

Locality 8. Rockport Quarry limestone (sub-lithographic facies) is exposed in the bed and along the banks of the Rainy River, SE. ¼, SE. ¼, Sec. 9, North Allis township.

Locality 9. The elevation of the Rockport at the river level is 653.5', while at the top of the Rockport it is 666.5'. Rockport Quarry limestone is exposed as a ledge approximately 14 feet high, extending for a distance of nearly 500 feet along the banks and in the bed of the Rainy River, NE. ¼, NE. ¼, Sec. 16, North Allis township.

Locality 10. The elevation of the Ferron Point-Genshaw contact is 676.5'. The lower 4 feet of the Genshaw is exposed 10 feet above the top of the Rockport Quarry limestone at locality 9. The 10 foot interval of the Ferron Point shows no outcrops but the Ferron Point type Hexagonaria is found in the river bed below the outcrop, NE. ¼, NE. ¼, Sec. 16, North Allis township.

Locality 11. An extension of locality 10 in the river bed consists of large fragments of Rockport Quarry limestone, center of Sec. 15, North Allis township.

Locality 12. Lower Genshaw float in quantity sufficient to be nearly in place is present in the bed of the Rainy River, approximately 1,000 feet north of the new bridge over the Rainy River on the road leading from highway M-211 east to the Village of Oequeoc, SW. ¼, Sec. 15, North Allis township.

Locality 13. The elevation at the crest of the falls is 739.4'. The lower 56 feet of the Genshaw formation is found in a discontinuous outcrop at and below the Rainy River falls, SW. ¼, Sec. 26, North Allis township. This outcrop exposes the lower Clathrodictyon zone and the three lower shale members. Shale member 3 is at the falls level; shale member 2 is at the base of the falls and shale member one is about 2,100 feet north of the falls in the bed and banks of the Rainy River.

Locality 14. The elevation at the top of the outcrop is 765.4'. The Clathrodictyon zone of the middle Genshaw is present in an abandoned tributary of the Rainy River, SE. ¼, Sec. 26, North Allis township.

Shale zone 4 is found five feet below the uppermost ledge of this outcrop. The exposure is 550 feet long and approximately 10 feet high at this locality with the Clathrodictyon zone being about 65 feet above the base of the Genshaw formation.

Locality 15. Elevation - 761.5'. The Gravel Point formation is exposed in the bulldozed portion of a field, 500 feet south of the Detroit and Mackinac Railroad, along the road between sections 13 and 14 of Allis township.

Locality 16. Elevation at the top of the black beds is 759.5'. The lower Genshaw formation, present as a discontinuous outcrop on Stony Creek, exposes about 10 feet of beds including a black, shaly, detrital limestone both above and below a shale zone. SE. ¼, SW. ¼, Sec. 20, North Allis township.

Locality 17. A flat-Stromotoporoid zone of the Genshaw formation is exposed on the quarter section road of Sec. 29, approximately ¼ of a mile east of highway M-211. This bed is probably one of the flat-Stromotoporoid zones found intercalated in the Clathrodictyon zone.

Locality 18. The elevation at the top of the outcrop is 804.5'. An exposure of the Clathrodictyon zone of the upper Genshaw is found north of the Rowe School.

Locality 19. Elevation - 821.5'. Beds belonging either to the Newton Creek or the Genshaw formations above the Killians are exposed in the outcrop in the SE. ¼, SE. ¼, Sec. 20, North Allis township. Although the limestone in the outcrop possesses crystalline character

similar to that of the Newton Creek limestone, it is dark gray rather than dark brown in color which suggests that it may possibly belong to the Upper Genshaw formation. The locality is the only one in the Onaway-Ocqueoc region that may be ascribed to the Genshaw formation above the Killians.

Locality 20. Elevation - 821.5'. Loose fragments of Newton Creek limestone and the Killians member of the Genshaw formation, possibly near their source, are found along the Rowe School Road at the old railroad grade crossing about 1¾ miles east of highway M-211, SE. ¼, SE. ¼, Sec. 28, North Allis township.

Locality 21. Elevation - 811.6'. Killians beds are exposed on a hillside along the old railroad grade approximately one mile north of the Rowe School Road, NW. ¼, Sec. 28, North Allis township. The Killians here is associated with fragments of a black, sub-lithographic, petroliferous limestone possibly of Upper Genshaw age.

Locality 22. Upper Genshaw beds are exposed in a field about 1,800 feet north of loc. 21 in the NE. ¼, Sec. 28, North Allis township.

Locality 23. The elevation at the top of the outcrop is 801.9' and at the bottom it is 775.0'. Upper Genshaw beds are exposed in a long rock ledge roughly paralleling the Rainy River channel in Sec. 22, North Allis township. Plate 3 shows the relationship of its location to localities 24, 42 and the Rainy River channel.

Locality 24. Elevation - 785.8'. The Clathrodictyon zone of the upper Genshaw formation is exposed in the same rock ledge as at location

25. The Clathrodictyon zone outcrops intermittently throughout the entire distance of this ledge.

Locality 25. Elevation - 804.4'. A fossiliferous shaly member of the upper Genshaw formation is exposed in the walls and diggings of an old abandoned well, SW. ¼, Sec. 28, North Allis township.

Locality 26. The elevation at the Ferron Point - Rockport Quarry contact as shown at point B on Plate 6 is 638.8'. The Rockport Quarry limestone together with the overlying Ferron Point formation is exposed in the abandoned Onaway Limestone Company quarry on the south shore of Black Lake. The Ferron Point formation in this locality is found only on the east end of the quarry. To the northeast of the quarry, along the shore of Black Lake, the lower Genshaw beds are exposed at the place where both the Rockport Quarry limestone and the Ferron Point shale dip into the lake, Sec. 7, North Allis township. Approximately 70 feet of composite section is exposed in this locality.

Locality 27. A flat-Stromotoporoid zone of the lower eleven feet of the Genshaw formation outcrops on the road leading north from point A designated on Plate 6, to the abandoned Onaway Limestone Company quarry at Black Lake. The outcrop is in Sec. 7, North Allis township.

Locality 28. Lower Genshaw beds outcrop on the south side of the road between highway M-211 and Ocqueoc Village, approximately 4/10 of a mile west of the village. This outcrop is so small that it is difficult to determine its correct position in the Genshaw section, N. ½, NE. ¼, Sec. 20, Ocqueoc township.

Locality 29. Elevation - 720.1'. Lower Genshaw, (Cup Coral zone) outcrops in the bed and banks of the Little Rainy River, five miles north of Cement School. The outcrop is in the lower 20' of section of the Genshaw formation and is exposed for a distance of approximately 500 feet. The same beds are exposed in a field bordering the river on the north in the SW. ¼, NW. ¼, Sec. 13, North Allis township.

Locality 30. Elevation - 760.0'. Lower Genshaw is exposed in a road cut at the corner of sections 16, 17, 21 and 20 in the Village of Ocqueoc. This outcrop extends as a ledge for a distance of approximately 500 feet to the east.

Locality 31. The elevation of the lowest ledge exposed in the river is 653.7'. Rockport Quarry limestone (dark facies) outcrops at Ocqueoc Falls, SE. ¼, Sec. 22, Ocqueoc township. About 30 feet of section is exposed in the bed and banks of the river. The outcrop extends for a distance of about 500 feet downstream from the bridge on highway US-23.

Locality 32. The elevation on the cup coral zone is 687.5'. Rockport Quarry limestone (dark facies) comes to the surface at the Disappearing River, Sec. 24, Ocqueoc township. It is difficult to measure the section at this location because of slumping caused by weathering of the softer shale zones. Approximately 20 feet of section is exposed but it cannot be tied into the Ocqueoc Falls section. One small stylolite zone together with shale members and thin beds of crystalline limestone are present at this location.

Locality 33. Elevation - 811.2'. Killians and Newton Creek fragments are found as float at the Vilburn School. The Newton Creek limestone is abundant as large blocks in the field just north of the school, NE. ¼, NE. ¼, Sec. 32, and SE. ¼, SE. ¼, Sec. 29, Ocqueoc township.

Locality 34. Elevation - 716.5'. Rockport Quarry limestone (dark facies) is exposed about 200 feet east of the highway US-23 bridge over the Little Ocqueoc River, SE. ¼, SW. ¼, Sec. 23, Ocqueoc township.

Locality 35. A flat-Stromotoporoid zone of lower Genshaw outcrops in the road bed 4/10 of a mile east of the corner of sections 20, 21, 28 and 29, North Allis township.

Locality 36. Elevation - 709.0'. The lower Genshaw (dark detrital bed) is exposed in an area 7/10 of a mile south of the quarter section road east of the Onaway State Park (Plate 6), on the line between section 16 and 17, North Allis township.

Locality 37. Elevation - 739.0'. A fossiliferous shale bed (No. 2) of lower Genshaw is overlain by a flat-Stromotoporoid zone in the road bed between sections 16 and 17 about 2/10 of a mile south of location 36, North Allis township.

Locality 38. Elevation - 745.0'. An exposure of the Clathrodictyon zone of lower Genshaw, located two-tenths of a mile north of the corner of sections 16, 17, 20 and 21, extends as a ledge for a distance of 200 feet east of the road, North Allis township.

Locality 39. The elevation at the top of the well is 753.0'. An 18 foot section of the Clathrodictyon zone and fossiliferous blue shale

(No. 2) is exposed in a dug well, SE. ¼, SE. ¼, Sec. 17, North Allis township. The well is bottomed in the blue shale member and a single specimen of Clathrodictyon was found one foot from the top of the well. This, together with other fossil evidence seems to indicate that the blue shale is the same as that found directly below the Rainy River falls.

Locality 40. Elevation - 837.5'. Koehler formation is exposed in the Onaway Stone Company quarry, approximately 200 feet south of the airport and 50 feet north of the Presque Isle Development Company well, NE. ¼, Sec. 5, Allis township.

Locality 41. Elevation - 756.9'. Genshaw beds are exposed in an excavation for a barn, one mile west of Ocqueoc falls, NW. ¼, NE. ¼, Sec. 28, Ocqueoc township.

Locality 42. Elevation - 767.0'. The Chonetes Fragilis zone is exposed in a continuation of the rock ledge described at locality 23 (Plate 3).

Locality 43. Elevation - 765.0'. The Genshaw formation outcrops on highway M-211 about two and one-half miles north of Onaway and 50 feet north of intersection of sections 19, 20, 29, 30, North Allis township.

Locality 44. The Rockport Quarry limestone (dark facies), with very little section showing, is exposed on the south bank of the Ocqueoc River, SW. ¼, NE. ¼, Sec. 27, Ocqueoc township.

Locality 45. The Genshaw formation outcrops on the west side of the road, ⅛ mile south of Godin School, SE. ¼, NE. ¼, Sec. 19, Ocqueoc

township.

Locality 46. Elevation - 701.9'. The contact between the Ferron Point and the Genshaw formations is exposed in the bed of the Rainy River about 3,310 feet below the falls, E. ½, SW. ¼, Sec. 26, North Allis township.

Locality 47. Elevation - 695.4'. Rockport Quarry limestone (sub-lithographic facies) is exposed in the bed of the Rainy River, 3,985 feet below the falls, E. ½, SW. ¼, Sec. 26, North Allis township.

Locality 48. The Gravel Point formation (?) is exposed in a cut-bank of the Detroit and Mackinac Railroad, one and one-fourth miles west of highway M-211. This outcrop is very small and shows not more than one foot of section.

Locality 49. Elevation - 621.0'. Rockport Quarry limestone (sub-lithographic facies) crops out in the bed and banks of the Rainy River (Plate 6), SW. ¼, NW. ¼, Sec. 9, North Allis township where the east-west quarter section road of Sec. 8 intersects the river.

Locality 50. Middle Genshaw outcrops in the road as a rock ledge on the roadside, 50 feet north of the Ocqueoc church, E. ½, NE. ¼, Sec. 29, Ocqueoc township.

Locality 51. Elevation - 830.0'. Logged by R. A. Smith from drillers notes and log, and from samples, the Presque Isle Development Company well located in the SE. ¼, NW. ¼, Sec. 5, T. 34 N., R 2 E., shows the following section through the traverse Group:

PLEISTOCENE:

	Thickness (Feet)	Depth (Feet)
Drift:		
Clay, pink, calcareous.	10	10
DEVONIAN:		
Traverse:		
Limestone; gray.	15	25
Limestone; buff to dark gray in color, argillaceous limestone with strong odor of petroleum.	100	125
Limestone; gray, granular, bituminous, fossiliferous, with crinoids and corals; much white calcite.	15	140
Shale: gray, soft, calcareous.	10	150
Limestone; gray with much disseminated calcite; fossiliferous (corals).	20	170
Limestone; dark, highly calcareous black shale; disseminated calcite.	80	250
Bell:		
Shale; gray, brown and black, slightly calcareous.	60	

Locality 52. Elevation - 787.0'. Record by C. F. Poindexter from drillers log and samples. The Lobdell-Emory Manufacturing Company well located 409 feet west and 220 feet north of the southeast corner of Sec. 26, T. 35 N., R. 2 E., was drilled through a Traverse section as follows:

PLEISTOCENE:	Thickness (feet)	Depth (feet)
Drift:	25	25
DEVONIAN:		
Traverse:		
Limestone; gray, shaly.	15	40
Limestone; gray, variegated, shaly, fossiliferous.	50	90
Limestone and dolomite; brown and dark brown, variegated.	30	120
Limestone; light brown.	18	138
Bell:		
Shale; no samples.	49	187

FACIES DEVELOPMENT

The Rockport Quarry limestone in this area is represented by two facies, namely: a lagunal, sub-lithographic type and a dark gray, argillaceous and fossiliferous type. This change of character occurs in a distance of less than 10 miles. Both facies are found at Black Lake (loc. 26) and in the Presque Isle Development Company well (loc. 51) with the sub-lithographic being the higher. In the Rainy River Falls area, it appears that the light facies is the only one represented while farther east, at the Ocqueoc Falls region, only the dark facies is found. It is possible that the light facies referred to above is here represented in a concealed interval although the short separation of the dark facies of the falls from the Ferron Point at loc. 6 would suggest that such is not the case. W. A. Kelly and G. W. Smith report only the dense facies at Shanty Rapids in the Afton-Onaway area.

A sharp uplift of the beds underlying the Rockport Quarry formation, might have caused the facies change by the formation of a barrier ridge which separated the open sea from the land. Such a ridge would have a lagunal type of deposit on the landward side and a detrital type on the seaward side. A study of the structures present in the Onaway-Ocqueoc region seems to suggest that structure alone was not the cause of the change in deposition. It is more probable that the facies change was the result of the inclination of the beds below the Rockport

Quarry formation together with the subsequent formation of a coral reef. Coral reefs, biostromes and bioherms are common in the Traverse Group and may have been responsible for the abrupt change in deposition.

REEF BUILDING ORGANISMS

Among the more important reef building organisms may be listed the cup corals, Favosites, Stromotoporoids and Bryozoa, all of which are common in the Traverse Group. Van Ingen (12) reports that, "the reefs vary from a few inches to 15 feet for the blanket type and up to 75 feet for certain true coral reefs in the Devonian. The reefs formed by Hydrozoa and Alcyonaria (Octocoralla and Favosites) do not appear to have required such pure water as do the true corals. They are found in formations that carry a considerable amount of argillaceous mud, for example, the Favosites--Halysites--Stromotopora reefs of the Rosendale region and elsewhere in the New York Silurian. This seems to be true of some of the gigantic cup corals, as seen in the 75 foot accumulation of these organisms in the Hamilton Shales of Lord's Hill, Tully Quadrangle, New York." As a rule, corals are found in waters less than 27 meters in depth, but some species can survive in waters as deep as 37 to 48 meters. Vaughn (13). Twenhofel (5) states that the upward growth of a coral reef has been determined at 1.5mm per year or approximately 30 cm. in 190 years.

Following are some of the theories that have been set forth

by geologists and biologists to explain the mode of formation of coral reefs.

1. Darwin (1842) brought forth the subsidence theory in which slow submergence of a shoreline would be gentle enough to allow reefs to grow up rapidly and remain near the surface.

2. Daly's Glacial Control Theory; is a modification of the subsidence theory proposed by Darwin. Daly suggests that the sea level throughout the equatorial area was lowered during glacial times, permitting the truncation of continental platforms by wave action. When the water level was again raised conditions were made favorable for the growth of corals.

3. Rein believed that organic deposits could accumulate on still-standing submarine summits.

4. Murray proposed a theory similar to that of Rein but explained the accompanying lagoons as resulting from solution.

5. Le Conte, Guppy and Vaughn report that reefs may grow upward from a shallow bottom at a considerable distance offshore.

6. Semper and Guppy believe that Pacific Ocean reefs grew upon rising foundations.

7. Agassiz, Guppy, Wharton and Gardiner suggest that reefs grow up from submarine platforms modified by wave action.

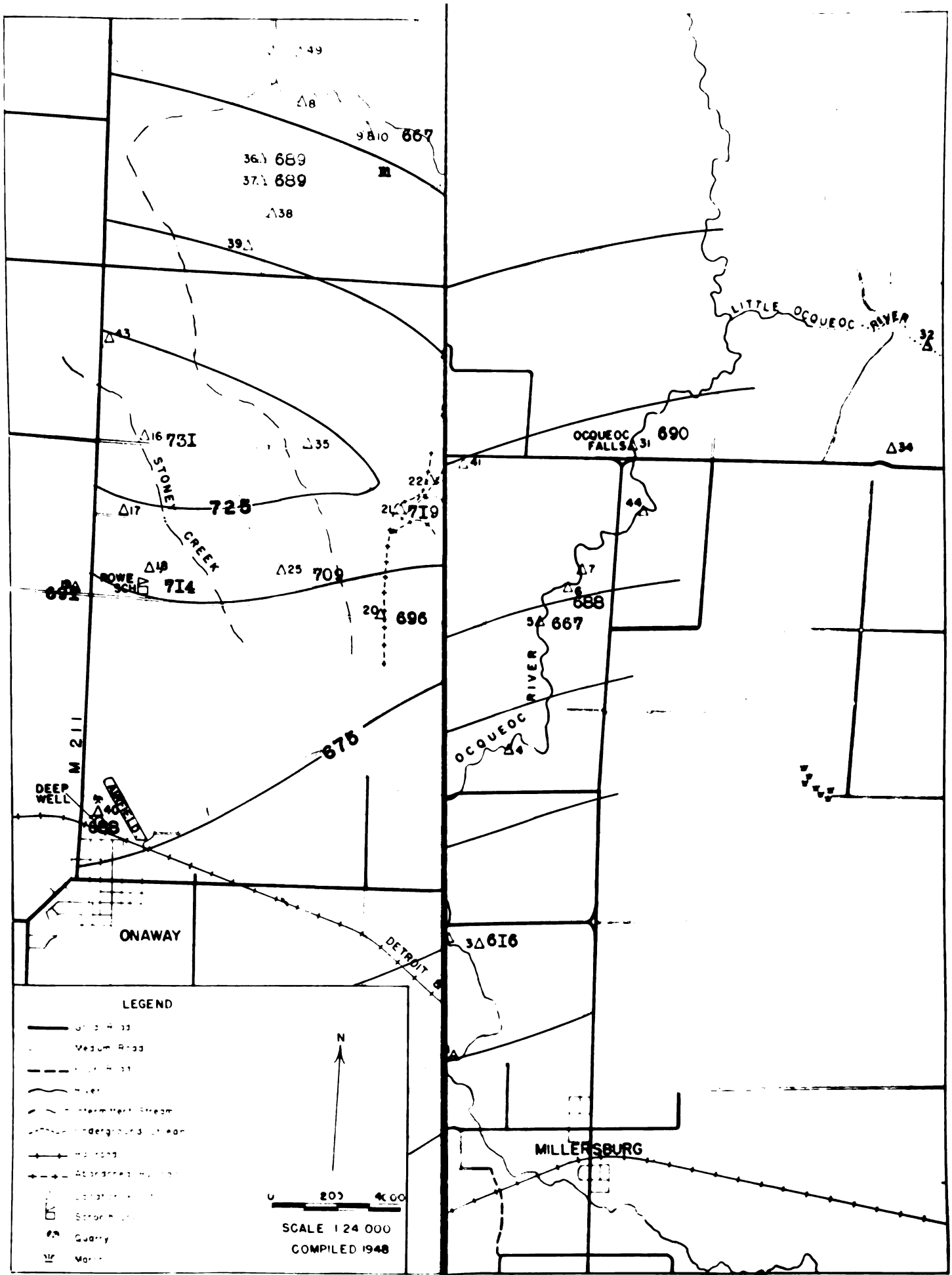
POSSIBILITY OF A BARRIER REEF IN THE ONAWAY-OCQUEOC AREA

The sub-lithographic facies in the area evidently represents

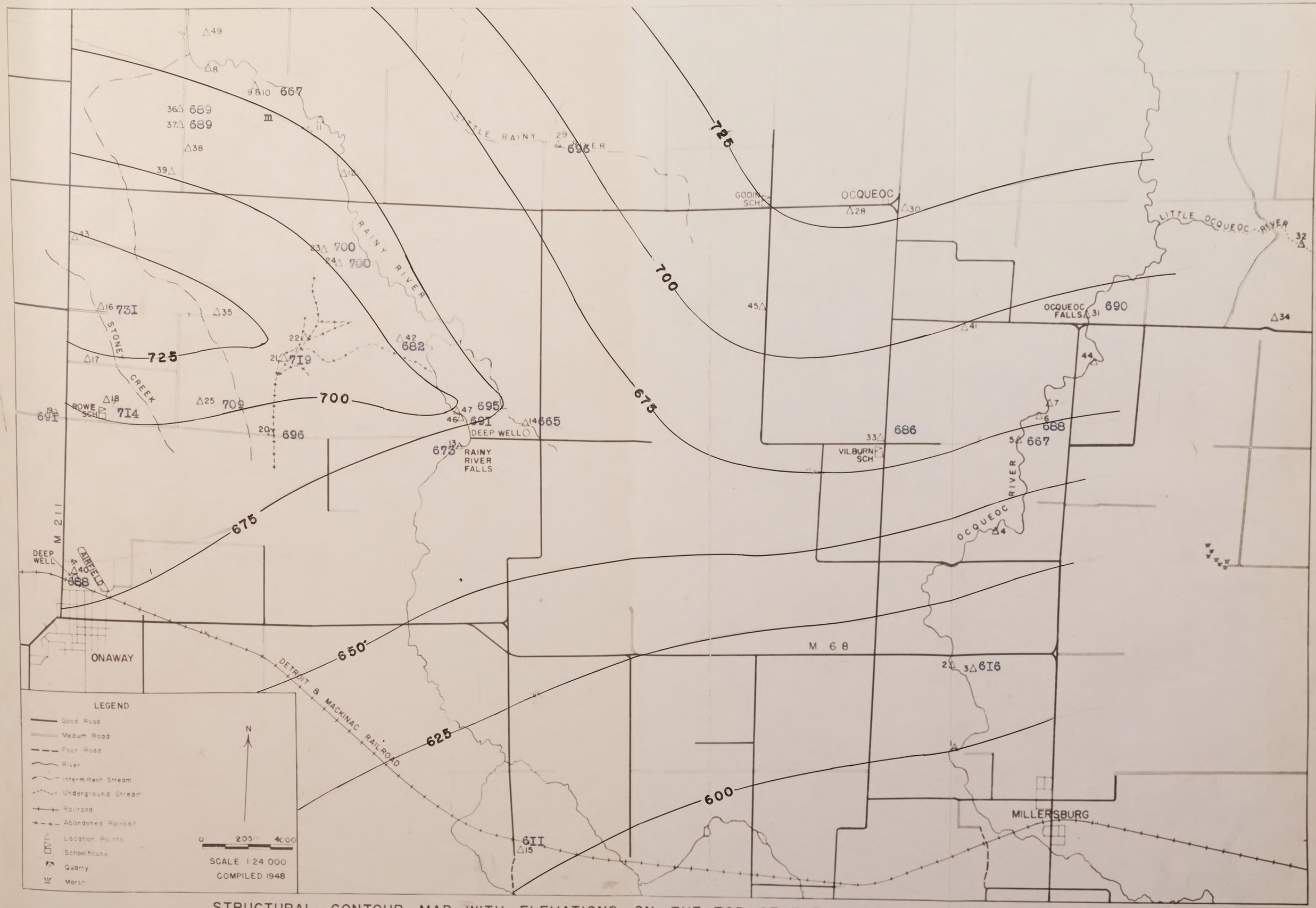
lagunal deposition. The light color and the lack of plant and animal remains suggest that land was rather remote from the reef. The dark facies containing Favosites and cup corals was undoubtedly the source of the reef building organisms.

The Bell shale at loc. 13 is 48 feet higher than at Onaway (loc. 51). The top of the Rockport Quarry limestone dips 15 feet in the same distance and thus shows a thinning of the Rockport Quarry limestone. This dip is due probably to a pre-Rockport structure in which the Bell shale represents the uppermost beds affected by a small uplift. The deposition of the dark facies is believed by the writer to have pinched out against the upraised portions in the beds of the Bell shale between Onaway and loc. 13 on the Rainy River and between Black Lake and loc. 13. The depth of the sea in the Onaway and Black Lake areas at the time of the Rockport Quarry limestone deposition was shallow enough to allow normal growth of the Favosites. The dark color of these beds would indicate that the shore line was much nearer to the Onaway-Ocqueoc region during this stage than it was during the sub-lithographic facies stage. A gentle subsidence of the land would place the shore line farther away and also cause the shallow water organisms to grow upward in order to survive. In the growth of the reef, the shoreward deposition would be of the lagunal type while seaward from the reef, the normal growth of organisms would give rise to the dark facies.

Favosites beds in the light colored sub-lithographic facies probably mark a period of subsidence that was too rapid to allow the



STRUCTURAL QUARRY FORMATION



STRUCTURAL CONTOUR MAP WITH ELEVATIONS ON THE TOP OF THE ROCKPORT QUARRY FORMATION

Plate 7

reef building organisms to keep pace with the lowering of the sea bottom, and was responsible for the dying off of the organisms. This could have occurred if the waters became too deep. A recurrence of reef-forming conditions would require merely a slowing up of subsidence.

In summarizing the facies change, it seems probable that a reef formed around a slowly subsiding submarine platform which was structurally high. The slow subsidence is offered as a possible cause of the upward growth of Favosites and cup corals which are common in the dark facies of the Rockport Quarry limestone. The reefs of which at least three are believed to have formed, are separated by episodes of rapid submergence and subsequent drowning.

Except for the facies change, no direct evidence exists to support the presence of reefs in the Onaway-Ocqueoc region. However, the area in which the reef would be expected to form has a surface exposure of Genshaw that would be from 10 to 115 feet above any such structure.

STRUCTURE

Small flexures in the Traverse Group are very common. Good exposures at various quarries show these small structures superimposed upon the regional dip of the formations. For this reason it is hazardous to attempt to calculate the dip on beds which have limited outcrops. Relatively steep dips result locally from these small flexures as shown

along the Rainy River about 3,000' below the falls and in the Afton quarry. The regional dip appears to be very gentle in a direction slightly west of south. This slight dip is brought out by the fact that approximately 115' of vertical section is exposed between locations 3 and 7 on the Ocqueoc River. These locations are 12,000' apart.

Plate 8 is a structural contour map based on elevations at the top of the Rockport Quarry formation. Elevations at localities where the Genshaw is exposed are subject to an error introduced by possible misplacement of that outcrop in the stratigraphic column. A composite stratigraphic column is illustrated on Plate 2 which is based on knowledge obtained from relatively small and scattered outcrops. The composite section was used in determining the position that the Genshaw outcrops should occupy in the Traverse section. Elevations at localities where the Rockport Quarry limestone, the Ferron Point shale, the Koehler formation and the Gravel Point formation were exposed serve to substantiate the elevations given to the localities where the Genshaw outcrops.

From the structural contour map it is evident that a small symmetrical anticline exists northeast of Onaway. In this report the structure is referred to as the Rainy River Anticline. Field evidence to support folding in this area is found in the Rainy River bed extending from location 9 to location 13. The former of these locations is an outcrop of the Rockport Quarry formation. To the southward along the river, the Rockport outcrop gives way to Genshaw float of sufficient

quantity to suggest proximity to its source. The Genshaw is replaced at loc. 47 by the sub-lithographic facies of the Rockport Quarry formation. At location 13, the Genshaw again outcrops in the river bed. The beds exposed in the scarp between locations 23 and 42 as shown on Plate 3 have a dip to the northeast. The top of the Rockport Quarry limestone drops approximately 19 feet between locations 21 and 24, and 38 feet between localities 21 and 12.

The nose of the anticline dips into a synclinal trough, (Onaway Syncline) described by W. A. Kelly and G. W. Smith. The beds west of the trough rise into a structural high forming the Black Lake anticline.

The Onaway anticline trends generally east and west and has a closure of about 50 feet. The plunge is eastward with a relatively slight dip. The beds appear to resume the normal regional dip along the Ocqueoc River. A saddle east of the Rainy River Falls area is suggested by the strongly dipping beds found near the Lobdell-Emory well (loc. 14). An increase in the angle of dip between the Rainy River Falls and the well, indicated by the elevations on the top of the Rockport Quarry formation, suggests that the relatively strong dip of beds observed at loc. 14 is not local, but may be of fairly widespread development.

CONCLUSIONS

The formations of the Traverse Group of Michigan that are

present in the Onaway-Ocqueoc region include; the Rockport Quarry limestone, the Ferron Point shale, the Genshaw formation, the Newton Creek limestone, the Koehler formation and the Gravel Point formation.

The presence of a barrier, whether due to uplift or to the formation of a coral reef is suggested by a facies change within the Rockport Quarry limestone in the Onaway-Ocqueoc region. The two facies are namely; a dark, argillaceous, detrital limestone and a sub-lithographic, dense, stylolite limestone. The detrital limestone contains fossils which could withstand wave action and probably represent the seaward side of the barrier while the sub-lithographic facies is a typical lagunal type of deposit.

Presence of the dark facies over most of the area suggests that this stage of deposition occurred previous to a period of subsidence. This submergence was slow enough to allow Favosites and cup corals to grow upward rapidly and remain at or near the surface of the water.

A small anticline with an east-west trend exists $2\frac{1}{4}$ miles north of the City of Onaway. This structure is fringed on the east by a small saddle.

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ABSTRACT

The Rockport Quarry limestone in the Onaway-Ocqueoc region is represented by two distinct facies, namely: a lagunal, sub-lithographic type, and a dark, argillaceous and fossiliferous type. This change in the character of the formation suggests the possibility of the presence of a barrier reef in the area separating the shore from the open sea. The extent and exact location of the reef, if present, is not known and at no location does it reach the surface. That the reef does not outcrop is to be expected because the Genshaw formation is exposed in the area where such a barrier could have formed, and thus places the reef below the surface. Subsidence of a small pre-Rockport structure with subsequent formation of a coral reef during the Rockport Quarry stage of deposition is brought forth as a possible explanation for the facies change. The common fossils in the dark facies of the Rockport Quarry limestone are cup corals and Favosites, both of which are reef-building organisms. Several Favosites beds contained within the sub-lithographic facies, are explained as having been formed during an interval of rapid submergence in which the reef building organisms were drowned. A slowing up of subsidence would be necessary to resume lagunal conditions. Without more data on the elevations of the formations below the Rockport Quarry formation it is not safe to conclude that a coral reef rather than an uplift is the cause of the facies change. However, a study of conditions for coral reef formation suggests that a reef may have been formed.

The stratigraphy of the Traverse Group in the Onaway-Ocqueoc region is described and compared with the Afton-Onaway and Thunder Bay regions

of Presque Isle County, Michigan. Formations that are present in the area covered by this report are the Rockport Quarry limestone, the Ferron Point shale, the Genshaw formation and the Gravel Point formation.

A structural contour map, with elevations based on the top of the Rockport Quarry limestone, indicates the presence of a small anticline, 2⅓ miles north of Onaway. This structure has an east-west trend and plunges to the east.