THE FERRON POINT AND GENSHAW FORMATIONS IN CHEBOYGAN AND WESTERN PRESQUE ISLE COUNTIES, MICHIGAN

Thesis for the Degree of M. S.
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George Wendell Smith

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FERRON POINT AND GENSHAW FORMATIONS
IN
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by

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INTRODUCTION

NATURE OF THE PROBLEM

This thesis is the result of an examination of the faunal zones of the Ferron Point and Genshaw formations in Cheboygan and western Presque Isle counties, Michigan. These formations are in the lower part of the Traverse Group of rocks of middle Devonian age. The primary objective of this study was the preparation of a geologic map and a structural contour map, based on the stratigraphic position of outcrops determined through faunal studies. The relation of the topography to the areas of outcrop is discussed.

Fossils collected at several exposures of the Ferron Point and Genshaw are listed. An attempt is made to determine those faunal zones which can be used as stratigraphic guides, since lithology is of little value for this purpose in the Genshaw formation. The distinctive lithologies of the Ferron Point formation and of the Killians member of the Genshaw aid in establishing the stratigraphic position of several outcrops. The brachiopoda which are of stratigraphic value in zoning are described. New species are not named inasmuch as it is understood that Dr. G. A. Cooper of the U. S. National Museum has in preparation a monograph on the Brachiopoda of the Traverse Group of Michigan. Fossils found to be of no use in stratigraphic zoning are not described but are included in the faunal lists.

LOCATION AND BOUNDARIES OF THE AREA

The region in which this study was made is in the north central part of the lower peninsula of Michigan. (See index map, Fig. 1). This report describes the Genshaw and Ferron Point formations in west-central Presque Isle and Cheboygan counties. The area, containing about 40 square miles, includes all known outcrops of the Genshaw and Ferron Point formations in Cheboygan county. The area in which outcrops are found is bounded on the north and south by the Pleistocene glacial drift in Townships 34 and 35 North. The irregular western edge of the area of outcrop lies about two and one-half miles west of Afton. (See Pl. I). This village is on the southern line of Sec. 36, T. 35 N., R. 2 W. The eastern boundary runs north and south two miles east of the Cheboygan-Presque Isle county line.

ACKNOWLEDGMENTS

The writer is deeply indebted to Dr. W. A. Kelly of the Department of Geology at Michigan State College for suggesting this area as a subject for study. Dr. Kelly gave freely of his time and knowledge in both the field and laboratory.

To Mr. H. K. Martin and Lt. W. J. Anderson the writer expresses his thanks for assistance in the field. Mr. Martin's aid in preparing the base map is gratefully remembered. Mr. J.A. Young, Jr., was most helpful with

INDEX MAP SHOWING LOCATION OF AREA STUDIED

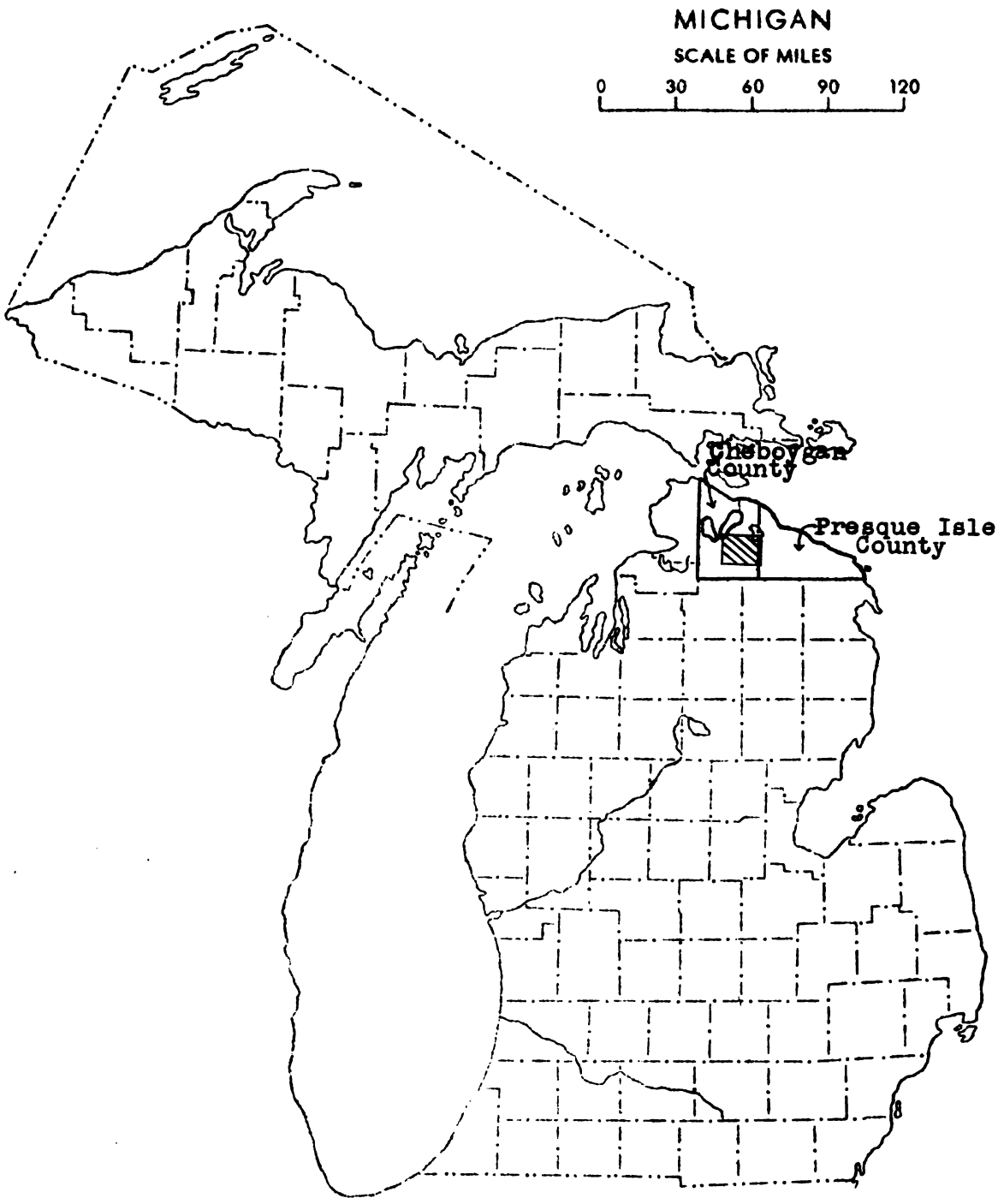

Figure 1.

paleontological problems. He and Dr. L. L. Ray have read the manuscript and offered helpful suggestions. Dr. S. G. Bergquist furnished much information concerning the surface features of the area. This assistance is thankfully acknowledged. The writer is indebted to J. B. S. for aid in the preparation of the manuscript.

The field work was made possible by financial assistance furnished by the Geological Survey Division of the Conservation Department of Michigan. Laboratory work was performed with the aid of facilities furnished by the Department of Geology and Geography, Michigan State College.

FIELD PROCEDURE

The writer first visited this area in May, 1941 and spent three days, under the guidance of Dr. W. A. Kelly, visiting outcrops of the Traverse Group of rocks. At this time a traverse was run, several sections measured, and fossils collected from outcrops of the Genshaw. In June, 1941, two and a half weeks were spent in measuring and describing stratigraphic sections, locating outcrops, and collecting fossils.

Outcrops not accessible by auto were located by pace and compass traverses "tied" to section corners. Preliminary faunal lists were prepared in the field. Most of the faunal zones were recognized in the field and were later confirmed by laboratory studies.

By utilizing these faunal zones and the distinctive lithologic characteristics of the Ferron Point formation and the Killians member of the Genshaw, it was possible to establish equivalence of outcrop sections. The thickest section of outcrop of the Genshaw formation is along Milligan Creek. The faunal zones found there were later discovered in similar stratigraphic positions in other exposures.

To obtain vertical control, essential to both structural and stratigraphic interpretations of the rocks, elevations were carried to every exposure by level and stadia rod traverses. Traverses were "tied" to U. S. Coast and Geodetic Survey bench marks or to secondary elevation points established by F. G. Dewell in 1935 by precise levelling.

The geologic map was prepared after the pace and compass traverses had been plotted and corrected and the stratigraphic position of each outcrop determined.

GENERAL TOPOGRAPHY OF THE AREA

The topography of this part of Cheboygan and Presque Isle counties is that typical of a region which has been subjected to continental glaciation. The surface is low and rolling, and the relative relief of the area does not exceed 275 feet.

The glacial debris is relatively shallow over most of the area, but it obscures the bed rock except

along the stream valleys where it has been removed. Only two natural exposures, in Secs. 34 and 36, T. 35 N., R. 1 E., are not along stream valleys. The deepest mantle of glacial material is in the approximate center of the area shown on the map. (Pl. I). From near the center of Sec. 12, T. 34 N., R. 1 W., to the point where Michigan Highway 23 turns northwest a mile north of Legrand the bed rock is concealed by a northwest trending esker. For at least a mile on each side of the esker the rocks are buried. No outcrops of the Genshaw or Ferron Point were found between Legrand and the Michigan meridian because of the glacial overburden.

An unpublished map prepared by Dr. S. G. Bergquist of the Department of Geology, Michigan State College, shows that sandy lake plain follows the valley of the Upper Black River. (See Pl. I). The map further shows that glacial till and ground moraine cover the remainder of the region, with the exception of a small area of glacial lake clay which extends from a mile and a half southwest of Legrand to within a quarter of a mile of Silver Lake. (See Pl. I).

The direction of movement of the ice across the area is shown by glacial striae on the rock pavement at Tower Dam which strike S. 27° E. Other striae on the Newton Creek limestone a mile and a half north of Onaway strike S. 32° E.

Drumlins occur at two localities in the area.

> "A series of well-defined elongated ridges with distinct troughs between them is situated

> on the till plain immediately east of Onaway. The drumlins in this area are composed of bouldery till containing a heterogeneous mixture of all types of material, much of it of local derivation. The till plain which carries the drumlins stands at an elevation of 800 to 900 feet above sea level and was formed by the ice of the Huron lobe as it retreated basin-ward from the main axis of the Port Huron moraine....They trend S. 40° E...." (Bergquist, 1942, p. 454.)

The lack of alignment between the strikes of the striae and the trends of the drumlins constitutes a problem far beyond the realm of this discussion.

Another group of drumlins occurs northeast of the village of Tower. These have been mapped (Bergquist, Unpublished Map) as occurring in sections 25, 26, 35, and 36, T. 35 N., R. 1 E., and in Sec. 1, T. 34 N., R. 1 E.

ABANDONED CHANNELS ALONG MILLIGAN CREEK

The close relationship between the topography and the areas where rocks crop out is best illustrated along Milligan Creek. Along the valley of the Milligan the glacial debris has been removed by stream erosion. Several abandoned channels were found along the creek valley. One of these abandoned channels, in Sec. 32, T. 35 N., R. 1 E., developed in two stages. It has left two rock terraces which expose about ten feet of Genshaw limestone. A continuous, natural ten-foot exposure of strata in the area of study is unusual because of the glacial drift. (See pages 5 and 6). For this reason and the fact that the development of the channel is probably related to the

SKETCH MAP OF A PORTION OF MILLIGAN CREEK

SHOWING ROCK TERRACES AND ABANDONED CHANNELS

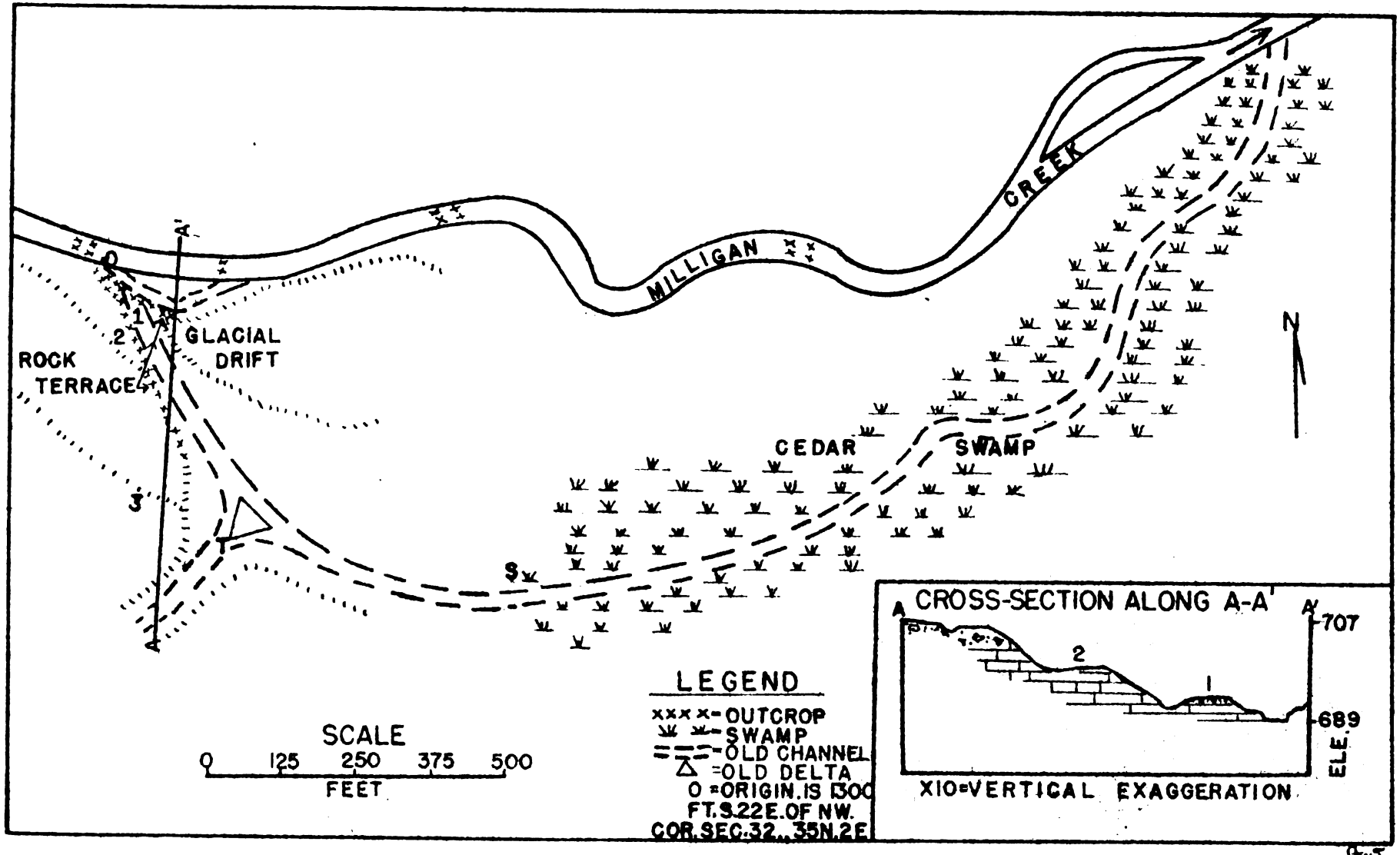

FIG. 2

The main channel was traced southeastward to a point where it enters a thick cedar swamp. (Point "S" in Fig. 2, and in Fig. B, Pl. II). About 2,000 feet down the stream there is a hanging valley with a 7-foot waterfall draining the swamp into the modern channel. This hanging valley forms the eastern terminus of the old channel.

Rejuvenation of the stream undoubtedly accounts for these rock terraces and the abandoned channels, but the specific agents responsible for the rejuvenation are difficult to determine. Increased cutting power because of an increase in load or a sudden increase in volume of water are common phenomena related to stream rejuvenation. Uplift is likewise commonly accepted as a cause. There is no evidence for any of these three processes along Milligan Creek. There are facts, however, which suggest another explanation for the observed changes in course.

The Genshaw limestone at the point where the old channels leave the present stream course ("C" in Fig. 2) possesses two joint systems. These strike S. 53° E. and N. 47° E. The stronger influence of the system striking S. 53° E. is shown by a three-foot waterfall at the point of divergence of the old channels from the modern stream bed. The downstream side of the waterfall is a slumped block of limestone which became loosened along the joint plane striking S. 53° E. Before rejuvenation took place, the stronger of the joint systems probably directed the

Fig. A.
View facing S.20°W. toward mouth of old tributary. "T", center of photograph is unconsolidated deltal remnant. "2", right center, is eroded remnant of Terrace 2, shown on Fig. 2. Foreground, bottom of old channel; background, glacial debris.

Fig. B.
View facing N.65°E. down old channel into cedar swamp. "T", right center, is same deltal remnant as above. "S" is edge of swamp and is in same position as "S" on Fig. 2.

PLATE II.

stream in its southeastward direction. Rejuvenation resulted in enough increased cutting power to allow the stream to cut a new channel in a more easterly direction, almost at right angles to the strong S. 53° E. joint system.

The writer believes that the two abandoned channels are representative of former local base-levels related to changes in water level of Black Lake. Milligan Creek empties into the Upper Black River and thence into Black Lake. In the Nipissing stage of lake development features below 625 feet were under water. (Bergquist, 1942, p. 455). The present level of Black Lake is 610 feet, or a sufficient difference in level to rejuvenate the streams draining into it. If this is the explanation for the rejuvenation, the influence of the joint system would have been decreased by the increased cutting power of the creek. Thus the creek found it easier to cut a new channel in a more easterly direction than to follow the old channel through the limestone.

DISTRIBUTION AND CLASSIFICATION OF THE GENSHAW AND FERRON POINT FORMATIONS

Distribution.--The type localities for the Ferron Point and Gensnaw formations are in the northeastern Alpena county, Michigan. The outcrops of these formations extend northwesterly from the type localities in interrupted belts through Presque Isle and part of Cheboygan counties. No outcrops of these formations are known west of Pigeon River

in the eastern half of R. 2 W. The distribution of the Genshaw and Ferron Point in those parts of Cheboygan and Presque Isle counties studied by the writer is shown on the geologic map. (Plate I). This area lies about 35 miles northwest of the type localities for the formations. The location of the outcrops upon which the map is based is given under the descriptions of geologic sections.

Classification.--These formations were first defined and described by Warthin and Cooper in 1935. Their original descriptions are:

"Killians limestone

Dark gray to black limestone with black shale layers. Overlain by gray and brown granular beds of Alpena limestone and underlain by gray shales and limestones of the Genshaw formation. Greatest measured thickness, twenty-three feet. Type locality, exposures along French Road, one-half mile south of the Killians resort, Long Lake, Alpena County, Michigan.

"Genshaw formation

Four persistent thin gray limestone beds, alternating with gray calcareous shales, all containing large species of Atrypa and Gypidula romingeri*. Overlain directly by black Killians beds, and underlain by clay shales of the Ferron Point formation. Measured thickness, fifty-one feet. Type locality, region around the Genshaw school, Sec. 13, T. 32 N., R. 8 E., Alpena County, Michigan.

"Ferron Point formation

Green to bluish clays, interbedded with argillaceous limestones, all carrying an abundance of fossils. Overlain directly by the calcareous shale of the Genshaw formation and underlain by the Rockport limestone**. Thickness, approximately thirty-five feet. Type locality, Rockport Quarry, Rockport, Alpena County, Michigan." (Warthin and Cooper, 1935, p. 526.)

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*Cooper now believes G. romingeri to be rare; the form is probably a Pentamerella? sp. (Cooper, G. A., Personal Communication, 1942).

**Changed to Rockport Quarry limestone by Cooper and Warthin, (1941, p. 260).

The descriptions quoted above have been somewhat altered recently (Warthin and Cooper, 1942, p. 19), so that the thickness of the Genshaw formation has been increased greatly. The Killians formation has been reduced to the rank of member of the Genshaw formation, and another member, the Newton Creek limestone, has been added above the Killians member.

> The Newton Creek is a "...brown, bituminous and crystalline limestone 25 feet thick exposed 12 feet above the floor of the Michigan Alkali Company Quarry, Alpena, Michigan, and extending to a thin black shale at the base of the Alpena limestone. The formation abounds in large Brachiopods: Cranaena, Pentamerella, Camerophoria, and Charionella." (Cooper and Warthin, 1941, p. 260.)

Only one outcrop of the Newton Creek limestone occurs in the area studied by the writer. In the southeast corner, Sec. 30, T. 35 N., R. 2 E., a brown, crystalline limestone crops out which is probably the equivalent of Cooper and Warthin's Newton Creek. The fauna of this limestone differs from that of the underlying Killians member of the Genshaw.

The Genshaw formation as redefined has a thickness of 116 feet at the type locality. In the Afton region a well, the Campbell No. 1, shows a thickness of 150 feet for the Genshaw, although the Newton Creek was not recognized. The thickest section of the Ferron Point, at Black Lake near Onaway, is only 9 feet thick. Thus the Ferron Point is thinner in this western group of

exposures, while the Genshaw is thicker.. Most of this added thickness of the Genshaw is in that part of the formation below the Killians, although the Killians member itself is 30 feet thick near Afton as contrasted with the 23 feet assigned to it in the eastern exposures..

Correlations.--The Genshaw and Ferron Point formations belong to the lower part of the Traverse Group of rocks.. The Ferron Point rests on the Rockport Quarry limestone and is in turn overlain by the Genshaw formation.. In the Afton area the top of the Genshaw is represented by the Killians member, while near Onaway a thin, but unmeasurable, section of probable Newton Creek limestone is at its top.. The Newton Creek is well-developed in Alpena county as described by Warthin and Cooper, where it is overlain by the Whitefish Bay limestone.. In the map area of this thesis, the Koehler limestone (Kelly, 1942) is above the Genshaw..

The position of the western outcrops of the Traverse Group with respect to the eastern outcrops near Lake Huron has been a subject of conjecture since 1841.. Nothing but dubious correlations were possible until the stratigraphic position of the rocks exposed in Cheboygan county were determined.. Kelly (idem.) has established the fact that the Gravel Point formation extends into Cheboygan county from its western exposures and is represented by strata overlying the Koehler and underlying the Beebe School formation.

The establishment of this correlation and the recognition of the Genshaw and Ferron Point formations in Cheboygan county now makes possible a direct correlation of the Traverse Group exposed on the shores of Little Traverse Bay with those which crop out on the eastern side of the state.

The subdivisions of the Traverse Group as recognized by many workers since 1841 are presented in Figure 3. This chart also shows the correlations of the various recognized subdivisions. The modern terminology applied to the eastern exposures is that of Warthin and Cooper, presented in 1941. The correlation of those sections with the Cheboygan and western Presque Isle outcrops of the Traverse Group is shown in the column headed "Kelly, 1942--G. W. Smith, 1942." The subdivisions made by Pohl (1930, p. 5) are those followed in modern terminology. These subdivisions are shown on Figure 3 in their correct stratigraphic position.

A correlation of the Traverse Group with the Hamilton of New York was first made by Winchell in 1861 (pp. 69-71). The first exact correlations of formations of the Traverse Group with formations of the New York Hamilton Group were announced by Warthin and Cooper in 1934 (pp. 13-17). Their publication the following year contained more complete information and established a correlation with the middle Devonian of other states in the northern

interior of the United States.. This abstract is quoted below:

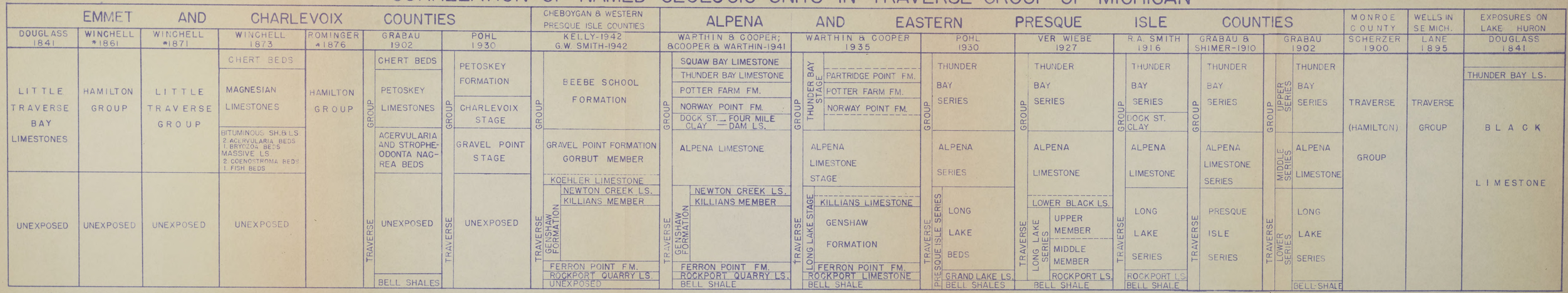
"Recent studies of Middle Devonian (Hamilton) sediments in New York,. Ontario, Michigan, Indiana, and Illinois demonstrate the greatest spread of the seas to have been in late Skaneateles and early Ludlowville time.. The Centerfield formation of New York, which is of lower Ludlowville age, contains an assemblage of unusual fossils, which are easily recognized and have a wide geographic range.. Foremost among these fossils is Spirifer divaricatus.. This assemblage can be traced across southwestern Ontario, where it occurs in the Encrinal and Coral beds of the Widder formation, to Michigan, where S.. divaricatus occurs at the top of the Alpena limestone on Thunder Bay River.. In Indiana the Beechwood limestone carries essentially the same assemblage of fossils as the Centerfield.. The Lingle limestone of Illinois contains many Beechwood species.. Thus, the Centerfield, or basal Ludlowville, can be traced in a great arc, from northern Michigan through western New York to southwestern Illinois..

"Establishment of the lower Ludlowville age of the formations mentioned indicates a Skaneateles age for the subjacent formations.. In the instances of the Arkona beds of Ontario, the Silver Creek of Indiana, and the Long Lake and Bell rocks of Michigan, the contained fossils corroborate this correlation.. The Misenheimer shale of southwestern Illinois appears to be a black shale facies of Skaneateles, rather than Marcellus, age, as heretofore supposed." (Cooper and Warthin, 1935, pp.. 376-377.)

The column labelled "Cooper and Warthin--1935" on Figure 3 shows the stratigraphic position of the Alpena limestone referred to above.. This column also shows the "Long Lake" formation, a term no longer used by Cooper and Warthin although it is retained by the Michigan Geological Survey.

In a recent publication Cooper and Warthin (1941, pp.. 259-260) add information regarding correlation of the Logansport limestone of north-central Indiana.. The Four-Mile Dam limestone of the Traverse Group ("Warthin and

CORRELATION OF NAMED GEOLOGIC UNITS IN TRAVERSE GROUP OF MICHIGAN



*ALSO APPLIED TO EASTERN EXPOSURES IN THUNDER BAY REGION

BROKEN LINES INDICATE UNCERTAINTY OF CORRELATION

COMPILED BY G. WENDELL SMITH — 1942

FIGURE 3.

Cooper; and Cooper and Warthin--1941" on Figure 3 shows stratigraphic position.) is now considered to have its closest affinities with the Logansport, although this Indiana limestone was once thought to be Onandaga in age. It necessarily follows that the Genshaw and Ferron Point formations are older than the Logansport, because they are older than the Four-Mile Dam limestone.

DESCRIPTION OF SECTIONS

In the following stratigraphic descriptions the locality numbers are those used by the writer. A few of these are localities which have been described in print by other workers, (Pohl, E. R., 1930; Deiss, C. F., 1932; McNair, A. H., 1937; Warthin, A. S., Jr., and Cooper, G. A., 1941), all of whom used the same numbers. The locality numbers below 53 which they used were "...established by the joint field party of the Michigan and United States Geological Surveys in 1926, and are used by Cooper in the U. S. National Museum." (Warthin and Cooper, idem., p. 9). The Museum of Paleontology at the University of Michigan also uses this system of numbering.

The writer has not duplicated any of the numbers that the other workers used in the map-area of this thesis. Those numbers in parentheses below the writer's locality numbers in the following discussion are those used by previous workers in the area.

The stratigraphic sections are described in descending order. They are composites of exposures usually within a few hundred feet of each other. The locality descriptions, however, tell the location of the outcrops which were used in the preparation of the composite sections.

Locality 1

Discontinuous outcrops in ledges along Pigeon River from the Old Elmer Dam down the river for about 1,500 feet. Located in Sec. 12, T. 34 N., R. 2 W.

Genshaw formation:

Bed No.	Lithology	Thickness Feet	Thickness Inches
7	Limestone: tan, dense, partly magnesian.	1	6
6	Shale: calcareous, light gray.	1	
	Covered interval	4	
5	Shale: gray, plastic.	1	
4	Limestone: buff-gray to brown, dense.	3	
3	Limestone: shaly, light gray.	2	6
	Covered interval	2	
2	Limestone: dense, black, poorly bedded.	3	
1	Limestone: dense, light gray, lower half contains shale layers.	3	
	Total Thickness	21	

Fossils:

Bed 6:

Echinoderma:
- Crinostyli

Bryozoa:
- Fenestella sp.

Brachiopods:
- Athyris sp.
- Atrypa sp. (large)
- Chonetes sp. aff. C. fragilis Stewart
- Delthyris? sp.
- Mucrospirifer sp. I
- Platyrachella? sp.
- Productella sp.

Pelecypods:
- Pterinea sp.

Cephalopoda:
- Gomphoceras sp.
- Cephalopoda, indet.

Bed 6 (Continued):
Trilobita:
Proetus sp.
Fish plate, indet.

Beds 3 and 4:
Coelenterata:
Favosites sp.
Brachiopoda:
Cyrtina alpenensis Hall and Clarke
Mucrospirifer sp. I
Pentamerella? sp.
Schizophoria sp.
Cephalopoda, indet.

Bed 1:
Coelenterata:
Favosites sp. (digitate type)
Prismatophyllum sp.
Brachiopoda:
Athyris sp.
Atrypa sp.
Chonetes sp. aff. *C. fragilis* Stewart
Pholidostrophia sp.
Platyrachella? sp.
Stropheodonta sp. aff. *S. demissa* (Conrad)
Pelecypoda:
Pterinea sp.
Trilobita:
Proetus sp.

Locality 2

Small exposure along southern branch of Little Pigeon River, where it crosses the western section line of Sec. 24, T. 35 N., R. 2 W.

Bed No.	Lithology	Thickness Feet	Inches
1	Limestone: gray, slabby, dense. Fossils: *Favosites* sp., *Prismatophyllum* sp., *Atrypa* sp., and *Schizophoria* sp.	1	8

Locality 3
(64), (65), (66)

Top of the sub-Killians Genshaw and also the Killians member in exposures chiefly in road cuts along the southern lines of Secs. 19 and 24, and along the western boundary of Sec. 30. The best section of the Killians was measured in the

old railroad cut in Sec. 30. Exact location of outcrops: SE¼, SE¼, Sec. 24; NE¼, NE¼, Sec. 25; SW¼, SW¼, Sec. 19: T. 35 N., R. 2 W; and NW¼, Sec. 30, T. 35 N., R. 1 W.

Jenshaw formation, Killians member:

Bed. No.	Lithology	Thickness Feet	Inches
5	Limestone: black, shaly, crinoidal.	5	6
4	Limestone: black, dense, thin-bedded.	3	
3	Limestone: black, dense. Poorly exposed.	12	
2	Limestone: black, shaly, gray-weathering. Base of Killians member.	5	
1	Limestone: gray, shaly, and tan, slabby. Poorly exposed.	2	
	Total Thickness	27	6

Fossils:

Bed 5 is composed of little else than crinostyli cemented together with black shaly limestone.

Bed 3:
- Crinostyli, indet.
- Brachiopoda:
  - Chonetes sp. aff. C. fragilis Stewart
  - Cyrtina sp.
  - Mucrospirifer sp. I
  - Platyrachella? sp.
  - Schizophoria sp.
- Trilobita:
  - Proetus sp.
- Fish plate, indet.

Bed 2:
- Coelenterata:
  - Favosites sp.
- Crinostyli, indet.
- Brachiopoda:
  - Athyris sp.
  - Mucrospirifer sp. I
  - Pholidostrophia sp.
  - Schizophoria sp.
  - Stropheodonta sp.

Locality 4
(63)

Outcrop of the Killians in Sec. 6, T. 34 N., R. 1 E., where STATE Highway No. 33 crosses Milligan Creek. The section is poorly exposed, and fossils were not collected.

Locality 4 (Continued)

Genshaw formation, Killians member:

Bed No.	Lithology	Thickness Feet	Thickness Inches
1	Limestone: black, shaly, slabby. Mucrospirifer sp. I abundant.	5 (Estimated)	

Locality 5

Milligan Creek exposures of the Ferron Point and Genshaw formations. A traverse was run and elevations carried upstream from the bridge of the Detroit and Mackinac railroad across Milligan Creek, where the top of the Rockport Quarry formation is exposed. The traverse ended where Milligan Creek crosses the western line of Sec. 31, T. 35 N., R. 1 E. Beds 14 to 19 were measured in a high bluff in the north-central part of Sec. 31, where the Milligan makes a turn to the northwest. (Due north of the section number "31" on Pl. I). Beds 10 and 13 are found between the above locality and the point where the creek crosses the eastern line of Sec. 30, T. 35 N., R. 1 E. Bed 10 is exposed at the base of the ridge about 100 feet north of the point where Milligan Creek crosses the line between Secs. 29 and 30, T. 35 N., R. 1 E. The other beds occur in ledge outcrops along the creek down the valley from this last point.

Genshaw formation:

Bed No.	Lithology	Thickness Feet	Thickness Inches
19	Limestone: gray, thin-and irregularly bedded.	7	
18	Limestone: gray, massive, fine to medium texture. Fragmentary fossils.	3	4
17	Shale: calcareous, light gray, soft.	1	
16	Limestone: gray, massive. Lower 6 inches is coquina.	1	6
15	Shale: calcareous, gray, crumbly.	1	4
14	Limestone: gray, poorly bedded. A 1-inch layer of shale at base.	2	6
13	Limestone: alternating light and dark gray, regularly bedded. Silicified fossils.	3	
12	Limestone: dark gray to black, shaly.	2	6
11	Limestone: light to dark gray, shaly layers. Poorly exposed.	9	
10	Limestone: gray to black. Medium and well bedded.	3	6
9	Limestone: dark to light gray, shaly. Covered interval.	10 4	6

Genshaw formation (Continued):

Bed No.	Lithology	Thickness Feet	Inches
8	Limestone: dark gray, shaly, thin and poorly bedded.	2	6
7	Limestone: gray, crystalline, poorly bedded.	2	6
6	Limestone: dark to light gray, shaly.	5	6
5	Limestone: blue-gray to black, argillaceous.	6	
4	Limestone: dark gray, argillaceous.	4	
	Covered interval.	6	
3	Limestone: dark bluish-gray, shaly.	3	
2	Limestone: gray, irregularly bedded.	3	
	Ferron Point formation:		
1	Limestone: greenish gray, soft, very shaly.	3	
	Covered interval. (Estimated).	1	
	Total Thickness	84	8

Top of Rockport Quarry formation.

Fossils:

Bed 17:

Coelenterata:

Favosites sp.

Brachiopoda:

Athyris sp.

Atrypa sp. (large)

Mucrospirifer sp. I

Stropheodonta sp.

Bed 15:

Coelenterata:

Favosites sp.

Horn Coral, indet.

Prismatophyllum sp.

Stromatopora? sp. (small mamelons; colony cylindrical; rounded ends.)

S.? sp. (large, widely spaced mamelons)

Crinostyli, indet.

Bryozoa, indet.

Brachiopoda:

Atrypa sp. (large)

Mucrospirifer sp. I

Stropheodonta sp. aff. *S. demissa* (Conrad)

S. sp.

Fossils (Continued):

Bed 14:

Coelenterata:

Aulopora sp.

Favosites sp. (digitate type)

Crinostyli, indet.

Bryozoa:

Fenestella sp.

Bryozoa, indet.

Brachiopoda:

Athyris sp.

Atrypa sp. (large)

Cyrtina sp.

Delthyris? sp.

Mucrospirifer sp. I

Pentamerella? sp. I

P.? sp. V

Platyrachella? sp.

Sieberella sp. II

Stropheodonta erratica var. solidicosta Winchell

Bed 13:

Coelenterata:

Favosites sp. (spheroidal coralla)

Prismatophyllum sp.

Crinostyli, indet.

Brachiopoda:

Platyrachella? sp.

Bed 10:

Brachiopoda:

Sieberella sp. I

Trilobita:

Proetus sp.

Bed 9:

Coelenterata:

Aulopora? sp.

Clathrodictyon cf. retiforme (Nicholson and Murie).

Favosites sp. (both dumose and digitate types).

Prismatophyllum sp.

Crinostyli, indet.

Bryozoa:

Fenestella sp.

Brachiopoda:

Atrypa sp.

Pentamerella? sp. I

P.? sp. V

Platyrachella? sp.

Sieberella sp. II

Stropheodonta sp.

Fossils (Continued):

Bed 8:

Coelenterata?:

Clathrodictyon cf. retiforme (Nicholson and Murie).

Bed 7:

Coelenterata?:

Clathrodictyon cf. retiforme (Nicholson and Murie).

Brachiopoda:

Strophеodonta sp. aff. S. demissa (Conrad)

Pelecypoda:

Pterinea sp.

Bed 5:

Coelenterata:

Horn coral, indet.

Brachiopoda:

Atrypa sp. (small)

Pentamerella? sp. V

Pholidostrophia sp.

Platyrachella? sp.

Schuchertella? sp.

Strophеodonta sp.

Bed 4:

Brachiopoda:

Atrypa sp. (large)

Pentamerella? sp. aff. P. dubia Hall

P.? sp. III

Bed 2:

Coelenterata:

Horn Coral, indet.

Brachiopoda:

Athyris sp.

Atrypa sp. (small)

Pentamerella? sp. IV

Strophеodonta cf. erratica Winchell

Bed 1:

Coelenterata:

Aulopora sp. aff. A. serpens Rominger

Favosites sp. (placenta type)

Brachiopoda:

Atrypa sp. (small)

Delthyris? sp.

Mucrospirifer sp. I

Pentamerella? sp. aff. P. dubia Hall

Strophеodonta erratica var. fissicosta Winchell

Locality 6

Exposures of the Killians member in road cut, NW cor., Sec. 9, T. 34 N., R. 1 E., and the small inlier of pre-Killians Genshaw in the ditch on south side of State Highway 33, opposite end of blind road, NE¼, Sec. 8, T. 34 N., R. 1 E.

Genshaw formation, Killians member:

Bed No.	Lithology	Thickness Feet	Inches
3	Limestone: black, dense, hard.	1	6
2	Shale: black, platy. Base of Killians.	2	6
1	Limestone: light gray, argillaceous.	2	
	Total Thickness	6	

Fossils:

Bed 3:
- Coelenterata:
  - Horn Coral, indet.
- Crinostyli, indet.
- Brachiopoda:
  - Chonetes sp. aff. C. fragilis Stewart
  - Platyrachella? sp.
- Fish plate, indet.

Bed 2:
- Coelenterata:
  - Stromatopora? sp.
- Bryozoa:
  - Fenestella sp.
- Brachiopoda:
  - Atrypa sp. (large)
  - Cyrtina alpenensis Hall and Clarke
  - Cyrtina sp. I
  - Cyrtina sp.
  - Mucrospirifer sp. I
  - Pholidostrophia sp.
  - Platyrachella? sp.
  - Productella sp.
- Pelecypoda, indet.

Bed 1:
- Coelenterata:
  - Favosites sp. (digitate type)
- Bryozoa:
  - Fenestella sp.
  - Bryozoa, indet.

Fossils (Continued):
Bed 1 (Continued):
Brachiopoda:
Atrypa sp. (large)
Chonetes sp. aff. *C. fragilis* Stewart
Cyrtina albenensis Hall and Clarke
Cyrtina sp.
Mucrospirifer sp. I
Pentamerella? sp. V
Pholidostrophia sp.
Platyrachella? sp.
Schizophoria sp.
Stropheodonta cf. *erratica* Winchell
Stropheodonta sp. aff. *S. demissa* (Conrad)
Stropheodonta sp.
Pelecypoda, indet.
Trilobita:
Proetus sp.

Locality 7
(28)

This Genshaw section is exposed below Power Dam in Sec. 3, T. 34 N., R. 1 E., along Black River.

Genshaw formation:

Bed No.	Lithology	Thickness Feet	Inches
9	Limestone: light gray, shaly.	2	2
8	Limestone: dull gray, hard, shaly.	1	
7	Limestone: tan to light gray, irregularly bedded, argillaceous.	2	4
6	Limestone: brownish gray, thick bedded, dense, hard, bituminous.	2	6
5	Limestone: light gray, soft, poorly bedded, lower 6 inches very shaly.	2	
4	Shale: calcareous, light gray.	1	
3	Limestone: black, shaly.	2	6
2	Limestone: light gray, hard.	2	6
1	Limestone: gray, shaly.	1	4
	Total Thickness	17	4

Fossils:
Bed 9:
Coelenterata:
Clathrodictyon cf. *retiformme* (Nicholson and Murie)
Favosites sp. (digitate type)
Brachiopoda:
Atrypa sp. (large)
Pentamerella? sp. I

Fossils (Continued):

Bed 8:
- Crinostyli, indet.

Bed 6:
- Brachiopoda:
  - Atrypa sp. (large and small)
  - Pentamerella? sp. I
  - Platyrachella? sp.

Bed 5:
- Coelenterata:
  - Aulopora sp.
  - Horn Coral, indet.
  - Favosites sp.
- Crinostyli, indet.
- Bryozoa:
  - Fenestella cf. megalopora Deiss
- Brachiopoda:
  - Athyris sp.
  - Atrypa sp. (large and small)
  - Mucrospirifer sp. I
  - Platyrachella? sp.
  - Stropheodonta sp. aff. S. demissa (Conrad)
  - S. sp.

Bed 4:
- Coelenterata:
  - Favosites sp. (both digitate and dumose types)
- Brachiopoda:
  - Athyris sp.
  - Atrypa sp. (large)
  - Delthyris? sp.
  - Mucrospirifer sp. I
  - Pentamerella? sp. I
  - P.? sp. V
  - Pholidostrophia sp.
  - Platyrachella? sp.
  - Productella sp.
  - Stropheodonta cf. erratica Winchell
  - S. erratica var. solidicosta Winchell
  - S. sp.
- Pelecypoda:
  - Pterinea sp.

Bed 3:
- Coelenterata:
  - Aulopora sp.
  - Prismatophyllum sp.
- Bryozoa:
  - Fenestella sp.

Fossils (Continued):
Bed 3 (Continued):
Brachiopoda:
Athyris sp.
Atrypa sp. (large)
Mucrospirifer sp. I
Pentamerella? sp. I
Pholidostrophia sp.
Platyrachella? sp.
Productella sp.
Sieberella? sp. II
Stropheodonta cf. *erratica* Winchell
S. erratica var. *solidicosta* Winchell
S. sp.

Bed 2:
Coelenterata:
Clathrodictyon cf. *retiforme* (Nicholson and Murie)
Crinostyli, indet.
Brachiopoda:
Atrypa sp. (large)
Pentamerella? sp. I
Platyrachella? sp.
Stropheodonta sp.
Trilobita:
Proetus sp.

Bed 1:
Coelenterata:
Favosites sp. (both digitate and spheroidal coralla present)
Prismatophyllum sp.
Crinostyli, indet.
Bryozoa:
Fenestella sp.
Bryozoa, indet.
Brachiopoda:
Atrypa sp. (large)
Delthyris? sp.
Mucrospirifer sp. I
Pentamerella? sp. I
P.? sp. VI
Platyrachella? sp.
Productella sp.
Schizophoria sp.
Sieberella? sp. II
Stropheodonta cf. *erratica* Winchell
S. erratica var. *solidicosta* Winchell
S. sp. aff. *S. demissa* (Conrad)
Pelecypoda:
Pterinea? sp.

Locality 8

Exposures found at four places along the road following the center line of Sec. 34, T. 35 N., R. 1 E. (See Pl. I). The northernmost outcrop is at the N. ¼ cor., Sec. 34, and extends about 100 feet south of the corner. No strata are exposed between this outcrop and a low scarp 1,230 feet south of the N. ¼ cor. In the scarp is exposed bed 6, which yielded only undetermined stromatoporoids. A concealed interval extends to the base of the hill at the center of the section. (See Fig. 4). Along this hill beds 4, 5, and 6 are exposed. Bed 6 is in the Clathrodictyon-Pentamerella zone and is best exposed 1,800 feet east of the center ¼ cor., Sec. 34. There are no outcrops from the top of the hill for a distance 3,300 feet south of the N. ¼ cor. At 3,300 feet, however, beds 7, 8, 9, 10, and 11 are seen in the roadcut. Bed 10 is a 2-foot layer of dense black limestone, typical of the Killians. A dip of 5° to the south taken on this member is the only dip measurable in Sec. 34.

The relatively long distance between outcrops and the lack of dip measurement makes interpretation of the stratigraphic relations of these outcrops difficult. One interpretation, considered to be the more probable, is shown on Fig. 4. This figure is based on the assumption that the exposures lie on the southern limb of a concentric anticlinal fold, as indicated by structural evidence

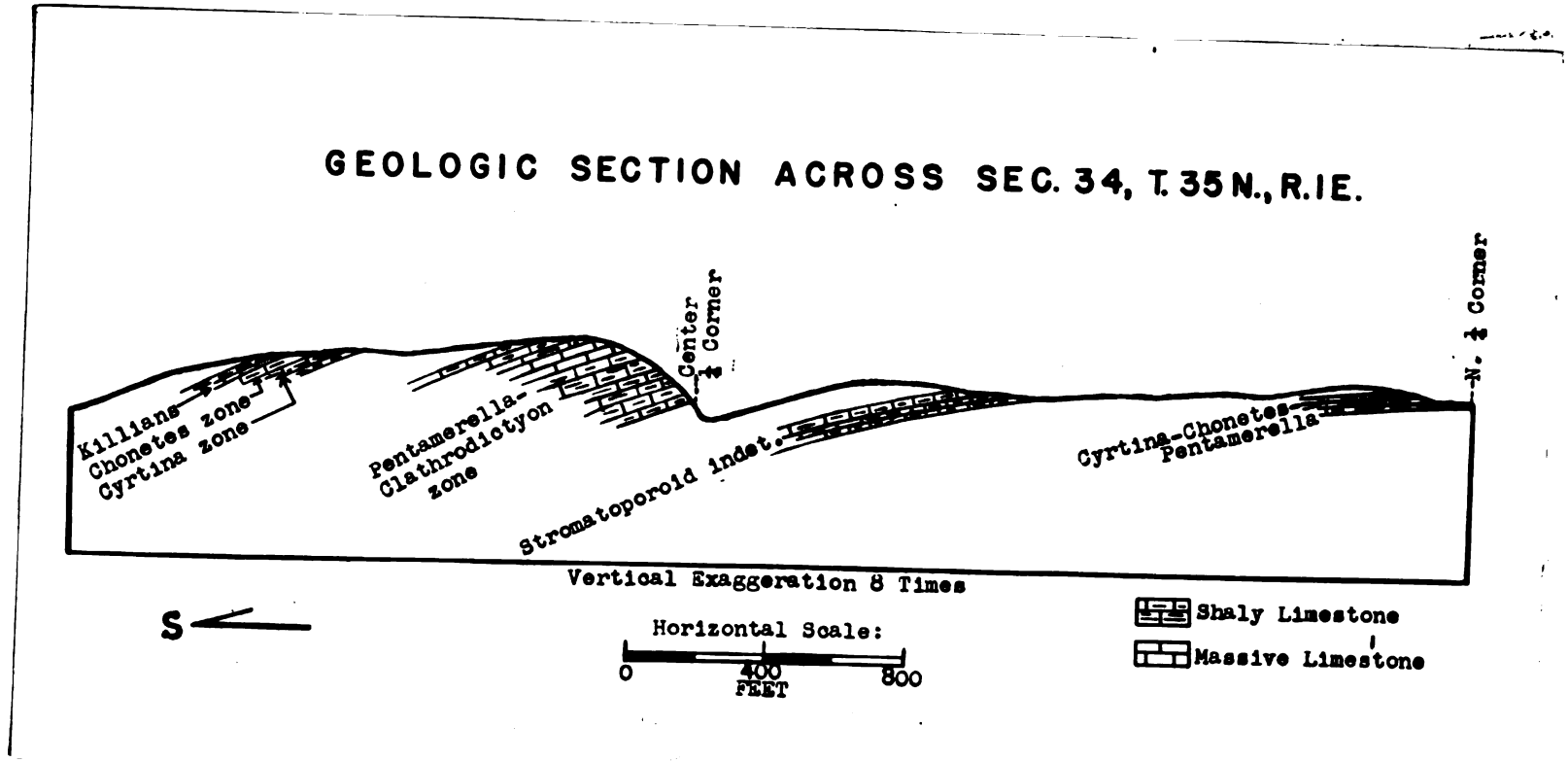

GEOLOGIC SECTION ACROSS SEC. 34, T. 35 N., R. 1E.
Killians
Chonetes zone
Cyrtina zone
Pentamerella-
Clathrodictyon
zone
Center ¼ Corner
Stromatoporoid indet.
Cyrtina-Chonetes-
Pentamerella
N. ¼ Corner
Vertical Exaggeration 8 Times
S
Horizontal Scale:
0
400
800
FEET
Shaly Limestone
Massive Limestone

FIGURE 4.

from outside of Sec. 34. (See Pl. III). The thickness of the beds based upon the cross-section is 101 feet. Bed 10 is the Killians limestone, although the exposed section is thin. Thus there would be 97 feet of strata, exposed and concealed, between the Killians exposure and the N. ¼ cor. of Sec. 34. This would make the calculated elevation on the top of the Rockport 733 feet at the N. ¼ cor., Sec. 34, T. 35 N., R. 1 E. (See Pl. III). An elevation of 720 feet is more compatible with structural evidence (see discussion below); consequently, Fig. 4 may represent an interpretation having 13 feet of possible error.

Another interpretation is shown on the correlation chart (Fig. 5). In this figure the outcrops are assumed to represent rocks lying directly on each other from north to south. This latter interpretation is considered to be less plausible than the former, for structural evidence is lacking, since the top of the Rockport would be found at an impossible elevation on the basis of the local structure. Furthermore, fossils collected from the N. ¼ cor., are those found elsewhere in the lower third of the Genshaw, and only the placing of this section on the limb of an anticline would allow this outcrop to occupy its proper stratigraphic position.

Locality 8 (Continued)

Genshaw formation, Killians member:

Bed No.	Lithology	Thickness Feet	Inches
11	Limestone: light gray, shaly.	1	
10	Limestone: black, dense, almost lithographic. Base of Killians.	2	
9	Shale: light gray, calcareous. "Chonetes zone" of Fig. 4.	4	6
8	Shale: light gray, calcareous, "Cyrtina zone".	4	
7	Limestone: black, shaly.	2	
	Covered interval. (Estimated).	15	
6	Limestone: gray, shaly, poorly exposed. Contains thin gray shale layers. "Pentamerella-Clathrodictyon zone".	25	
5	Limestone: massive, light gray.	3	
4	Limestone: light gray, very shaly.	2	
	Covered interval.	15	
3	Limestone: gray, argillaceous.	6	6
	Covered interval. (Estimated).	15	
2	Limestone: dark gray to black, dense.	4	
1	Shale: light gray, calcareous.	2	
	Total Thickness	101	

Fossils:

Bed 10:

Coelenterata:
- Horn coral, indet.
- *Prismatophyllum* sp.

Brachiopoda:
- *Athyris* sp.
- *Atrypa* sp. (large)
- *Cyrtina alpenensis* Hall and Clarke
- *Pholidostrophia* sp.
- *Platyrachella*? sp.

Cephalopoda:
- *Gomphoceras*? sp.

Trilobita:
- *Proetus* sp.

Fish plate, indet.

Bed 9:

Coelenterata:
- *Favosites* sp. (digitate and dumose types)

Bryozoa:
- *Fenestella* sp.
- Bryozoa, indet.

Fossils (Continued):
Bed 9 (Continued):
Brachiopoda:
Athyris sp.
Atrypa sp.
Chonetes sp. aff. C. fragilis Stewart
Cyrtina sp.
Mucrospirifer sp. I
Pholidostrophia sp.
Platyrachella? sp.
Productella sp.
Stropheodonta erratica var. solidicosta Winchell
S. sp.
Ostracoda, indet.

Bed 8:
Brachiopoda:
Atrypa sp.
Cyrtina alpenensis Hall and Clarke
Cyrtina hamiltonensis Hall
Cyrtina sp. I
Cyrtina sp.
Mucrospirifer sp. I
Pholidostrophia sp.
Platyrachella? sp.
Stropheodonta cf. erratica Winchell
S. sp. aff. S. concava Hall
S. sp. aff. S. demissa (Conrad)
S. sp.

Bed 6:
Coelenterata:
Clathrodictyon cf. retiforme (Nicholson and Murie)
Brachiopoda:
Cyrtina alpenensis Hall
Pentamerella? sp. I
P.? sp. III
P.? sp. V
P.? sp. VI
Platyrachella? sp.
Trilobita:
Proetus sp.

Bed 4:
Coelenterata:
Clathrodictyon cf. retiforme (Nicholson and Murie)
Favosites sp. (digitate type)
Prismatophyllum sp.
Crinostyli, indet.
Bryozoa:
Fenestella sp.

Fossils (Continued):
Bed 4 (Continued):
Brachiopoda:
Atrypa sp.
Cyrtina hamiltonensis Hall
Pentamerella? sp. V
P.? sp. VI
Platyrachella? sp.
Productella sp.
Stropheodonta sp.

Bed 3:
Coelenterata:
Stromatopora sp. (large, widely-spaced mamelons)

Bed 2:
Brachiopoda:
Mucrospirifer sp. I
Pholidostrophia sp.
Platyrachella? sp.
Pelecypod, indet.

Bed 1:
Brachiopoda:
Athyris sp.
Atrypa sp.
Chonetes sp. aff. C. fragilis Stewart
Cyrtina alpenensis Hall and Clarke
Mucrospirifer? sp.
Mucrospirifer sp. II
Pentamerella? sp. aff. P. dubia Hall
P.? sp. III
P.? sp. IV
Pholidostrophia sp.
Platyrachella? sp.
Schizophoria sp.
Strophecdonta erratica var. fissicosta Winchell
S. erratica var. solidicosta Winchell
S. sp.
Pelecypoda:
Pterinea sp.
Indet. (Glyptodesma type)
Trilobita:
Proetus sp.
Fish plate, indet.

Locality 9

Section exposed at the base of the ridge, known locally as Limestone Hill, on the western line of Sec. 22, T. 35 N., R. 1 E., 1,780 feet north of the SW cor. Outcrop begins about 10 feet above the base of the Genshaw formation.

Locality 9 (Continued)

Genshaw formation:

Bed No.	Lithology	Thickness Feet	Inches
2	Limestone: light to dark gray, poorly bedded.	5	
1	Limestone: light gray, shaly. Poorly exposed.	8	
	Total Thickness	13	

Fossils

Bed 2:

Coelenterata:

Stromatopora? sp. (large, widely spaced mamelons)

Crinostyli, indet.

Bryozoa, indet.

Brachiopoda:

Atrypa sp.

Cyrtina sp.

Stropheodonta sp.

Pelecypoda, indet.

Trilobita, indet.

Bed 1:

Coelenterata:

Prismatophyllum sp.

Stromatopora? sp. (large, widely spaced mamelons)

Crinostyli, indet.

Brachiopoda:

Pentamerella? sp. VI

Platyrachella? sp.

Stropheodonta sp.

Locality 10

Top of the sub-Killians as well as the Killians member of the Genshaw formation found in low cuestas in the NE¼, SW¼, Sec. 36, T. 35 N., R. 1 E., two and a half miles northeast of Tower.

Genshaw formation, Killians member:

Bed No.	Lithology	Thickness Feet	Inches
3	Limestone: black, dense, shaly layers	4	6
2	Shale: black, calcareous. Base of Killians member.	7	6
1	Limestone: light gray to black, argillaceous.	7	
	Total Thickness	19	

Locality 10 (Continued)

Fossils:

Bed 3:

Coelenterata:

Favosites sp. (spheroidal corallum)

Bryozoa, indet.

Cephalopoda:

Gomphoceras sp.

Bed 2:

Coelenterata:

Aulacophyllum sp.

Favosites sp. (digitate type)

Prismatophyllum sp.

Stromatopora? sp. (large, widely spaced mamelons)

Crinostyli, indet.

Bryozoa:

Fenestella sp.

Brachiopoda:

Athyris sp.

Atrypa sp. (large)

Mucrospirifer sp. I

Pholidostrophia sp.

Platyrachella? sp.

Productella sp.

Schizophoria sp.

Schuchertella? sp.

Stropheodonta sp.

Pelecypoda, indet.

Trilobita:

Proetus sp.

Fish plate, indet.

Bed 1:

Coelenterata:

Prismatophyllum sp.

Stromatopora? sp. (small mamelons)

Crinostyli, indet.

Brachiopoda:

Atrypa sp. (large)

Chonetes sp. aff. *C. fragilis* Stewart

Cyrtina alpenensis Hall and Clarke

C. sp. I

Delthyris? sp. I

Mucrospirifer sp. I

Pentamerella? sp. VI

Platyrachella? sp.

Locality 11
(29)

Composite section of the Ferron Point and the lowest beds of the Genshaw obtained from the exposures in the abandoned quarry of the Cnaway Limestone Co. at Black Lake and in the cliff along the southern shore of the lake, in Sec. 7, T. 35 N., R. 2 E. The fauna from the Ferron Point formation is the best preserved of any in the area of study.

Genshaw formation:

Bed No.	Lithology	Thickness Feet	Inches
4	Limestone: dense, gray, slightly argillaceous.	7	
3	Limestone: dense, light gray, thick- and well-bedded.	3	
2	Limestone: dense, massive, thick-bedded. Many overturned coralla of Prismatophyllum sp. Base of Genshaw.	6	6

Ferron Point formation:

1	Shale: greenish-gray, thin-bedded, plastic, intercalated limestone layers.	9	
	Total Thickness	25	6

Top of Rockport Quarry formation.

Fossils:

Bed 4:
- Coelenterata:
  - Prismatophyllum sp.
- Brachiopoda:
  - Pentamerella? sp. III
  - P.? sp. IV

Bed 2:
- Coelenterata:
  - Prismatophyllum sp.
  - Stromatopora? sp. (very small, closely spaced mamelons)
- Crinostyli, indet.
- Brachiopoda:
  - Sieberella sp. I

Bed 1:
- Coelenterata:
  - Aulopora sp. aff. A. serpens Rominger
  - Cystiphyllum sp.
  - Favosites sp. (digitate type)
  - Horn coral, indet.
  - Prismatophyllum sp.

Fossils (Continued):
Bed 1 (Continued):
Echinoderma:
Crinostyli:
CF6 cf. A Davies
CC cf. 2 Davies
CC cf. 4 Davies
CC7A Davies
CC3 cf. A Davies
CC indet. Davies
Bryozoa:
Fenestella sp.
Bryozoa, indet.
Brachiopoda:
Athyris sp.
Atrypa sp. (small)
Chonetes sp. aff. *coronatus* (Conrad)
C. sp. aff. *C. fragilis* Stewart
Delthyris? sp.
Mucrospirifer sp. I
M. sp. II
Pentamerella? cf. *pavilionensis* Hall
Schuchertella sp.
Pelecypoda, indet.
Pelecypoda:
Pterinea cf. *flabellum* (Conrad)
Gastropoda?:
Tentaculites sp. aff. *gyracanthus* (Eaton)
T. cf. *scalariformis* Hall
Trilobita:
Proetus sp. I (small)
P. sp. (large)

Locality 12

Intermittent exposures of the Genshaw found along an escarpment trending approximately east-west in the SE¼, Sec. 25, T. 35 N., R. 1 E. Best exposed along road 1,100 feet south of the W¼ cor., extending in escarpment to the E¼ cor., Sec. 30, T. 35 N., R. 2 E.

Genshaw formation:

Bed No.	Lithology	Thickness Feet	Inches
5	Limestone: gray, shaly.	2	
4	Limestone: gray, argillaceous.	5	
3	Limestone: light gray, shaly.	2	6
2	Limestone: dark gray to black, poorly bedded, dense.	2	6
1	Limestone: dark gray, dense, unevenly bedded.	10	
	Total Thickness	22	

Locality 12 (Continued)

Fossils:

Bed 5:
- Coelenterata:
  - Stromatopora? sp. (large, widely spaced mamelons)

Bed 4:
- Coelenterata:
  - Prismatophyllum sp.
- Crinostyli, indet.

Bed 3:
- Coelenterata:
  - Prismatophyllum sp.

Bed 1:
- Coelenterata:
  - Favosites sp.
  - Prismatophyllum sp.
  - Stromatopora? sp. (small, closely spaced mamelons)
- Brachiopoda:
  - Atrypa sp.
  - Cyrtina sp.
  - Pentamerella? sp.
  - Platyrachella? sp.
  - Stropheodonta sp.

Locality 13

Section obtained by traverse run from 1,330 feet east of center, Sec. 32, past Rowe School to last Genshaw outcrop 1,400 feet north of W.¼ cor., Sec. 29, T. 35 N., R. 2 E. Exposures are found intermittently along low escarpment trending N. 40° W. This section also includes one small exposure which is 1,580 feet north of the last-named Genshaw outcrop in Sec. 29; found along the highway.

Genshaw formation:

Bed No.	Lithology	Thickness Feet	Inches
7	Limestone: dark gray, thin-bedded.	2	
	Concealed interval.	7	
6	Shale: calcareous, light gray.	1	
5	Limestone: light to dark gray, massive.	2	6
4	Limestone: tannish gray and shaly at top, grades into light gray, thin-bedded at base. "Clathrodictyon zone".	7	
	Concealed interval.	5	
3	Limestone: gray, massive, dense.	2	

Locality 13 (Continued)

Genshaw formation:

Bed No.	Lithology	Thickness Feet	Inches
2	Limestone: light gray, shaly, thin-bedded	2	
	Concealed interval.	8	
1	Limestone: massive, well-bedded, dark gray, shaly at base.	3	
	Total Thickness	39	6

Fossils:

Bed 7:
- Horn corals, indet.
- Crinostyli, indet.
- Bryozoa, indet.
- Brachiopoda:
  - Atrypa sp.
  - Pentamerella? sp. I
  - Platyrachella? sp.
  - Stropheodonta sp.

Bed 6:
- Brachiopoda:
  - Pentamerella? sp. V

Bed 5:
- Coelenterata:
  - Stromatopora? sp. (small, widely spaced mamelons)
- Bryozoa:
  - Fenestella sp.
- Brachiopoda:
  - Athyris sp.
  - Atrypa sp.
  - Mucrospirifer sp. I
  - Pentamerella? sp.
  - P. sp. I
  - Pholidostrophia sp.
  - Platyrachella? sp.

Bed 4:
- Coelenterata:
  - Clathrodictyon cf. retiforme (Nicholson and Murie)
  - Prismatophyllum sp.
- Brachiopoda:
  - Platyrachella? sp.
  - Stropheodonta sp. aff. S. demissa (Conrad)
  - S. sp.
- Pelecypoda, indet.

Fossils (Continued):
Bed 1:
Coelenterata:
Favosites sp. (dumose type)
Brachiopoda:
Atrypa sp.
Mucrospirifer sp. I
Pholidostrophia sp.
Platyrachella? sp.
Stropheodonta sp.

Locality 14

Rocks exposed 180 feet south of SE cor., Sec. 30, T. 35 N., R. 2 E., one and one-half miles north of Cnaway. Not shown on the correlation chart, Fig. 5. The upper two beds, beds 2 and 3 below, are probably the lower part of the Newton Creek limestone. The fossils contained are so different from those found in the top of the subjacent Killians member, bed 1 below, that the writer did not study them. Dr. G. A. Cooper of the U. S. National Museum is examining this faunule to determine whether or not it is typical of the Newton Creek.

Genshaw formation, Newton Creek limestone member:

Bed No.	Lithology	Thickness Feet	Inches
3	Limestone: tan to brown, crystalline, dense, hard.		1
2	Limestone: light tannish-gray, pure, dense, crystalline. Base of Newton Creek.		1

Killians member:

1	Limestone: black, bituminous, shaly.		2
	Total Thickness		4

Fossils:
Bed 1:
Coelenterata:
Favosites sp.
Crinostyli, indet.
Bryozoa, indet.
Brachiopoda:
Athyris sp.
Atrypa sp.
Pentamerella? sp. V
Platyrachella? sp.
Pholidostrophia sp.
Productella sp.
Schizophoria sp.
Sieberella? sp. II
Stropheodonta sp.

Locality 15

Ledges of Killians limestone below water level on Upper Black River in E½, Sec. 13, T. 34 N., R. 2 E. No collections were made.

Locality 16

Section obtained by study of the samples of the exploratory well, Campbell No. 1, drilled in S½, NE¼, Sec. 7, T. 34 N., R. 1 W. The detailed descriptions are limited to the Genshaw and Ferron Point formations, but the general lithology and thickness of the overlying and underlying formations is also given. Elevation at surface, 847 feet above sea level.

Formation	Lithology	Thickness	Depth
Glacial drift		25	25
Gravel Point			
Gorbut member			
	Grey and black limestone	15	40
Koehler			
	Buff and gray limestone	60	100
Genshaw			
Killians member			
	Limestone: dark gray, argillaceous.	5	105
	Limestone: gray porous, and black laminated. Pyrite. Fossil fragments.	5	110
	Limestone: black, shaly. Bryozoa.	5	115
	Limestone: black. Pyrite. Bryozoa, crinostyli.	5	120
	Limestone: black to light gray argillaceous with a little brown dolomite. Crinostyli, bryozoa, gastropod. Pyrite.	10	130
	Total thickness, Killians	30 feet	
	Limestone: light to dark gray, argillaceous. Crinostyli, Tentaculites sp., brachiopods.	5	135
	Limestone: hard, dense, argillaceous, buff; some grey dolomitic. Bryozoa.	10	145
	Limestone: light gray, argillaceous.	5	150
	Limestone: light gray, shaly.	15	165
	Limestone: gray to white, calcite crystals. Crinostyli, brachiopods, bryozoa. Some pyrite.	5	170
	Limestone: light gray shaly. Pyrite. Crinostyli, Tentaculites sp., Bryozoa.	15	185
	Limestone: gray, argillaceous. Pyrite. Crinostyli, Cyrtina? sp., bryozoa.	15	200

Formation	Lithology	Thickness	Depth
Genshaw (pre-Killians, Continued)			
	Limestone: gray, black streaked, dense. Pyrite, bryozoa, Tentaculites sp., brachiopods.	5	205
	Limestone: gray, argillaceous. Crinostyli, Stropheodonta? sp.	5	210
	Limestone: gray, dense, argillaceous. White calcite fragments. Crinostyli and brachiopod fragments.	10	220
	Limestone: dark gray, shaly, bituminous streaks. Pyrite, bryozoa and an ostracod.	5	225
	Limestone: dark gray. Calcite crystals. Crinostyli, bryozoa, Tentaculites sp.	5	230
	Limestone: gray, dense, argillaceous. Pyrite. Bryozoa, crinostyli, ostracod.	10	240
	Limestone: dark gray, argillaceous. Calcite and pyrite crystals. Crinostyli, bryozoa.	8	248
	Total thickness of Genshaw (including Killians)	148	
Ferron Point			
	Shale: calcareous, light gray, soft, plastic when wet. Fragments of brachiopods; crinostyli.	7	255
Rockport Quarry			
	Limestone: buff, lithographic at top, stylolitic; lower 20 feet is black, bituminous, some dolomitic.	50	305
Bell shale			
	Dark gray, limy shale. Pyritiferous. Crinostyli abundant.	90	395

Top of Dundee limestone.

SYSTEMATIC DESCRIPTIONS OF FOSSILS

Phylum BRACHIOPODA
Order PROTREMATA Beecher

Genus CHONETES Fischer de Waldheim 1837

The observed characteristics of the Genshaw and Ferron Point representatives of this genus coincide with Weller's description. (1914, pp. 78-79. Also consulted was Hall and Clarke, 1892, p. 303). Two species of the genus are recognizable; each has a limited stratigraphic range.

Chonetes aff. C. fragilis Stewart 1927

Chonetes fragilis Stewart, Ohio Geol. Survey; 4th Ser., Bull. 32, 1927, pp. 38-39.

Description.--Shell concavo-convex; subsemicircular in outline; small---dimensions of average specimen: length, 10 mm., width, 13 mm., thickness, 3 mm. Greatest width at mid-length of shell, but some specimens exhibit an extended hinge line which makes the shell mucronate with hinge-line width equal to greatest breadth of valves. Ventral valve gently convex with rounded apex near or slightly anterior to center of valve; postero-lateral region somewhat flattened. Concave cardinal area narrow, making a small angle with the plane of valve, postero-lateral margins of cardinal area bear about five spines at oblique angles. Triangular delthyrium small and closed by a sharply convex deltidium. Small papillae on inner surface of ventral valve.

Dorsal valve concave, concentric with inner surface of ventral valve; cardinal area narrow--less than 1 mm. wide.

Surface of both valves finely multicostellate; fine, low, rounded costellae are crossed by concentric growth lines; costellae number 16 in 5 mm. on ventral valve 5 mm. from beak. Bifurcation common on anterior half of shell.

Remarks.--C. aff. C. fragilis closely resembles C. fragilis Stewart from the Silica shale of Ohio, but Dr. G. M. Ehlers of the Museum of Paleontology at the University of Michigan has compared the Genshaw forms with topotypes of C. fragilis and states that the

> "...Genshaw specimens have more rounded costellae than typical examples of C. fragilis; they probably belong to a distinct species. There are a very few small shells in the Silica shale which resemble the Genshaw specimens in respect to the rounded character of the costellae; they differ from the latter, however, in being relatively wider." (Ehlers, 1942, Personal Communication.)

These observations were confirmed by the writer after comparison of the Ferron Point and Genshaw forms with topotypes of C. fragilis in the possession of the Geology Department at Michigan State College.

This species was found at several localities occupying positions in the transitional beds at the base of the Killians member and in a zone about 95 feet lower, in the Ferron Point formation. This is the form from which the "Chonetes zone," best exposed in Sec. 34, north of Tower, derives its name because of the abundant and consistent occurrence of these forms.

Several specimens of C. aff. C. fragilis were collected from beds at the N. ¼ cor., Sec. 34, north of Tower,

and from the Ferron Point at Black Lake. This, then, is a recurrent form.

Chonetes aff. C. coronatus (Conrad) 1842

Strophomena carinata Conrad, Jour. Acad. Nat. Sci., Philadelphia, vol. 8, 1842, p. 257, pl. 14, fig. 13. (Not available for reference.)
Chonetes coronatus Prosser, Md. Geol. Surv., Middle and Upper Dev., 1913, p. 148, pl. 11, figs. 18-21.
Chonetes coronatus Stewart, Ohio Geol. Survey, 4th Ser., Bull. 32, 1927, pp. 37-38.

Description.--This species differs from C. aff. C. fragilis in: being larger, with average dimensions: length, 13 mm., width, 18 mm., estimated thickness, 3 mm.; in having fewer (12) and larger costellae in 5 mm. at distance of 5 mm. from beak instead of 16 as in C. aff. C. fragilis; in having more spines on each side of beak (6 or 7); and in having more and much coarser papillae on the interior of the ventral valve.

Remarks.--Comparison of this Ferron Point form with C. coronatus from the Silica shale of Ohio shows the Cheboygan and Presque Isle County form to be much more finely costellate, and much thinner, although the two are similar in size. Miss Grace Stewart, who has identified C. coronatus from the Silica shale states: "The large specimens have slightly stronger striations than is usual in the species,..." (Stewart, op. cit., p. 38.)

This statement would indicate that the Ferron Point Chonetes may be quite as near C. coronatus from the New York Hamilton as the Silica shale forms, differing chiefly in being thinner. The characteristic shallow undefined sulcus along the middle

of the ventral valve is faint in some of the specimens collected from the Ferron Point formation.

Genus PENTAMERELLA Hall 1867

The generic status of the following described members of the genus Pentamerella is not firmly established. Hall (1867, p. 373) established the genus, but later investigations (Hall and Clarke, 1894, p. 245) showed the necessity for additional diagnostic features. Schuchert and Cooper (1932, pp. 171-177) added further diagnostic criteria, but it is still difficult to separate the genera Pentamerella, Sieberella, and Gypidula.

Cooper (1942, Personal Communication) states that he has seen forms with a "rectimarginate anterior commissure" and others "with a slight flexure developed in a ventral direction." The Genshaw forms show a slight flexure in a dorsal direction, but all other diagnostic criteria described by Schuchert and Cooper are observed in the forms studied by the writer. Cooper believes that his species is more like Pentamerella in its ornamentation than true Gypidula. He indicates his intention of calling the form Pentamerella? in his own work. The same terminology will be followed here.

A portion of Schuchert and Cooper's generic description upon which the determinations are based is quoted below:

> "Exterior.--Outline subtriangular to subpentagonal; hinge-line narrow; cardinal extremities rounded; lateral profile biconvex, the ventral valve having the greater convexity. Anterior commissure uniplicate; dorsal fold

> usually low, in some species nearly obsolete. Ventral interarea narrow, curved, apsacline, beak incurved strongly, umbo swollen; delthyrium with incipient deltidial plates. Dorsal interarea obsolete, beak curved under that of the ventral valve. Surface usually multicostate, occasionally smooth. Shell substance fibrous, impunctate.
> "Ventral interior.--Teeth narrow and sharp; spondylium duplex shallow;...septum short....
> "Dorsal interior.--Netothyrial cavity deep; plates supporting brachial processes broad and flat, supported by thin curved plates which unite in the mid-line of the shell to form a cruralium that in some specimens is supported by a low duplex septum...." (Schuchert and Cooper, 1932, p. 176).

Pentamerella? sp. I

Description.--Ovate to subtriangular in outline; biconvex, ventral valve exhibiting greater convexity. Length equal to width or slightly greater; thickness two-thirds to three-quarters times the length. Dimensions of a large specimen: length and width, each 39 mm., thickness, 31 mm.; the forms vary but little from these dimensions.

Ventral valve flattened in mesial area; steep umbonal flanks, gentler slope toward anterior. An incipient fold appears to be present on anterior half of ventral valve of some shells; anterior commissure shows slight flexure in the dorsal direction. Beak very strongly incurved, obscuring foramen and overlapping beak of opposite valve. Cardinal area small, concave, and narrow; concavity variable in degree. Posterior half of umbo faintly plicate, beak smooth; anterior half of umbo and remainder of valve covered by costae, 26 to 30 in number; 8 costae on fold of

specimen with 30 costae. Internally, the V-shaped spondylim has short supporting septum.

Dorsal valve convex with prominent rounded umbonal ridge; greatest depth posterior to mid-length of valve. Dorsal fold, faint on some specimens, on anterior two-thirds of valve. Internally, the septal plates converge downward, uniting to form a single septum which is attached to the inner surface of the dorsal valve in a single straight line. The upper septa join the "thin curved plates" of Schuchert and Cooper.

Remarks.--The dorsal fold is of generic significance since it is the only criterion for distinguishing Pentamerella? from Sieberella. These specimens are more heavily costate and much larger than any of the other species of Pentamerella? found in the Genshaw. There is some variation in the form of specimens, even from the same bed, as well as in the number of plications, in the steepness of the umbonal slopes, and in the convexity of the dorsal valve.

Pentamerella? sp. I is limited to the Genshaw beds below the Killians and occurs in greater abundance than any other form of the Pentameracea. The best specimens were collected at Rainy River Falls which is three and a half miles northeast of Onaway. Good specimens were also found at the exposure at Tower Dam.

Pentamerella? sp. aff. P. dubia Hall 1860

Spirifer dubius, Hall, 13th Rept., N. Y. State Cab. Nat. Hist., 1860, p. 90
Pentamerella dubia, Hall, Pal. of New York, vol. IV, 1867, p. 379, pl. LVIII.
Pentamerella dubia, Hall and Clarke, Pal. of New York, vol. VIII, 1894, pl. LXXI, figs. 32-37.

Description.--Shell subtriangular in outline; biconvex, convexity of valves nearly equal; umbo of dorsal valve swollen. Dimensions of average specimen: length 22 mm., width, 20 mm., thickness, 15 mm. Both ventral sulcus and dorsal fold nearly obsolete and slightly unsymmetrical. There are 16 costae on anterior border of ventral valve, 4 of which are in sulcus. Interior not seen, but worn exterior of a dorsal valve indicates convergence of septa to join inner surface in a single straight line.

Remarks.--Most of these specimens are poorly preserved. They differ from P.? sp. I in their much smaller size, in having faint costae and these only on anterior extremity of shell, and in being longer than wide. This form resembles P. dubia. (Hall, 1860, p. 90; Hall, 1867, p. 379, pl. LVIII, figs. 38 and 39, not 40-43; Hall and Clarke, 1894, p. 242 and 245, pl. LXXI, figs. 34 and 35, not 32-33, 36-38.) The only difference is that the dorsal valve of the Genshaw forms is relatively longer. Not all of Hall's figures illustrate specimens similar to those found in the Genshaw; only those figures named above do, but Hall's written descriptions do cover the Genshaw forms.

This species is limited to the lower 20 feet of the Genshaw.

Pentamerella? sp. III

Description.--Shell subovate in outline; biconvex, ventral convexity much greater. Dimensions of an average specimen: length, 23 mm.; width, 23 mm.; thickness, 16 mm. Incipient deltidial plates not observed, but these forms were referred to Pentamerella? because of the dorsal fold. The dorsal fold is weak, as is the sulcus in the ventral valve. Eighteen faint costae occur on anterior half of shell; umbo smooth; 5 costae on fold.

Remarks.--P.? sp. III has all the characteristics of P.? sp. aff. P. dubia except that it has a somewhat less prominent dorsal umbo, a more obtuse umbonal angle, and a nearly ovate outline. Part of the original shell material is preserved in most specimens.

These forms are found in greatest numbers in the lower 20 feet of the Genshaw, but some are found as high as 60 feet above the base.

Pentamerella? sp. IV

Description.--Ventral valve subtriangular to subpentagonal in outline; ventral valve convex, beak incurved. No dorsal valves available for study. Length slightly more than width. Dimensions of average ventral valve: length, 20 mm., width 24 mm., thickness 13 mm. No sulcus or fold. Sixteen broad rounded costae, very faint on some specimens. Slightly concave interarea. Ventral interior shows sharp, anteriorly directed teeth.

Remarks.--Only 3 ventral valves, each from a different locality, are available for study. These are referred to the genus with hesitancy because they lack the ventral fold that would place them in Sieberella. The other genus to which they might be referred is Gypidula, and since diagnostic characters of that genus are found only in the dorsal valve, it cannot be proved that these forms are not of Gypidula. These ventral valves differ from P.? sp. aff. P. dubia in being larger, in having a slightly wider umbonal angle, in having coarser costae, and lacking any trace of a sulcus. P.? sp. IV differs from P.? sp. III in its more nearly triangular outline, in being more coarsely plicate---only 7 costae in 15 mm., as against 9 in 15 mm. on P.? sp. III---and in having a smaller umbonal angle. There is some variation in the degree of flattening of the umbo in these forms.

These specimens indicate that P.? sp. IV is limited to the lower 20 feet of the Gensnaw.

Pentamerella? sp. V

Remarks.--These forms are large, multicostate, differing from P.? sp. I in having much flatter valves with resultant decrease in thickness and in being coarsely and very irregularly costate. Dimensions of an average specimen: length 38 mm., width 37 mm., thickness 24 mm. Individual variations of this species are numerous, but the normal tendency is for bifurcation to occur on the crest of the umbo.

This form is limited to the middle and upper parts of the Genshaw, the lowest occurrence being about 20 feet above the base.

Pentamerella? sp. VI

Remarks.--This species is represented by only 5 ventral valves, 4 of which are fragmentary. The observed characters, however, are those of P.? sp. I with the exception that the ventral valve has a more convex umbo, contrasting sharply with the flattened umbo of P.? sp. I.

All specimens occur in the middle Genshaw with the exception of one which is from the top of the formation.

Pentamerella? cf. pavilionensis Hall 1867

Pentamerella papilionensis Hall, Pal. of New York, vol. IV, part I, 1867, pp. 377-378, pl. 58, figs. 28-37.
Pentamerella pavilionensis Hall and Clarke, Pal. of New York, vol. 8, part II, 1894, p. 245.

Remarks.--This species possesses the ornamentation, size, and conspicuous dorsal fold of P. pavilionensis as described by Hall. It differs in being triangular in outline, not subovate.

This form was found in the Ferron Point formation in the exposures at Black Lake. Several specimens from the Ferron Point formation in the Rockport Quarry in Alpena County closely resemble the Black Lake forms. P.? cf. pavilionensis is limited to the Ferron Point in Cheboygan and western Presque Isle counties.

Genus PHOLIDOSTROPHIA Hall and Clarke 1894

Pholidostrophia sp.

Description.--Several specimens from various positions in the stratigraphic column are placed in the genus Pholidostrophia (Hall, 1867, pp. 104-105; Hall and Clarke, 1892, p. 287) because of the following observed characteristics: shell semi-circular to semi-elliptical in outline; concavo-convex; greatest width at about mid-length of valve. Dimensions of an average-size specimen: length, 15 mm.; width, 19 mm.; thickness, 4 mm. Hinge line denticulate, ends rounded. Ventral valve has low convexity, but in degree this feature is variable in the specimens studied; beak small and protrudes slightly; cardinal area narrow; deltnyrium closed. Dorsal valve concave, paralleling inner surface of ventral; beak minute.

Ventral interior pustulose; exhibits a very low double ridge separating the muscle scars which cover more than half of shell; muscle scars deeply impressed, narrow at posterior, widening toward anterior margin. Dorsal interior not observed.

Shell thin and fragile; smooth, except for fine growth lines; invariably nacreous.

Remarks.--No attempt is made to determine the specific status of the members of this genus found in the Gensnaw and Perron Point formations. The characteristics of specific value in this genus are so few and difficult of observation that

identifications should be made by comparing forms with the original type specimens. The only two features of a variable nature in the forms studied are convexity of the ventral valve and size. These were found to be of no value for stratigraphic purposes.

Genus PRODUCTELLA Hall 1867

Productella sp.

Remarks.--Undifferentiated species of this genus occur in relatively small numbers in the Genshaw formation. The specimens collected exhibit the typical characteristics of the genus as described by Weller (1914, Text, pp. 97-98) and Hall (1867, p. 153). The Genshaw forms collected are in a poor state of preservation and this, combined with their scarcity, renders them of little stratigraphic value. The shells are small, deeply concavo-convex, with straight hinge-line, narrow cardinal area, closed delthyrium. The ventral exterior is irregularly spinose.

Genus SCHIZOPHORIA King 1850

Schizophoria sp.

Description.--About a score of specimens of this genus, (Hall and Clarke, 1892, pp. 211-213; Weller, Stuart, 1914, pp. 161-162) many badly crushed, were found in the Ferron Point and Genshaw formations. Their general characters are

described below: shell subcircular in outline; dorsibiconvex; shallow sulcus on anterior half of ventral valve widening toward anterior margin where its width is equal to one-half width of valve. Greatest width about at midlength of shell, cardinal extremities rounded. Ventral beak short, rounded, and flat. Deep muscle scars on floor of the ventral valve are subovate in outline. These scars are bordered on the lateral margins by sharp, narrow ridges, and are divided by a much coarser rounded ridge between the two depressions. Dorsal interior not seen. Surface highly multicostellate.

Remarks.--Because of the crushing and the fact that specimens are few in number, they do not warrant attempts at specific identification. The stratigraphic range of the genus is from the Perron Point through the Killians member, although the greatest number of specimens came from the Glenshaw just below or definitely within the Killians member. The specimens are from several localities.

Genus SIEBERELLA Oehlert 1887

Generic description of Schuchert and Cooper (1932, p. 175):

> "Description.--Exterior.--Outline galeatiform as in Gypidula, hinge-line fairly arcuate; cardinal extremities rounded. Lateral profile biconvex, the ventral valve usually with the greater convexity. Anterior commissure sulcate; ventral fold usually defined only on the front half of the shell. Ventral interarea rather wide for the sub-family, curved, apsacline, delthyrium open, beak incurved,

> umbo swollen. Surface multicostate; shell substance fibrous, impunctate.
> "Ventral interior.--Like Gypidula. (idem. p. 174: Delthyrial cavity deep; teeth strong, narrow, elongate; dental plates convergent, forming a narrow spondylium, supported by a duplex septum for part of its length; free at the front end. Septum short.)
> "Dorsal interior.--The tripartite character of the cardinalia is essentially the same as that of Gypidula, but the septal plates, instead of uniting directly with the floor of the valve, unite with a low median septum."

Sieberella sp. I

Description.--Subtriangular in outline; longer than wide, although a few specimens are slightly wider than long, making them subovate; biconvex, although dorsal valve nearly flat. Dimensions of a small specimen: length, 40 mm. (approximated); width, 42 mm.; thickness, 30 mm., of which 24 mm. is thickness of ventral valve alone. Dimensions of largest specimen: length, 53 mm.; width, 45 mm.; thickness, at least 30 mm., although these dimensions were modified somewhat by crushing.

Ventral valve convex, semicircular in outline from side view. Faint fold on anterior three-quarters of shell serves to establish generic status. Anterior commissure sulcate ventrally, beak recurved to cover dorsal beak and obscure foramen. Umbo narrow, tapers fast posteriorly; umbonal slopes steep from narrow crest. Cardinal area very small and invisible in complete specimens. Shell multicostate except on posterior extremity of beak; costae 22 to 28 in number at anterior margin; bifurcation common but at

variable distances from beak; coarsest costae are in median region of the valve. Internally as in foregoing description of Schuchert and Cooper; only the septum and spondylium were observed.

Dorsal valve nearly flat, but posterior one-third curves up strongly beneath the ventral beak to give illusion of convexity. Umbo slightly raised; in some forms definitely depressed. Wide, shallow, anterior sulcus on all specimens. Dorsal interior as in Pentamerella? sp. I above.

Remarks.--This species is easily distinguished from all other Pentameracea in the Genshaw by its wide, shallow dorsal sulcus and its narrow, fast-tapering umbo and beak. The generic distinction between Sieberella and Pentamerella as given by Schuchert and Cooper was observed; viz.: Pentamerella has a dorsal fold, while Sieberella has a sulcus on the dorsal valve. Their internal structures are usually alike.

This form occurs sparingly in the lower half of the Genshaw. Lowest occurrence is very near the base; highest about 50 feet above base.

Sieberella? sp. II

Remarks.--Several Pentamerids are doubtfully assigned to Sieberella because of a faint fold on the ventral valve. S.? sp. II differs from all other Pentamerella and Sieberella in the Genshaw by having a wide hinge line. Only ventral valves of the species were found.

This form ranges from 45 to 60 feet above the base of the Genshaw but is not very common.

Genus STROPHEODONTA Hall 1852

Strophedonta sp.

Many fragmentary and poorly preserved specimens from several localities are here referred to Strophedonta sp. Most forms are small and exhibit the generic characteristics (Hall and Clarke, 1892, pp. 284-293), but no attempt was made to determine their specific status. Other specimens, better preserved, are described briefly below.

Strophedonta cf. erratica Winchell

Strophedonta erratica Winchell, The Grand Traverse Region, Ann Arbor, Mich., Dr. Chase's Steam Printing House, 1866, p. 93. (Not available for reference.)
Strophedonta erratica, Ehlers and Kline, Contr. Mus. Pal., Univ. of Michigan, vol. 14, no. 10, 1934, pp. 150-151; pl. I, figs. 4-9.

Remarks.--The forms from the Genshaw formation are compared to S. erratica after examination of plastocotypes in the possession of the Department of Geology at Michigan State College. The Genshaw specimens are commonly larger than Winchell's species. The specimens collected indicate that S. cf. erratica occurs sporadically throughout the Ferron Point and Genshaw formations and has no stratigraphic value.

Strophedonta erratica var. solidicosta Winchell

Strophedonta erratica var. solidicosta Winchell, The Grand Traverse Region, Ann Arbor, Michigan, Dr. Chase's Steam Printing House, 1866, p. 93. (Not available for reference.)
Strophedonta erratica var. solidicosta, Ehlers and Kline, Contr. Mus. Pal., Univ. of Michigan, vol. 14, no. 10, 1934, pp. 153-154, figs. 14-19.

Remarks.--Several Strophedonta from the Genshaw are placed

in this variety after comparison with plastocotypes and with a score of topotypes from the Gravel Point formation at its exposure in the Petoskey Portland Cement Co. quarry on Little Traverse Bay. The Genshaw forms, which were collected from several outcrops in different stratigraphic positions, exhibit no greater individual differences than do the Gravel Point forms.

Stropheodonta erratica var. fissicosta Winchell

Remarks.--S. erratica var. fissicosta was collected from three exposures of the Ferron Point formation in the area under consideration. The Ferron Point variety attains a greater size and some specimens are more finely costellate than the plastocotypes from the Gravel Point formation with which they were compared. This variety was collected only from the Ferron Point formation.

Stropheodonta sp. aff. S. demissa (Conrad)

Strophomena demissa Conrad, Jour. Acad. Nat. Sci., Philadelphia, vol. VIII, 1842, p. 258, pl. 14, fig. 14. (Unavailable to the writer---cited in Schuchert, C., U. S. Geol. Surv., Bull. 87, 1897, p. 421.)
Stropheodonta demissa Hall, Pal. of New York, vol. 4, part I, 1867, pp. 101-104, pl. XVII, figs. 2a-2g, 2k-2s.

Remarks.--Many somewhat crushed and weathered forms of Stropheodonta from the Genshaw formation are of the S. demissa type. A specimen of S. demissa from the Hamilton of New York, collected at Smokes Creek, Windom, N. Y., was available for comparative study. The Genshaw forms are larger and more gibbous. Dimensions of an average specimen: length, 32 mm.;

width 39 mm.; thickness, 13 mm. Variations within the Genshaw species are confined chiefly to ornamentation and convexity of the ventral valve. Some specimens are nearly flat in mesial area of ventral valve, with an abrupt slope on the anterior one-fifth of valve; others are uniformly convex, although the degree of convexity is variable.

A form of rare occurrence has 5 or 6 low, very broad rounded costae, each covered with 14 or 15 fine costellae. These specimens are doubtfully referred to S. sp. aff. S. demissa.

Stropheodonta sp. aff. S. demissa occurs from 25 feet above the Ferron Point to the bottom of the Killians member of the Genshaw formation.

Stropheodonta sp. aff. S. concava Hall 1867

Stropheodonta concava Hall, Pal. of New York, vol. IV, part I, 1867, pp. 96-98, pl. 16.

Remarks.--This species is the largest Brachiopod collected. It is similar in size to S. concava Hall. Dimensions: length, 48 mm.; width, 52 mm.; thickness, 18 mm. Ventral umbo swollen; anterior slope long and gentle. Finely multicostellate; other features poorly preserved.

Order TELOTREMATA Beecher

Genus CYRTINA Davidson 1858

That portion of Weller's generic diagnosis (Weller, Stuart, 1914, p. 286) upon which the identifications are based is quoted below:

> "Shells small, semipyramidal in form, with... non-plicated mesial fold and sinus, and simply plicated lateral slopes. Pedicle valve with a high, vertical or arched cardinal area which may be symmetrical or more or less distorted, the delthyrium narrowly triangular, closed with a convex pseudodeltidium which is perforated at a point below the apex by a subcircular...foramen.... Internally the dental lamellae are strongly developed and converge rapidly toward the inner surface of the valve, before meeting which they become joined in a single median septum which continues to the floor and extends anteriorly beyond the center, of the valve. Brachial valve very shallow, with narrow, inconspicuous cardinal area..... Shell substance strongly punctate."

Cyrtina alpenensis Hall and Clarke

Cyrtina umbonata alpenensis, Hall and Clarke, Pal. of New York, vol. 8, part II, 1894, p. 362, pl. 28, figs. 16-20.

Description.--Shell rounded pyramidal to semiglobose, slightly wider than long, with greatest width along hinge line. Cardinal extremities angular, near 90 degrees. Dimensions of an average specimen: length, 19 mm.; width, 21 mm.; thickness, 13 mm.

Ventral valve rounded pyramidal with strongly incurved beak; lateral slopes steep, becoming gentler toward the cardinal extremities; broad and rounded mesial sulcus with faint obsolete plication on each slope; sulcus originates at beak and becomes wider and deeper toward

anterior margin of valve, extending in front, in some specimens nearly horizontally.. Cardinal area strongly concave, marked by horizontal and very faint vertical striations; delthyrium narrow and triangular, closed by convex pseudo-deltidium perforated in upper one-fourth by elongate, narrow foramen which is often concealed by the incurved beak.. Each lateral slope has 8 to 10 plications with coarsest near sulcus, becoming finer toward lateral margins; at distance of 1 cm. from beak there are from 4 to 7 plications in 5 mm.

The ventral interior shows the characteristics of the genus: a strong median septum reaches at least three-quarters the length of the valve; near posterior extremity two dental plates, originating at sides of delthyrium, form a sharp V-shaped support for septum; a small knife-like ridge, due to downward extension of the septum, occupies the angle of the V.

Dorsal valve semiovate in outline; beak slightly extended posteriorly; posterior hinge line nearly straight. Gently convex with greater convexity in middle of valve where sharply convex fold raises surface; posteriorly fold is narrow and low, widening and becoming higher toward anterior, median line in some forms marked by a faint groove from posterior to anterior extremities. Valve flattened at cardinal extremities; each lateral slope has 5 to 8 plications which become progressively smaller toward lateral margins..

Internally, the brachial valve contains a bifid cardinal process. Other characters not observed.

Surface of both valves marked by concentric growth lines at irregular intervals. Shell punctate.

Remarks.--This species of Cyrtina from the Genshaw has a variable number of plications; Hall and Clarke's figures indicate only 5 plications on each lateral slope, but their written description fails to assign any limits to the number. This form is placed in C. alpenensis, a distinct species---not in a variety of C. umbonata. C. alpenensis is the most abundant species of Cyrtina in the Genshaw formation.

This species illustrates well the recurrence of a fauna. It is found in the lower 20 feet of the Genshaw, but is not found from 20 to about 90 feet above the base. It occurs again and in greatest abundance from about 90 feet above the base of the Genshaw up through the lower Killians where it is associated with Mucrospirifer sp. I.

Cyrtina sp. I

Description.--Shell rounded semi-pyramidal in outline; much wider than long, with greatest width at hinge line. Cardinal extremities mucronate, acutely angular. Dimensions of an average specimen: length, 18 mm.; width, 23½ mm.; thickness, 9½ mm.

Ventral valve with low convexity; moderately incurved beak. Lateral slopes of umbo steep but flattening

toward lateral margin so that extreme one-fourth of valve at each lateral extremity is very gently sloping; slope toward anterior of valve uniformly medium convex. Mesial sulcus narrow on beak, widening anteriorly; shallow throughout its length, extended in front. Cardinal area moderately concave; delthyrium as described for C. alpenensis. Each lateral slope covered with 9 to 11 plications which are progressively finer from sides of sulcus toward lateral margins.

Ventral interior as in Weller's generic description.

Dorsal valve semi-elliptical in outline; slightly concave, with umbo raised above the semicircular depression surrounding it. Hinge line straight and wide; beak protrudes slightly. Crushing has altered the contours of all the brachial valves available for study, but above features seem to be the true ones. Fold similar to that of C. alpenensis. Seven to 9 plications on each side of fold, becoming finer at lateral margins. Interior not seen.

Growth lines form concentric pattern on surface of valves; shell punctate.

Remarks.--This species is readily separable from the other Cyrtinas in the Genshaw by its wide hinge line, sharp cardinal extremities, its much thinner and lower ventral valve, and the depressed dorsal valve.

This rare species was found only in the transitional zone at the top of the Genshaw where it grades into the Killians member.

Cyrtina hamiltonensis Hall

Cyrtina hamiltonensis Hall, Pal. of New York, vol. 4, part I, 1867, p. 268, pl. 44, figs. 28, 29, 40 (not figs. 26-27, 30-33, 39, 41-52) and pl. 27, figs. 3 and 4 (not figs. 1-2).

Remarks.--This species accords with Hall's description, but his description and the accompanying figures indicate a wide variation in characters. Undoubtedly his species is broadly defined, and the Genshaw forms are comparable to the following of his figures: pl. 44, figs. 28, 29, and 40; pl. 27, figs. 3 and 4.

This form occurs sparingly in the transitional zone at the top of the Genshaw and base of the Killians.

Note: Several species of this genus identical with the Afton-Onaway forms were collected near Grand Lake in Alpena and eastern Presque Isle counties. At Long Lake Lodge on the south side of Long Lake C. alpenensis occurs sparingly, and at a stratigraphic position about 15 feet below it C. hamiltonensis occurs in minor numbers. C. hamiltonensis also is found in small numbers on the east side of Long Lake in the northwest corner of Sec. 33 along U. S. Highway 23, T. 33 N., R. 8 E. Both C. hamiltonensis and C. alpenensis occur very abundantly about 0.4 mile southeast of the northwest corner of Sec. 3, T. 32 N., R. 8 E. along U. S. Highway 23, and C. alpenensis exhibits the same variations as those specimens collected in Cheboygan and Presque Isle counties to the west. The fossils from the eastern area are nearly pure white and are beautifully preserved.

Genus ATRYPA Dalman 1828

Description.--The following observed characters were used in assigning these specimens to the genus Atrypa (Dalman, 1828; Hall and Clarke, 1894, pp. 163-175; Weller, Stuart, 1914, pp. 284-285): shell subcircular in outline, dorsibiconvex, ventral valve nearly flat; greatest width anterior to hinge line; ends of hinge line rounded. Surface covered with many radiating costellae crossed by concentric growth lines. Ventral beak incurves over the small cardinal area and conceals delthyrium and beak of dorsal valve. Interior shows large and widely separated teeth in the ventral valve; conical spiralia were observed to converge toward point of greatest convexity in the dorsal valve.

Atrypa sp.

Remarks.--Forms assigned to this genus occur in greater numbers than any other brachiopod in the Ferron Point and Genshaw formations. Because of the very great number of variations, it is not considered feasible to differentiate them in the time allowed for this study.

Among the variations noted are differences in ratios of width to length to thickness; varying convexity of the ventral valve, especially as to the sharpness of the median crest line; slight variations in ornamentation; and wide divergence in sizes.

This last feature is of value, however, for the relative numbers of large and small specimens of Atrypa

are different at the top and bottom of the formations. The Ferron Point has yielded only small specimens of Atrypa, averaging 13 to 19 mm. wide, with the largest not over 25 mm. in width. The lower Genshaw beds are likewise characterized by a great number of specimens comparable in size to those in the Ferron Point. In the Genshaw beds from 1 to 20 feet below the Killians, as in the exposures at Tower Dam, for example, as well as in the Killians itself, large specimens of Atrypa, from 30 mm. to 45 mm. wide, are common. While the smaller specimens do occur in these latter positions also, they are in greatly reduced numbers.

Genus SPIRIFER Sowerby 1815
Subgenus MUCROSPIRIFER Grabau 1931*

Mucrospirifer sp. I

Description.--Subtriangular and conspicuously mucronate in outline; biconvex, with ventral valve exhibiting greater

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*The subgeneric definition by Grabau is in a Chinese publication (see bibliography) not available to the writer, since the only two known copies in the U. S. are at the Library of Congress and in the Library of the Smithsonian Institute in Washington, D. C. The citation for the subgenus in Nomenclator Zoologicus does not give the genotype. Schuchert and Dunbar (1941, p. 213) figure Mucrospirifer pennatus, originally described by Atwater (1820, pp. 244-245, pl. 1, figs. 2-3). M. pennatus has the same general characters as those observed on the Genshaw and Ferron Point forms. Schuchert (1897, p. 401) considers Spirifer mucronata Hall (1857, p. 216, pl. 34, figs. 1-32), and S. mucronatus Hall and Clarke (1894, p. 17, pl. 29, fig. 8; pl. 34, figs. 13-22) as synonymous with S. pennatus. Thus, Mucrospirifer pennatus is considered by the writer to display the characters of the subgenus, at least. Actually, the terminology from which the name is derived would indicate that it is probably the genotype. On the basis of these facts, the Genshaw and Ferron Point species are confidently referred to the subgenus Mucrospirifer.

convexity. Cardinal area narrow---2 mm. high--and tapering toward lateral extremities; hinge line straight, extended, invariably the widest part of shell. Average dimensions: length, 26 mm.; width, 49 mm.; thickness, 17 mm. Mesial sulcus in ventral valve contains a single low, rounded costa which in a few specimens is quite faint; fold on dorsal valve marked by a single faint mesial groove. Surface of both valves multicostate but no bifurcation occurs; the sharp costae---usually 10 to 16, but more numerous on larger specimens---are crossed by many concentric growth lines. Low beak on ventral valve incurved over very narrow cardinal area. No median septum in ventral valve; conical spiralia directed toward cardinal extremities.

Remarks.--This species from the Genshaw formation closely resembles Spirifer mucronatus (Conrad) as described and illustrated by Hall (1867, pp. 216-218, pl. 34, figs. 1-23). The more mucronate forms from the Genshaw are very similar to fig. 15 of pl. 34 in Hall (idem.); the narrower Genshaw forms resemble closely Hall's figs. 9, 11, and 12 of pl. 34.

The more mucronate forms in the Genshaw are most abundant at the transitional zone at the base of the Killians member and up into the lower Killians. It is common for well-preserved specimens only 20 mm. long to have a hinge line width of over 85 mm. The highly mucronate forms are usually thinner than the narrower ones. Thus, there are two features of a variable nature in this species of Mucrospirifer: width and thickness. Since both gibbous

and thin forms, as well as moderately and extremely mucronate forms, all occur in association in nearly every outcrop of similar stratigraphic position, these variabilities are not considered of stratigraphic value.

The species itself is useful, however, for a great abundance of this form in association with Chonetes aff. C. fragilis has proved to be a definite indicator of the lower Killians and the transitional zone for a few feet below it.

Mucrospirifer sp. II

Remarks.--This species is very abundant in the Ferron Point formation; none was collected from the Genshaw. It differs from M. sp. I above in that it is semicircular in outline and while the hinge extremities are somewhat attenuated, they are not mucronate; the dimensions are grossly different, for the largest specimen of M. sp. II measures: length, 20 mm.; width, 28 mm.; thickness, 14 mm. Further, the sharp costae are 10 or 11 in number on each flank. One probably pathologic form is subtriangular in outline and the mesial sulcus is marked by an off-center coarse costa. No published descriptions consulted apply to this form.

The stratigraphic range of this species is limited to the Ferron Point formation. It is a distinct and stratigraphically valuable form.

Subgenus DELTHYRIS Dalman 1828

Delthyris? sp.

Remarks.--A very few small specimens are placed in this subgenus although it is not feasible to section one of the specimens to prove the presence of the diagnostic septum. (Zittel, 1927, p. 411.) These shells from the Genshaw and Ferron Point are similar in ornamentation and outline to Spirifer bidorsalis Winchell (Ehlers and Kline, 1934, pp. 168-169, pl. IV, figs. 24-31). They differ in that they have a straight fold and sulcus, whereas the axis of the fold and sulcus in S. bidorsalis is curved; furthermore, they are somewhat larger than that species.

The Genshaw and Ferron Point forms are also similar in size, ornamentation, and outline to S. bimesialis Hall (Hall and Clarke, 1894, pl. 34, figs. 23-26).

The few specimens collected come from various stratigraphic positions in the Genshaw and Ferron Point; they are of little value in zoning the formations.

Genus ATHYRIS McCoy 1844

Athyris sp.

Remarks.--Members of this genus are not as abundant as most of the other Brachiopoda in the Genshaw and Ferron Point formations in Cheboygan and western Presque Isle counties. The few specimens collected from each outcrop are insufficient to show features of stratigraphic value.

The following generic characteristics, described by Weller (1914, Text, pp. 404-405), were recognized on the Gensnaw and Perron Point forms: shells transversely subelliptical in outline; subequally biconvex with full-length fold on the dorsal valve giving it the sharper convexity; shallow to sharp, deep sulcus on anterior one-third of ventral valve. Ventral beak incurved, concealing foramen. Surface of both valves covered with broad concentric lamellae marking each period of growth.

FAUNAL ZONES AND CORRELATION OF SECTIONS

There are seven faunal zones in the Ferron Point and Genshaw formations in the area investigated. The distribution of the most abundant fossils, including those used in establishing the faunal zones is shown on Fig. 6. The stratigraphic position of the strata in each outcrop, based on the faunal zones, is shown on the correlation chart, Fig. 5.

The Ferron Point formation contains a faunal association of distinctive species of Chonetes, Pentamerella, and Mucrospirifer. The faunal zones in the Genshaw formation, in ascending order, are: the Chonetes-Pentamerella zone; the lower Pentamerella zone; the Clathrodictyon-Pentamerella zone; Cyrtina zone; Mucrospirifer-Chonetes zone; and the Mucrospirifer-Chonetes-Gomphoceras zone.

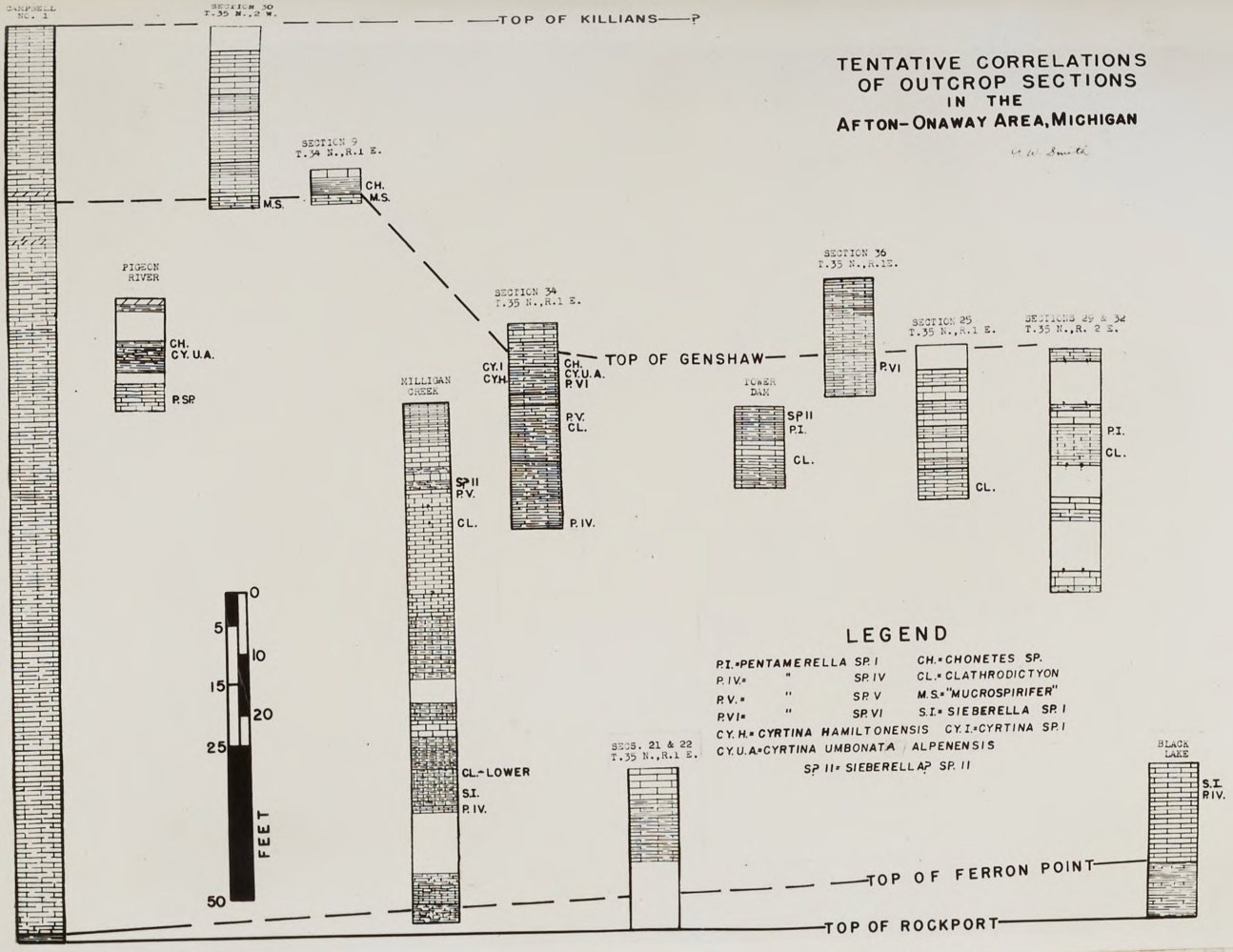
The Ferron Point is relatively easy to identify because it possesses several diagnostic fossils, and is characteristically a soft, gray, calcareous shale. The fossils found limited to this formation are Chonetes sp. aff. coronatus, Mucrospirifer sp. II, and Pentamerella? cf. pavilionensis. Other characteristic fossils in the Ferron Point are Aulopora sp. aff. A. serpens, Pterinea cf. flabellum, and several species of Tentaculites. The last-named forms are not in themselves definitive of the Ferron Point, but are common associates of the diagnostic fossils.

DISTRIBUTION OF SPECIES

LOCALITY NO.	1			2	3		4	5					6		7	8				9	10			11		12	13				14
BED NO. *= Killians: '=Ferron Point	6-7	3-5	1-2	1	2-5*	1	1*	14-19	10-13	8-9	2-7	1'	3-2	1	1-10	10-11	7-9	4-6	1-2	1-2	2-3	1	2-4	1'	1-5	7	4-6	2-3	1	1*
COELENTERATA:																														
Clathrodictyon cf. retiforme										a					a			a									a			
Prismatophyllum sp.			r	c				c	a	c					a	r		c		a	c	a	a	c	c		a			
BRACHIOPODA:																														
Athyris sp.	a		c		r			r			r				c	c	r		r		r			r			r			r
Atrypa sp.	a		a	c				c		a	c	c	r	a	a	c	a	c	a	c	c	c		a	c	c	c		c	c
Chonetes sp. aff. C. coronatus																								a						
C. sp. aff. fragilis	a		a		c									c			a		c			r		a						
Cyrtina alpenensis		c											c	a		a	a		c			c								
C. hamiltonensis																	a	c												
C. sp. I													c				a					c								
C. sp.					c			r					r	r			r			r					r					
Delthyris? sp.	r							r				r			r									r						
Mucrospirifer sp. I	c	c			c		c	c				r	a	a	a		a		a		a	a		a			c		c	
M. sp. II																			a					a						
Pentamerella? cf. pavilionensis																								a						
P.? sp. aff. P. dubia											r	r							c											
P.? sp. I								a		c					a			c								c	r			
P.? sp. III											r							c	c				c							
P.? sp IV											r								r				c							
P.? sp. V	r										r			c	c			c	c											r
P.? sp. VI															c			c		r		c								
Platyrachella? sp.	c		c		c			c	c	c	c		c	c	a	c	c	c	a	r	c	a				a	c		c	c
Sieberella? sp. I									r														c							
S.? sp. II								r		r						r														
Stropheodonta cf. erratica											c			c	c		cc													
S. erratica var. fissicosta												c							c											
S. erratica var. solidicosta								c							c	c			c											
S. sp. aff. S. demissa	r							r			c			r	c	c														
CEPHALOPODA:																														
Gomphoceras sp.		c														c					c									
TRILOBITA:																														
Proetus sp.	c		c		c	a			c					c	r	c		c	a		c			c						

a=abundant; c=common; r=rare

FIGURE 6.



KEY TO LITHOLOGY:

Shale

Calcareous Shale

Magnesian limestone

Thin-bedded limestone

Thick-bedded limestone

FIGURE 5.

by Sieberella? sp. I in association with the two forms for which the zone is named. S.? sp. I is found from 50 feet above the base down to the bottom of the Genshaw formation.

The Cyrtina zone overlies the Pentamerella-Clathrodictyon beds, and its top is about 100 feet above the base of the Genshaw. This four and a half foot zone contains at least three species of Cyrtina in great numbers. The zone is best exposed at Locality 8..

The sub-Killians Genshaw grades upward into the lower part of the black shales and limestones of the Killians member. The transitional strata are characterized by an abundance of Mucrospirifer sp. I and Chonetes sp. aff. C. fragilis, and is referred to as the Mucrospirifer-Chonetes zone. Fish plates of an undetermined genus and pygidia of the trilobite Proetus are also abundant in the transitional zone.

The highest strata which can be assigned with certainty to the Genshaw are the black limestones of the Killians member. In the western half of the area the Killians is overlain by the Koehler limestone.. The exact contact has not been observed, but there is no difficulty in distinguishing between these two units, for the Koehler is a light gray to buff, fairly pure, lithographic limestone. The Killians is a distinctive black color, and is characterized throughout by Mucrospirifer sp.. I and Gomphoceras sp. In the lower part, Chonetes sp. aff. C. fragilis is abundant. The Killians member is, then, the Mucrospirifer-Chonetes-Gomphoceras zone.

The Killians member is recognized at the following localities: 3, (p. 17); 4, (p. 18); 6, (p. 23; 8, (p. 27); 10, (p. 32); 14, (p. 38); 15, (p. 39); and 16, (p. 39). Most of the Killians fossils have a distinctive mode of preservation in which their outer surfaces have been penetrated by black bituminous material which stands in strong relief against the nearly white calcium carbonate preserving the rest of the animal. Particularly does the coral Favosites show this type of preservation.

The uppermost Genshaw in the area is represented by a thin section of limestone exposed two miles north of Afton. It is referred to the Newton Creek member, but because its stratigraphic position is still in doubt, it is not placed on the correlation chart, Fig. 5. Brief examination of the fossils indicates that the species of Platyrachella?, Pholidostrophia, Strophеodonta, and Stromatopora? collected from this exposure are unlike those in the Killians or sub-Killians strata, which are exposed in the vicinity at a topographically lower elevation.

No single outcrop reveals all of the faunal zones described, but the section north of Tower (See Fig. 4) shows a maximum of recognized zones. The Milligan Creek exposures show all of the sub-Killians zones but do not include any of that member nor the transitional zones at its base.

ENVIRONMENT OF DEPOSITION

The sediments forming the Ferron Point and Genshaw formations were deposited under marine conditions in a temperate to tropical climate. This is suggested by the character of the organic remains found in these deposits. Bryozoa, brachiopods, crinoids, cephalopods, pelecypods, and corals are all abundant in these formations. It is thought that reef corals, which are represented in the Genshaw and Ferron Point by Favosites and stromatoporoid hydro-corals, require temperatures above 68° F. (Twenhofel, 1932, p. 141). This probable truth, together with the fact that warm climates are best suited to the precipitation of calcium carbonate would indicate a warm environment of deposition for the formations under consideration.

Near shore or shallow water was the probable immediate environment of deposition for these formations. Many overturned colonies of Prismatophyllum, sometimes two feet in diameter, attest to the strong wave action that prevailed, thus indication shallow water. The thick shells of the very abundant genera, Pentamerella and Sieberella, in the Genshaw are further proof of shallow, marine environment. Reef corals, such as Stromatopora and Favosites, as as well as the abundant bryozoa in these beds, indicate warm, shallow, marine waters. (Twenhofel, idem., pp. 173-174).

Since shallow water is indicated, it is probable that the region in which the Ferron Point and Genshaw were deposited was located near the northern edge of the Traverse basin of deposition. According to Hake and Maebius:

> "In its major aspects the depression within which the Traverse formation was deposited is an elongated basin, with its principal axis in a northwest-southeast position and situated approximately beneath the inner portion of Saginaw Bay. The maximum observed depth of this basin occurs northwest of the north shore of Saginaw Bay, but it cannot be stated that this is the greatest depth of the basin because there has not been enough drilling along the apparent northwest prolongation of the axis to define the area of maximum subsidence." (1938, p. 449).

If this axis is prolonged in the direction suggested by these authors, it would lie about 60 miles southwest of the area of study. The area studied would then be nearer the deeper parts of the basin than would the type localities for the Ferron Point and Genshaw. This may be an explanation for the greater thickness of Genshaw found in Cheboygan county than at the type locality in Alpena county to the southeast. The fact that the Ferron Point is thinner in this more western area as compared with the type locality in Alpena county needs another explanation. Erosion immediately after the deposition of the Ferron Point is not probable, for there is no field evidence for a disconformity; consequently, it may be assumed that upward and downward oscillations of the sea bottom were common in the Traverse basin of deposition. Newcombe (1933, pp. 75-76)

believes that these oscillations are responsible for the alternating shale, calcareous shale, and limestones that compose the Traverse Group.

According to Pohl (1930, p. 34) the Traverse seas maintained a northern connection. The connecting seaway

> "...successively advanced from the northward across the Laurentian mass into an irregularly and intermittently sinking basin occupying southwestern Ontario, northwestern Ohio, all of the Southern Peninsula, and the eastern part of the Northern Peninsula of Michigan, and opening by way of James Bay and Hudson Bay to the Arctic and the North Atlantic Oceans." (Pohl, 1939, p. 34.)

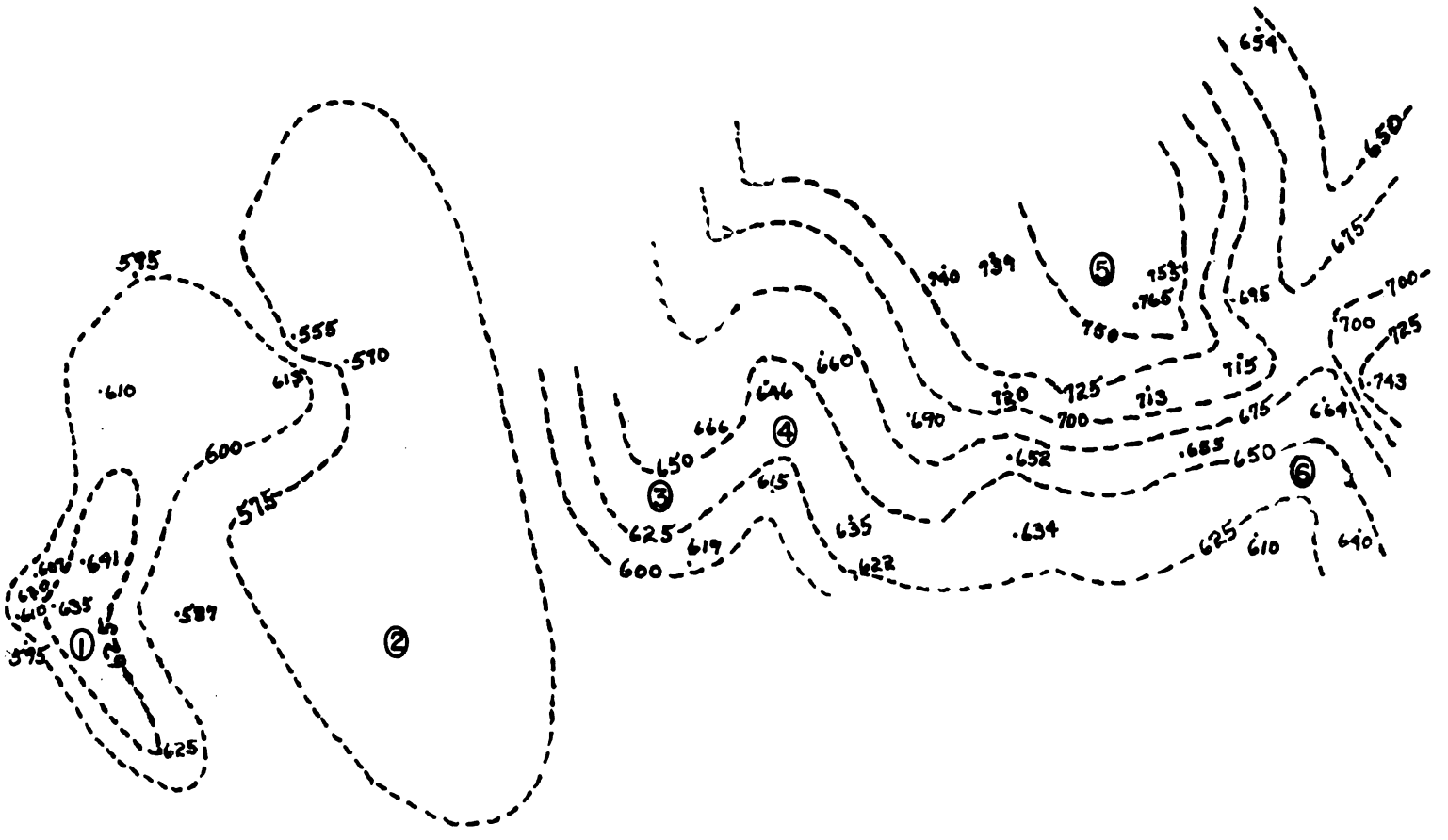
Cooper and Warthin (1935, pp. 376-377) indicate by their correlations that a Ludlowville and Skaneateles seaway also extended into southwestern Ontario, New York, Indiana, and southwestern Illinois. Paleogeographic maps prepared by Schuchert (Schuchert and Dunbar, 1941, p. 198) also show these areas as part of the same sea with a southern seaway extending down the Mississippi valley and joining the Atlantic ocean.

STRUCTURAL GEOLOGY

The area investigated is in the north-central part of the Michigan structural basin. (Newcombe, 1933, Pl. III). The regional dip, when calculated from Newcombe's structural contour map (idem.), is about 30 feet per mile to the southwest. That the regional dip is very gentle is substantiated by the fact that the greater part of the

STRUCTURAL CONTOUR MAP
AFTON-ONAWAY AREA, MICHIGAN

STRUCTURAL CONTOUR MAP
AFTON-ONAWAY AREA, MICHIGAN



CONTOURS DRAWN ON TOP OF ROCKPORT QUARRY FORMATION. CONTOUR INTERVAL 25 FEET.

PLATE III

AFTON-ONAWAY AREA, MICHIGAN

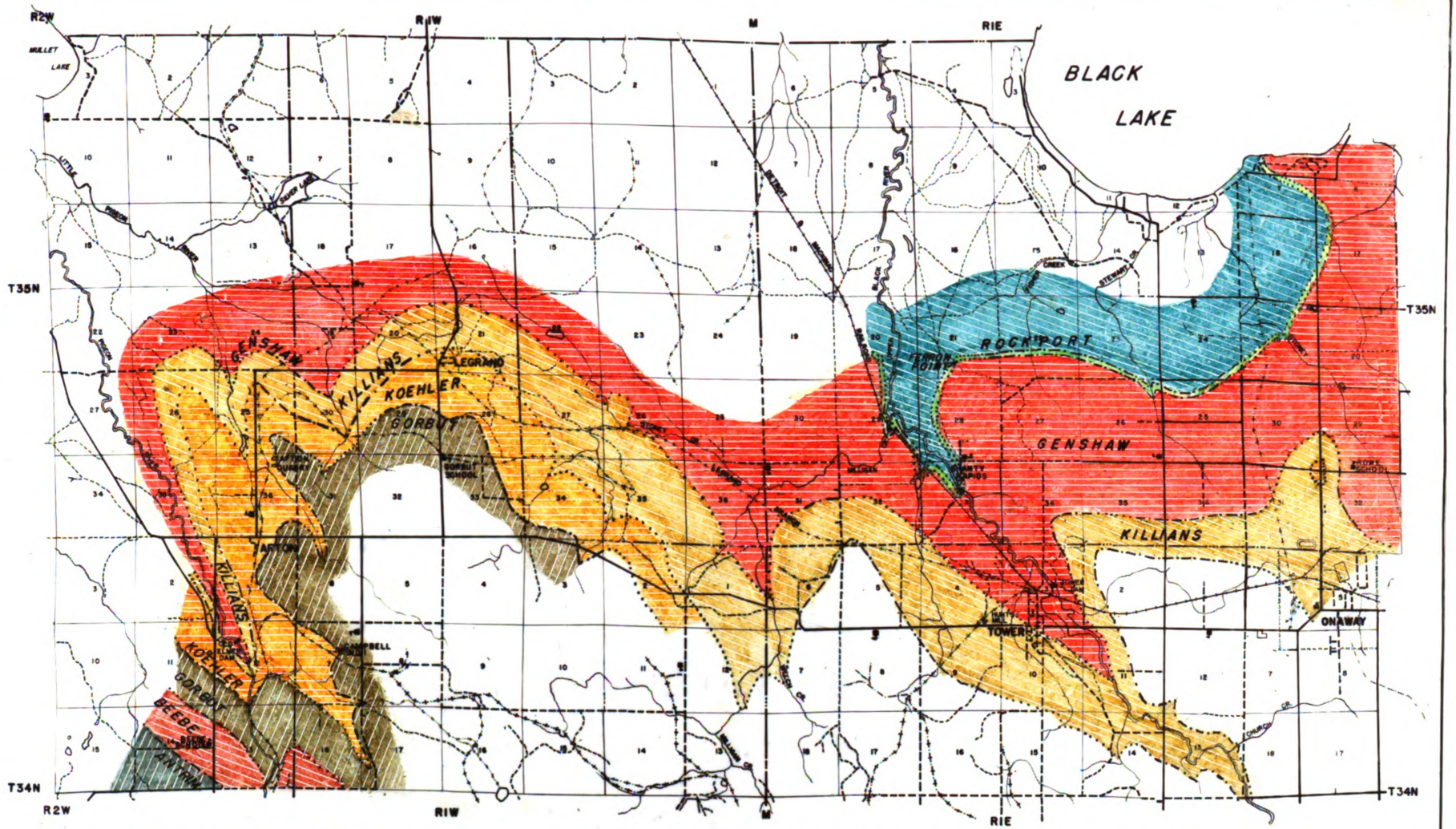


PLATE I

Traverse Group---from near the base of the Rockport Quarry formation to the base of the Antrim shale---is exposed between Black Lake and the Antrim outcrop near the center of Sec. 14, T. 34 N., R. 2 W. (See Pl. I). The elevation of the lowest bed in the Rockport Quarry formation, about 20 feet above its base, is 610 feet at Black Lake. The elevation of the base of the Antrim about 15 miles southwest of Black Lake, in Sec. 14 one-half mile west of the Beebe School, is 765 feet, plus or minus 10 feet. Consequently, there is a maximum difference in elevation between the two outcrops of only 175 feet. The Traverse Group which crops out intermittently from Black Lake to the Antrim exposure is about 400 feet thick, as shown by the Campbell No. 1 well in Sec. 7, T. 34 N., R. 1 W. Thus there is too great a thickness of rock for it to be exposed in the 165 feet of difference in elevation unless a dip of about 16 feet per mile is assigned to the strata. That this rate of dip is merely a component and not the true dip cannot be ascertained by any evidence in the area of this study. Because of the many minor and subordinate flexures, discussed below, in the area, local dips may exceed 16 feet per mile, but there are undoubtedly local reversals of dip. Consequently, 16 feet per mile to the southeast is merely an average of these local inclinations.

There are many minor flexures in the rocks in this region. In the Afton Quarry and along Milligan Creek,

minor folds were seen. Exposed strata in the valley of the Milligan often changed direction of dip every few hundred feet. Plate III is a structural contour map showing the structural features subordinate to the regional dip, but which are of greater areal extent than the small minor flexures.

The contours are drawn on the top of the Rockport Quarry formation because the dense, buff, lithographic limestone at the top of this unit is readily recognizable in both well samples and outcrops. In the field the overlying Ferron Point shale may be concealed, but its former presence is suggested at one locality, at least, by widening of the valley at the railroad bridge over Milligan Creek. Furthermore, these contours show the structures in the Ferron Point and Genshaw formations better than would contours on an older formation, such as the Dundee. ~~Also~~, Also, there are more wells which reach the Rockport.

The elevations on the Rockport were obtained by subtracting the thickness of the rocks between the top of the Rockport and a particular zone from the known elevation of that zone or bed. Since the faunal zones have a stratigraphic range of several feet---35 feet, for the Pentamerella-Clathrodictyon zone, is the maximum---the elevations found on the top of the Rockport Quarry formation are necessarily correct only within the limits possible in determining the stratigraphic position of the

faunal zones.. In most calculations the possible error is not over 7 feet, for the stratigraphic position of outcrops of questionable position when considered by themselves can be determined more definitely by their relation to nearby outcrops of recognizable zones. This method of determining elevations is not exact, but it is the only method feasible in this study. The qualitative accuracy of the method is considered to be good since the structures indicated by the contours on Plate III are also strongly suggested by supporting evidence..

Structural features shown on Plate III include from west to east: the Pigeon River anticline, an unnamed syncline, a small structural nose, succeeded by a minor syncline. The major structural feature in the eastern half of the map is the Black Lake anticline, which is bordered on the southeast by the Onaway syncline.

The presence of the Pigeon River anticline in the southwestern corner of the map ("1" on Pl. III) is dictated by several lines of evidence. The Chonetes-Mucrospirifer beds of the Genshaw formation have an elevation 40 feet higher at Old Elmer Dam than in the SW¼, Sec. 19, T. 35 N., R. 1 W. There is, then, a rise in elevation to the south from the outcrops in Sec. 19. A marked southeast dip from the Vizina well (SE¼, Sec. 1, T. 34 N., R. 2 W.) to the Campbell No. 1 well (NE¼, Sec. 7, T. 34 N., R. 1 W.) is attested by records of a 54-foot drop in elevation

of the top of the Rockport. This direction of dip is also shown by the eastward swing made by the line of outcrop of the Gorbut member of the Gravel Point formation where it crosses the shallow intermittent-stream valley in SE¼, SE¼, Sec. 7, T. 34 N., R. 1 W. An opposite dip, to the southwest, is indicated by the presence of Koehler, Gorbut, and Beebe School beds between the Genshaw outcrops on the Pigeon River and the Antrim outcrop in Sec. 14, one-half mile west of Beebe School. The thickness of rock represented by the three formations could not be fitted into the distance between these outcrops without a definite southeast dip because there is insufficient topographic relief. Furthermore, there are southeast-dipping cuestas of the Beebe School beds in Sec. 11, T. 34 N., R. 2 W. (See Pl. I). A west dip is indicated by four elevations calculated to the top of the Rockport in Secs. 1, 11, and 12, T. 34 N., R. 2 W. It is improbable that all four elevations would be wrong.

In the area between an imaginary north-south line drawn one mile east of the Gorbut School and a parallel line following the Michigan meridian, a broad, shallow syncline is shown on Plate III (Indicated by the number "2"). Absence of outcrops makes it impossible to determine detailed structural features in this limited area, but a syncline is indicated by the contours on each side of the structure. In addition, the change of strike

from northeast to northwest of the formations is suggestive of a syncline. A small structural high ("3", Pl. III) lies to the east of the larger syncline.

A small syncline with a north-south axis roughly parallel to the line between Sec. 31 and 32, T. 35 N., R. 1 E., is shown on the structural map ("4", Pl. III). Differences in elevation and the supporting evidence furnished by the northward reentrant of the outcrop line of the top of the Killians in Secs. 5 and 6, T. 34 N., R. 2 W., are the bases for showing such a structure.

The largest structural feature in the eastern part of the area is an irregular anticline ("5", Pl. III). It will be referred to as the Black Lake anticline because that is the nearest major geographic feature. The probable high point of this structure, at an elevation of 765 feet, is about two and one-half miles south of the southernmost point of Black Lake. The contour lines outlining this structure are based largely on subsurface records of elevations directly on the top of the Rockport Quarry formation, on elevations of outcrops of the Rockport, or on the base of the killians member of the Genshaw. These data are probably correct within five feet. The Pentamerella-Clathrodictyon zone was used as the datum plane in obtaining elevations on the Rockport at the following localities: Tower Dam; Rowe School; on the line between Sec. 25, T. 35 N., R. 1 E. and Sec. 30, T. 35 N., R. 2 E.; and on the line

between Secs. 29 and 30, T. 35 N., R. 2 E. (See Pl. III). Since the Pentamerella-Clathrodictyon zone is 35 feet thick, some of these elevations may have a maximum error of 18 feet. There is no indication that this is true, since the contour lines drawn on the basis of these elevations are in accord with all known facts.

No closure can be proved for the north end of the Black Lake anticline, but there is evidence for dips in every other direction away from the probable crest in NE¼, Sec. 26, T. 35 N., R. 1 E. A strong dip to the northeast between this high point (elevation, 765 feet) and the top of the Rockport Quarry formation at Black Lake is made necessary by the fact that the elevation at the latter locality is only 654 feet.

The locality in which the elevations on the Clathrodictyon-Pentamerella zone are found is on the southeastern and eastern flanks of the anticline. It is this series of elevations which indicate a syncline southeast of the Black Lake anticline. This structure, ("6", Pl. III), called the Onaway syncline because of proximity to that town, trends approximately north. The presence of this syncline is inferred from several facts. In the SE¼, SE¼, Sec. 30, T. 35 N., R. 2 E. (See Pl. I) there is an outcrop of strata which lie near the top of the Genshaw. These beds probably belong to the Newton Creek limestone, and are the stratigraphically highest strata in this part

of the map-area. They could not crop out at an elevation of 824 feet if there was not a downward flexure of the rocks.

Supporting evidence for the Cnaway syncline comes from the log of the well drilled in the SE¼, NW¼, Sec. 5, T. 34 N., R. 2 E. The record of this well (Smith, R. A., 1914, p. 215) shows the top of the Dundee at a depth of 310 feet. The elevation at the surface is 830 (plus or minus) feet A.T. By allowing 120 feet for the combined thickness of the Bell Shale and the Rockport, the top of the Rockport would be at 640 feet in the well. This elevation establishes the eastern limb of the syncline.

An outcrop of Koehler limestone in the railroad cut in the W½, Sec. 6, T. 34 N., R. 2 E., gives a reason for believing that there is a southeast dipping limb on the Cnaway syncline, or the equivalent of a southeast dipping limb of the Black Lake anticline to the northwest. The outcrop of Koehler is indicative of dip to the southeast because it is only one mile southeast of south-east dipping cuestas of the Killians in the SW¼, Sec. 36, T. 35 N., R. 1 E. (See Pl. I). There is only 8 feet difference in elevation between these outcrops, and at least 45 feet of strata occur between the two. The disappearance of this thickness of strata implies that there is a southeast dip, the more so because the cuestas of the Killians in Sec. 36 dip to the southeast.

Dips to the south, although probably components, were recorded at Tower Dam and on the Killians limestone a mile and a half north of Tower. A southeast dip was shown by the top of the Rockport exposed at Shanty Rapids.

Thus dips in every direction except north from the crest of the Black Lake anticline are indicated by direct measurement or by calculating elevations on the top of the Rockport and contouring the data.

SUMMARY AND CONCLUSIONS

This study shows that the Ferron Point formation has a maximum thickness of 9 feet in Cheboygan and western Presque Isle counties, as compared to the 30 feet assigned to it at the type locality. The Genshaw formation is 34 feet thicker in the area studied than at the type locality. It has a maximum thickness of 150 feet near Afton; the thickness at the type locality in Alpena county is 116 feet.

The stratigraphic position of all known outcrops of these two formations in the area may be determined by recognition of the faunal zones. The Ferron Point formation is usually lithologically distinct and contains the diagnostic fossils Chonetes cf. coronatus, Pentamerella? cf. pavilionensis, and Mucrospirifer sp. II. The six faunal zones in the Genshaw formation, in ascending order are: Chonetes-Pentamerella zone; lower Pentamerella zone; Clathrodictyon-Pentamerella zone; Cyrtina zone; Mucrospirifer-Chonetes zone; and the Mucrosprifer-Chonetes-Gomphoceras

zone of the Killians member.

The limestones of the Ferron Point and Genshaw were deposited near the northern end of the Traverse Basin of deposition in middle Devonian time under warm, shallow-water, marine conditions. The formations are of Skaneateles age and are equivalent to the Arkona beds of Ontario, The Silver Creek of Indiana, and the Misenheimer shale of Illinois. Direct correlation with the Ferron Point and Genshaw formations at their type localities is possible, but no rocks of similar age are found on the western side of the state along Little Traverse Bay.

The geologic structure of the area is simple, with the Pigeon River anticline, the Black Lake anticline, and the Onaway syncline superposed on the low regional dip to the southwest. Minor local flexures are abundant.

Glacial debris obscures the rocks in most of the area, but stream erosion has removed the drift so that several exposures occur along stream valleys. Rejuvenation of Milligan Creek, one of the principal streams, is thought to be related to glacial lake stages.

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