A FIELD AND PETROGRAPHIC STUDY OF THE SANDSTONES AND CONGLOMERATES OF THE PORCUPINE MOUNTAINS, ONTONAGON COUNTY, MICHIGAN

by

HATEM HUSSEIN EL-KHALIDI

A THESIS

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INTRODUCTION

1. Location

The Porcupine Mountains area is located in Ontonagon and Gogebic Counties, between the Iron and the Presque Isle Rivers in the Upper Peninsula of Michigan (Map 1). The area is a State park, which is easily reached from Silver City, Michigan, on State Highway M-107.

2. General Topography

The Porcupine Mountains rise from the shore of Lake Superior in T. 51 N., Rs. 42, 43, and 44 W, as roughly concentric ridges parallel to the shore line.

The first ridge, rising from the shore of Lake Superior, reaches a height of 850 to 900 feet above the lake level, within a mile and a half to the south (Plate 1). It then descends abruptly 400 feet into the valley of the Carp River. This river follows a very irregular course from its headwaters to the southeast, empties into the Lake of the Clouds, and then proceeds in a southwesterly direction and empties into Lake Superior at a location in the northeast corner of Gogebic County.

Beyond the Carp River to the south, there is a steep escarpment leading up to an eroded plateau and the valley of the Little Carp River. Knobs and ridges occur, but these are not as extensive or as steep as the first ridge. In this area the highest elevations of the Porcupine Mountains occur. The highest point, as listed by the Michigan Department of Conservation, is Government Peak. It is 2,023 feet above sea

MAP I- SHOWING LOCATION OF AREA STUDIED AND THE AREAL DISTRIBUTION OF THE KEWEENAWAN SERIES level, or 1,421 feet above the level of Lake Superior; but as far back as 1908, A.C. Lane and others have indicated that this figure is too high. Lane believed it to be closer to 1,860 feet above sea level. More recent and accurate measurements based on field work and study of aerial photographs by Dr. W.A. Kelly of the Department of Geology, Michigan State College, show that another peak to the southeast of Government Peak is the highest. Dr. Kelly assigns an elevation of 1,900 to 1,950 feet above sea level to this peak.

The Little Carp River empties into Mirror Lake in the heart of the Porcupine Mountains, then into Lily Pond to the southwest, and finally into Lake Superior at a location approximately one mile southwest of the mouth of the Carp River.

Rainfall in the Porcupine Mountains is relatively heavy, and the elimination of the meteoric water by drainage and evaporation is small; thus, large swamp areas are present. Some areas around the valley of the Carp River are swamps. Others are located about a mile southeast of Government Peak.

3. General Geology

The rocks that outcrop in the Porcupine Mountains belong to the series known as the Keweenawan. A description of the general character of the Keweenawan rocks is essential to the understanding of the rocks of the Porcupine Mountains, because of the very close relationship between them and the other Keweenawan rocks that outcrop elsewhere, especially in the Keweenaw Peninsula and along the Black River to the southwest of the Porcupine Mountains.

Distribution of the Keweenawan Rocks: The area in which these rocks are exposed lies in the southern segment of the pre-Cambrian shield of North America and forms a part of the Lake Superior basin. Along the south shore of the lake, the area extends from Keweenaw Point in Michigan southwestward through northern Wisconsin and into Minnesota. The Keweenawan rocks border the north shore of Lake Superior in Minnesota to the Canadian boundary, crop out in Isle Royale, and in Canada appear in the Black Bay and Thunder Bay districts, and extend to the area around Lake Nippigon.

Character of the Rocks: The Keweenawan series are comprised of coarse clastic sediments together with intrusive and extrusive igneous rocks. Both the base and the upper part of the series are composed of sediments. The basal sediments, with a maximum thickness of 1,500 feet, are overlain by great thicknesses of basaltic lava flows interspersed with relatively thin sediments and acidic lava flows. The upper part of the Keweenawan series is composed wholly of thick conglomerate overlain by thin shale which, in turn, is overlain by thick sandstone.

Age of the Rocks: In the Gogebic Iron Range of Michigan, the Keweenawan is underlain by Penokee-Gogebic iron series which are upper-Huronian in age. In the Black River section there is a space of nearly half a mile between the lowest exposures of the Keweenawan, and the highest exposures of the Penokee-Gogebic; thus, no direct evidence of an unconformity exists. Irving* suggested that a disconformity

* Irving, R.D., "The Copper Bearing Rocks of Lake Superior", United States Geological Survey, Monograph 5, p. 24 (1883).

occurs between the Keweenawan and Huronian. A complete discussion of a possible conformity or unconformity between the Keweenawan and the Huronian is given by Irving and Van Hise in the United States Geological Survey, Monograph 19, on the Penokee-Gogebic Range.

Overlying the upper Keweenawan without apparent unconformity or abrupt change in character, is the Lake Superior sandstone which is considered by the United States Geological Survey to be upper-Cambrian in age.

The United States Geological Survey groups the Keweenawan as upper-Proterozoic, of pre-Cambrian age. Some geologists disagree with this classification. A.C. Lane* argues that

* Lane, A.C., "The Keweenawan Series of Michigan," Michigan Geological Survey, Publication 6 (Geol. Series 4), 2 vol., 983 pp. (1911).

since the apparently major unconformity lies below the Keweenawan series, rather than above it, the major division between the Cambrian and the pre-Cambrian should be placed at the base of the Keweenawan series. Other geologists believe that at least the upper Keweenawan should be classified as Cambrian.

The main arguments for the Cambrian age of the upper Keweenawan sediments are:

1. Both are red sandstones of the same lithologic character.
2. No basal conglomerate to the Cambrian against the upper Keweenawan has been discovered; whereas, there is a very thick one at the base of the upper Keweenawan containing a wide variety of pebbles of the intrusives as well as extrusives of the lower Keweenawan.

Some of the arguments against the idea of the Cambrian age of the upper Keweenawan are:

1. The unconformable overlap of the Potsdam sandstone of upper-Cambrian age on the upper Keweenawan.
2. The lack of fossils.
3. The presence of pebbles of Keweenawan in the Cambrian along the Keweenawan fault shore cliff.

General Stratigraphy:

In the writer's opinion, Irving's* division of the Keweenawan series into upper and lower is more logical than the divisions suggested by various other geologists, because it is based on the fact that the upper Keweenawan is devoid of any evidences of igneous activity and is composed wholly of clastic sediments. The lower Keweenawan, on the other hand,

* Irving, R.D., "The Copper Bearing Rocks of Lake Superior," United States Geological Survey, Monograph 5 (1883).

is composed mostly of a succession of basic lava flows interstratified with sediments.

Below is a generalized stratigraphic column of the Keweenawan rocks (after A.C. Lane and A.E. Seaman)*:

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* Lane, A.C., and Seaman, A.E., "Notes on the Geological Section of Michigan," Part I. The Preordovician, Report of the State Board of Geological Survey of Michigan, p. 24 (1908).

Name of formation or group	Thickness in feet	General characteristics
	Upper Keweenawan	
Freda Sandstone	900-(?)	Red sandstone with some felsite and basic igneous debris
Nonesuch Shale	350 to 600	Dark fissile shale beds with some sandstone
Outer Conglomerate	1,000 to 3,500	Coarse felsite conglomerate, some sandy lenses
	Lower Keweenawan	
Lake Shore Traps	400 to 1,800	Basaltic lavas with upper amygdaloidal parts
Great Conglomerate	340 to 2,200	Coarse felsite conglomerate
Eagle River Group	1,417 to 2,400	Mostly basic lava flows with frequent sedimentary beds
Ashbed Group	1,456 to 2,400	Mainly basic lava flows with 50 feet of conglomerate
Central Mine Group	3,823 to 25,000	Mainly basic lavas with copper bearing conglomerate zones
Bohemian Range Group	(?) to 9,500	Mainly basic lava flows with intrusive gabbro; some conglomerate beds

Sedimentary Rocks: The sedimentary rocks are subordinate in the lower Keweenawan series; but they constitute the entire thickness of the upper series where they are composed of conglomerate, sandstone, and shale.

The sediments are predominantly red in color, feldspathic, and poorly sorted. They exhibit ripple marks, cross-bedding, and mud cracks; and so far as known, are devoid of fossils. According to Lane*, their characteristics indicate that they were deposited largely under terrestrial conditions.

* Lane, A.C., "The Keweenawan Series of Michigan," Michigan Geological Survey, Publication 6 (Geol. Series 4), 2 vol., 983 pp. (1911).

The conglomerates are composed mainly of felsite clasts, and range in thickness from a few inches to 3,500 feet. Some zones have been traced by geologists many miles along the strike. The conglomerates form a very small proportion of the lower Keweenawan and a large proportion of the upper Keweenawan.

In general, the felsite conglomerates are of silicious composition, the most abundant rocks in them being felsite and quartz porphyry, although basic pebbles occur in minor quantities. Most of the pebbles are well rounded. The conglomerate beds are generally lenticular, thinning or thickening rather rapidly along the strike. The coarser material, with boulders rarely exceeding a foot in diameter, is usually found in rather thick beds.

At the top of the Keweenawan series occur the Nonesuch shale and the Freda sandstone formations. The Nonesuch formation consists of black and red shales interstratified with layers of red sandstone. The Freda sandstone which represents the uppermost member of the Keweenawan series is mainly a red sandstone with some felsite and basic igneous rock debris.

Source of the Sediments: The composition of material of the felsite conglomerate and the sandstones is similar to that of several masses of felsite and acidic porphyries that outcrop in the area. These and other old masses that have been eroded probably acted as a source of the sediments.

A.C. Lane* and others have suggested that certain exten-

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* Lane, A.C., "The Keweenawan Series of Michigan," Michigan Geological Survey, Publication 6 (Geol. Series 4), 2 vol., 983 pp. (1911).

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sive acid flows immediately succumbed to erosion, forming a nearly contemporaneous conglomerate and sandstone. Butler and Burbank* suggested that the conglomerate pebbles were not

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*Butler, B.S., Burbank, W.S., and Collaborators, "The Copper Deposits of Michigan," United States Geological Survey, Prof. Paper 144 (1929).

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of immediate local derivations, but came from long-lived uplands composed mainly of felsite and quartz porphyry. They infer that the debris from these uplands, together with a small proportion of other material from different sources, was spread on the adjacent plains occupied by the basic lava flows. The Porcupine Mountains area is an example of such an upland.

The Igneous Rocks: The igneous rocks are divided primarily into two classes; namely, the basic flows and the acid porphyries.

The basic flows make up the greater part of the Keweenawan series. These are fine grained, basaltic, crystalline rocks. They consist of a lower compact portion that grades upwards into vesicular and amygdaloidal parts. The flows are interstratified with layers of unaltered red sandstone and conglomerate. The basic flows are true eruptives and constitute successive flows from fissures. This suggestion was introduced by Irving* and later accepted by various

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* Irving, R.D., "The Copper Bearing Rocks of Lake Superior," United States Geological Survey, Monograph 5, p. 139 (1883).

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other geologists.

The acid rocks like the basic, are true eruptives, mainly porphyritic, and occur between layers of basic rocks.

Structure: The Keweenawan series in Michigan occur on the southern rim of the Lake Superior syncline or basin. Butler and Burbank* suggest that this basin was probably formed

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* Butler, B.S., Burbank, W.S., and Collaborators, "The Copper Deposits of Michigan," United States Geological Survey, Prof. Paper 144 (1929).

during Keweenawan time. The lower Keweenawan rocks dip steeply, and the upper ones dip progressively less steeply northwestwardly towards the center of the Lake Superior basin. The Keweenawan rocks are faulted. The greatest fault in the region is the Keweenaw fault which bounds the Keweenawan series on the south from Keweenaw Point to Lake Gogebic. It is a thrust fault with a northwesterly dip, along which the basaltic series have been shoved over the Lake Superior sandstone of upper Cambrian age. There is very little discordance between the dip of the fault and the dip of the beds of the flows. Many branch faults and fissures are associated with the Keweenaw fault. Butler and Burbank*

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* Butler, B.S., Burbank, W.S., and Collaborators, "The Copper Deposits of Michigan," United States Geological Survey, Prof. Paper 144 (1929).

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suggested that the movement along the Keweenaw fault probably did not begin until late Keweenawan time, much of it occurring after the Lake Superior sandstone was deposited.

Ore Deposits in the Keweenawan Rocks: In Michigan, the area of exposed Keweenawan rocks was one of the greatest copper districts of the world and outstanding in the deposits of native copper. This area forms a belt in the Keweenaw Peninsula two to four miles wide and 100 miles long, 26 miles of which has been highly productive. This district is now almost exhausted.

The copper lodes are of three types: (1) amygdaloidal, which occur in the upper permeable parts of flows. Native copper occupies the vesicles. The lodes average 13 feet in thickness and contain from 0.6 to 1.5 per cent copper, (2) the conglomeratic lodes, in which native copper fills the interstices, (3) fissure veins, in which the native copper occurs in fissures and joints.

Butler, Burbank and other geologists consider that the copper deposits were formed by hydrothermal solutions given off from underlying basic intrusives. They believe that the structure is pre-ore in origin, and that the relations of copper beneath impervious cappings indicate rising rather than descending solutions. The solutions rich in copper, sulphur, and arsenic were guided upward by the permeability of the conglomerates and amygdaloidal tops. The hematite of the lava tops yielded oxygen which combined with the sulphur and arsenic, causing reduction of copper to native metal.

<u>General Structure of the Porcupine Mountains</u>: In the Porcupine Mountains the succession of rocks and their structure do not conform exactly with the structure of the Keweenawan rocks to the northeast and the southwest. In their geologic map of the Porcupine Mountains and vicinity, F.E. Wright and A.C. Lane* indicated the existence of a large

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* Wright, F.E., and Lane, A.C., Preliminary Geological Map of the Porcupine Mountains and Vicinity, <u>Michigan Geological Survey Rept. for 1908</u>, pl. 1 (1909).

fold with a general northeasterly trend. The general structure is, moreover, complicated by the existence of numerous transverse and cross faults. The most prominent fault is the Main Porcupine Fault that borders the southern edge of the main felsite (Red Rock) area which forms the central portion of the Porcupine Mountains. Here the Red Rock is in direct contact with the Nonesuch shale. The Main Porcupine Fault is a transverse fault with a general northeasterly trend. According to Wright and Lane*, it extends from sec. 1,

* Wright, F.E., and Lane, A.C., Preliminary Geological Map of the Porcupine Mountains and Vicinity, Michigan Geological Survey Rept. for 1908, pl. 1 (1909).

T. 50 N., R. 42 W., westwards to sec. 7, T. 50 N., R. 42 W., and thence southwestwards to sec. 18, T. 49 N., R. 43 W. Any relation between this fault and the Keweenaw Fault has yet to be established.

The detailed geology of the Porcupine Mountains is still in the most part unknown. More extensive field work is needed to throw more light on the problem. Moreover, attempts at the correlation of the numerous core drilling data which exist will lead to a much clearer picture of the Porcupine Mountains problem.

Stratigraphy of the Porcupine Mountains: Following is a generalized stratigraphic column of the Porcupine Mountains area. The information given here was taken mostly from Irving*, with some modifications by the writer.

* Irving, R.D., "The Copper Bearing Rocks of Lake Superior," United States Geological Survey, Monograph 5 (1883).

Name of formation	Description of formation	Thickness in feet
	Upper Keweenawan	
Nonesuch Shale	Gray shale and dark sandstone	600
Porcupine Mountains Sandstone	Sandstone with thin conglomerate zones	1,500 to (?)
	Lower Keweenawan	
Lake Shore Traps	Basaltic flows, amygdaloidal at top	300 to 500
(?)	Sandstone and conglomerate	1,900
(?)	Diabase, melaphyre, amygdaloids, diabase porphyry, one bed of porphyry-conglomerate	400
Red Rock(?)	Felsites and quartziferous porphyries, banded rhyolite	(?)

All the above formations, with the exception of the Red Rock, show a general northeasterly trend and northwesterly dip, except in an area along the Iron River about one mile south of the Lake Superior shore. Here the outcropping

Nonesuch shale exhibits marked anomalies in strike and dip indicating the probability of the existence of the "nose" of the main fold in that area. On the other hand, these anomalies in strike and dip might be as a result of the faulting.

The Red Rock, according to Irving*, shows no apparent

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* Irving, R.D., "The Copper Bearing Rocks of Lake Superior," United States Geological Survey, Monograph 5 (1883).

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trends; but Thaden*, who spent the summer season of 1949

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* Thaden, R.E., Personal communication

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studying the Red Rock in the field, disagrees with Irving's conclusions. Thaden indicated that the Red Rock exhibits definite trends. He also observed that the exposed contacts of the Red Rock with the basaltic lava flows are faulted. The reader, however, has to be content with this statement unsupplemented by evidence until the full text of Thaden's paper on the Red Rock is completed.

4. Purpose of Study

The purpose of this paper is to report the structure and petrology of exposed sandstones and conglomerates in the northern part of the Porcupine Mountains along assigned traverses, and to investigate the possibilities of correlations of these rocks between the traverses.

The traverses along which the writer studied and sampled these rocks were confined to that sedimentary formation stratigraphically above the Lake Shore Traps formation (Map 2). On Plate 14 accompanying the United States Geological Survey Professional Paper 144, the name assigned to the formation is the Outer conglomerate. This name was first given to the formation by Irving*. He suggested that

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* Irving, R.D., "The Copper Bearing Rocks of Lake Superior," United States Geological Survey, Monograph 5 (1883).

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since it lies directly above the Lake Shore Traps, it was correlated with the Outer Copper Harbor conglomerate that outcrops in the Keweenaw Peninsula, and which also lies directly above the Lake Shore Traps. The Outer conglomerate in the Keweenaw Peninsula is composed essentially of coarse conglomerate with thin lenses of sandstone, and the name seems descriptively appropriate. Gordon* described the Outer conglomerate along the Black River section southwest of the Porcupine Mountains. Here the lower two-thirds of the formation is coarse conglomerate, and the upper one-third is sandstone. In the northern part of the Porcupine Mountains, the writer found the majority of the outcrops to be sandstones with thin zones of conglomerate. It may be argued that the exposed rocks along the traverses comprise only a small percentage as compared to the unexposed rocks; thus, the unexposed rocks

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* Gordon, W.C., and Lane, A.C., "A Geological Section From Bessemer Down Black River," Michigan Geological Survey Rept. for 1906, pp. 397-507, map (1907).

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might be conglomerates rather than sandstones. From his observations in the field, the writer noted that the conglomerate zones are more resistant to weathering than are the sandstone zones, and they occur in the form of knobs and prominent ridges (Figure 1) as contrasted with the sandstone outcrops that lie adjacent to the surface of the ground (Figure 2). Thus, if the rocks in the area were mostly conglomerate, more knobs and ridges would have observed. It is, therefore, inferred by the writer that along the traverses the rock is mostly sandstone with subordinate zones of conglomerate.

Dr. W.A. Kelly* of the Department of Geology, Michigan

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* Kelly, W.A., Personal communication

State College, pointed out that since the writer found more sandstone than conglomerate, the name Outer conglomerate seems very inappropriate and is misleading to the reader. Moreover, even though the formation lies directly above the Lake Shore Traps, it might not be the same formation as the Outer Copper Harbor conglomerate. Also, the name Outer conglomerate is inappropriate since it signifies no geographical locality. Dr. Kelly suggested the name Porcupine Mountains Sandstone for that sandstone formation in the Porcupine Mountains that lies stratigraphically above and in contact with the Lake Shore Traps. Thus the name: Porcupine Mountains Sandstone is introduced in this paper.

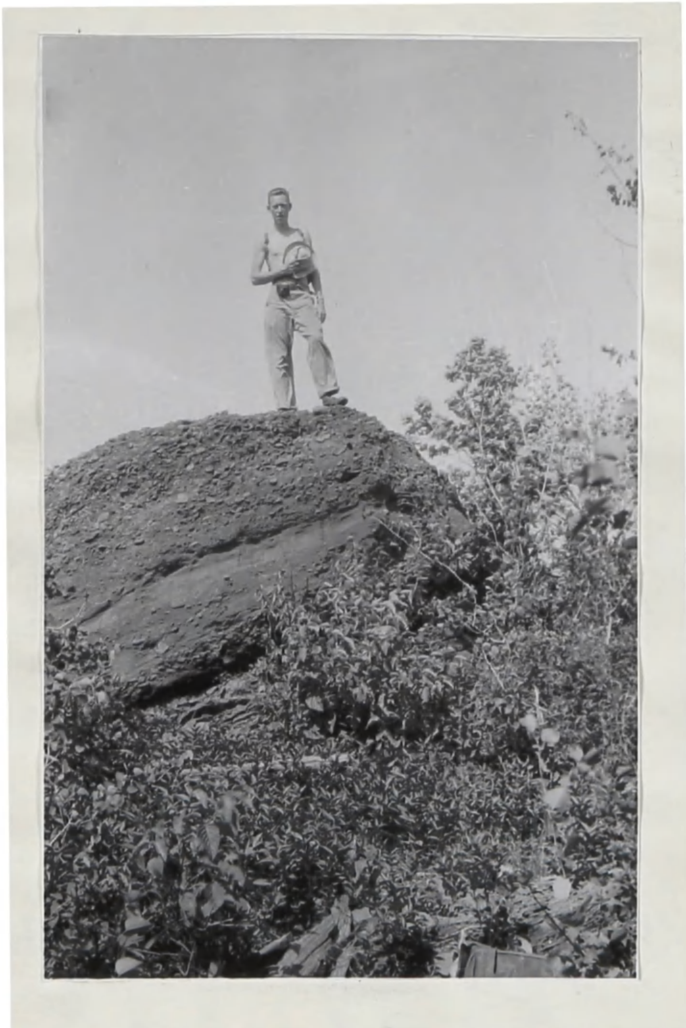

Figure 1. A typical conglomerate knob. Note the sandstone lens contained.

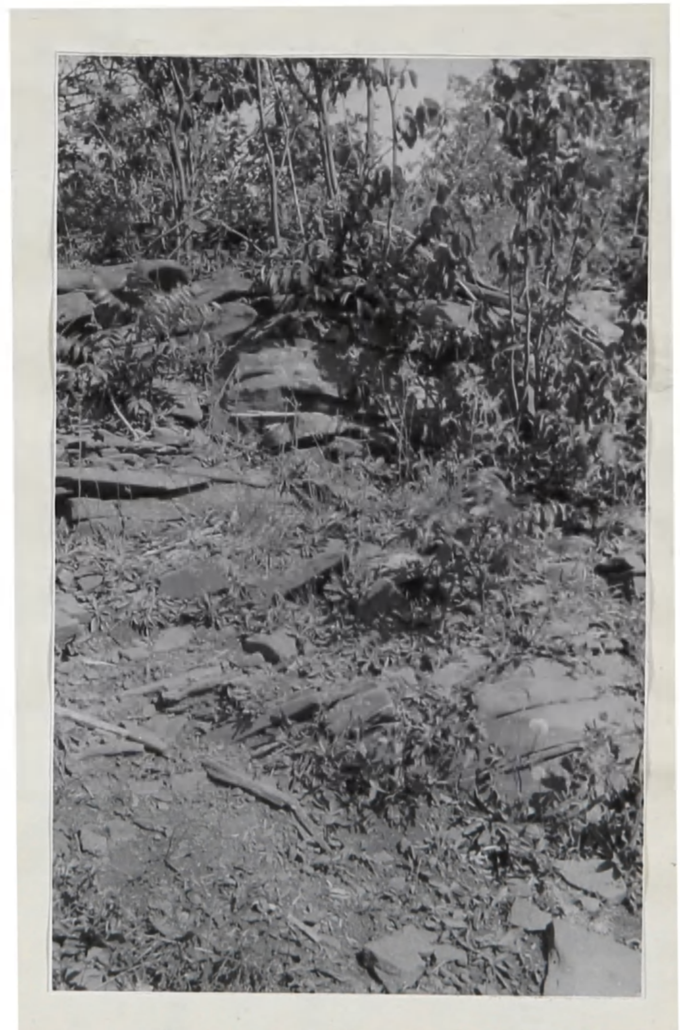

Figure 2. A typical bedded sandstone outcrop adjacent to the ground level.

PROCEDURE

1. Field Procedure

The field work of this study was completed in the summer of 1949. Six traverse lines or sections, perpendicular to the general strike of the Porcupine Mountains Sandstone, were assigned and traversed (Map 2). Traversing was done mainly by pace and compass. Along Section I where the brush was scanty, distances were measured with a steel tape. In other locations where the brush was very thick and accurate pacing or taping was impossible, the position of the outcrops was located by the use of aerial photographs.

Samples were collected from outcrops along the traverses. Where exposed rocks were continuous, samples were collected from the different lithologic zones. Strike and dip of bedding as well as prominent joints and other primary structures were observed, measured, and recorded.

2. Laboratory Procedure

In the laboratory, the samples were examined with the aid of a binocular microscope. Their descriptions are tabulated in the appendix accompanying this paper. Pebbles collected from the different conglomerate zones were classified and tabulated.

Exact mineral and petrographic determinations of the sandstones were made by examining selected thin sections. Also thin sections of type samples of the pebbles were examined and classified.

Sandstone grain size classifications in this paper follow the standards of the United States Bureau of Soils:

1. Very fine grained --- .05-.10 mm
2. Fine grained --- .10-.25 mm
3. Medium grained --- .25-.50 mm
4. Coarse grained --- .50- 1.0 mm
5. Gravel --- 1.0 mm and up

Sphericity and roundness measurements were made on the pebbles and sand grains by the visual quantitative methods described by G. Rittenhouse* and W.C. Krumbein**.

* Rittenhouse, G., "A Visual Method of Estimating Two-dimensional Sphericity," Journal of Sedimentary Petrology, Vol. 13, pp. 79-81, abstract (1943).

**Krumbein, W.C., "Measurement and Geological Significance of Shape and Roundness of Sedimentary Particles," Journal of Sedimentary Petrology, Vol. 11, pp. 68-69, plate 1, abstract (1941).

To determine the sphericity and roundness of the sand grains, a portion of each sandstone sample was crushed, and the loose grains examined under a binocular microscope. Ten grains were picked at random, and their sphericity and roundness were determined by comparing their two-dimensional images seen under the microscope with the images of standard grains and pebbles reproduced in the two charts of Rittenhouse and Krumbein. The calculated average sphericity and roundness of the ten grains for each sample, together with the sphericity and roundness of the pebbles, are tabulated in the appendix.

An attempt was made to correlate the exposed rocks along the traverses by means of:

1. The distinct lithologic characteristics of the outcrops.
2. The sphericity and roundness of the sand grains.

DESCRIPTION OF SECTIONS

Section I

The location of Section I is shown on Map 2. This section follows the course of Cuyahoga Creek from Location 1 on Highway M-107 northward to Location 2 on the shore of Lake Superior. Taping was started at the north edge of Highway M-107 at Location 1 following the course of Cuyahoga Creek and continued northward to Lake Superior. Outcrops were confined to the bed of the creek.

Following is a tabulated record of the traverse along Section I:

Position	Distance in feet	Bearing	Slope	Thickness in feet	Remarks
1	Location 1	-	-	-	Amygdaloidal lavas (Lake Shore Traps) (Sample 11)
1-2	102	N. 0° W.	15°	-	Amygdaloidal lavas (Lake Shore Traps)
2-3	98	N. 28° E.	10°	-	Amygdaloidal lavas (Lake Shore Traps)
3-4	100	N. 3° W.	5°	-	Amygdaloidal lavas (Lake Shore Traps) (Sample 13)
					Concealed interval

Position	Distance in feet	Bearing	Slope	Thickness in feet	Remarks
4-5	29	N. 32° E.	0°	2.0	Conglomeratic sandstone
				0.2	Conglomerate Bedding: strike S. 85° E., dip 23°, N. 5° W. (Samples 14 and 15)
				15	Concealed interval
5-6	38	N. 0° W.	5°	1.5	Conglomeratic sandstone Bedding: strike S. 86° E., dip 23°, N. 4° W. (Sample 16)
				4	Concealed interval
6-7	18	N. 2° W.	10°	3.0	Sandstone Bedding: strike N. 85° E., dip 23°, N. 5° W. (Sample 17)
				30	Concealed interval
7-8	106	N. 15° E.	5°	2.5	Conglomeratic sandstone (Sample 18)
				20	Concealed interval
8-9	63	N. 13° E.	3°	1.3	Sandstone, faint crossbedding (Sample 19)
				5	Concealed interval

Position	Distance in feet	Bearing	Slope	Thickness in feet	Remarks
9-10	17	N. 20° E.	15°	18.5	Conglomerate (Sample 20)
				20	Concealed interval
10-11	77	N. 3° E.	10°	3.5	Conglomeratic sandstone Bedding: strike N. 87° E. dip 26°, N. 3° W. (Sample 21)
				1,400	Concealed interval
11-12	Location 2	N. 0° W.	-	31.0	Sandstone and conglomeratic sandstone, mud cracks present
				1.0	Conglomerate Bedding: strike N. 86° W. dip 24°, N. 4° W. (Samples 1 to 10)

Section II

The location of Section II as shown on Map 2 extends from Location 3 on Highway M-107 to Location 4 on the shore of Lake Superior. A pace and compass traverse was conducted along this section.

Following is a tabulated record of the traverse along Section II:

Position	Distance in feet	Bearing	Slope	Thickness in feet	Remarks
1	Location 3	-	-	9.0	Sandstone cut by calcite veinlets Bedding: strike N. 75° E. dip 27°, N. 15° W. Joints: N. 8° W., vertical S. 45° W., vertical (Sample 1)
				640	Concealed interval
1-2	2,541	N. 0° W.	10°	2.5	Conglomeratic sandstone Bedding: strike N. 73° E. dip 26°, N. 17° W. Joints: N. 50° E., vertical S. 20° E., dip 80° W. S. 30° W., vertical (Sample 2)
				70	Concealed interval
2-3	180	N. 0° W.	0°	3.0	Sandstone cut by calcite veins (Sample 3)

Position	Distance in feet	Bearing	Slope	Thickness in feet	Remarks
				50	Concealed interval
3-4	123	N. 0° W.	0°	3.5	Sandstone, irregular leaching Joints: N. 60° E., vertical (Samples 4, 5, and 6)
				30	Concealed interval
4-5	90	N. 0° W.	5°	3.6 1.0 0.5	Conglomeratic sandstone Conglomerate Sandstone Joints: S. 20° E., vertical (Samples 7, 8, and 9)
				50	Concealed interval
5-6	150	N. 0° W.	5°	3.0	Sandstone Joints: N. 70° W., vertical S. 16° E., vertical (Sample 10)
				20	Concealed interval
6-7	69	N. 0° W.	10°	4.5	Sandstone (Sample 11)
				90	Concealed interval
7-8	269	N. 0° W.	5°	3.5	Conglomeratic sandstone Bedding: strike N. 71° E. dip 27°, N. 19° W. (Sample 12)

Position	Distance in feet	Bearing	Slope	Thickness in feet	Remarks
				15	Concealed interval
8-9	90	N. 0° W.	15°	2.5	Conglomeratic sandstone Bedding: strike N. 70° E. dip 28°, N. 20° W. (Sample 13)
				15	Concealed interval
9-10	51	N. 0° W.	5°	5.0	Conglomeratic sandstone (Sample 14)
				35	Concealed interval
10-11	132	N. 0° W.	10°	2.0	Conglomerate Joints: S. 25° E., vertical (Sample 15)
				15	Concealed interval
11-12	90	N. 0° W.	15°	3.0	Sandstone, massive, cut by calcite veins (Sample 16)
				600	Concealed interval
12-13	Location 4	N. 0° W.	0°	31.5	Sandstone showing mud cracks and ripple marks Bedding: strike N. 70° E. dip 25°, N. 20° E. Joints: S. 50° E., vertical (Samples 17 to 25) Calcite vein six inches thick, trends S. 16° E., vertical

Section III

Section III extends from Location 5 on Highway M-107 to Location 8 on the shore of Lake Superior as shown on Map 2.

Following is a tabulated record of the pace and compass traverse along Section III:

Position	Distance in feet	Bearing	Slope	Thickness in feet	Remarks
1	Location 5	-	-	-	No outcrops
				730	Concealed interval
1-2	Location 6	N. 20° W.	0°	0.5	Sandstone
				2.6	Conglomeratic sandstone
					Bedding: strike N. 71° E.
					dip 24°, N. 19° W.
					(Samples 1 and 2)
				10	Concealed interval
2-3	45	N. 0° W.	10°	0.5	Sandstone
				1.0	Conglomerate
				0.9	Conglomeratic sandstone
					Bedding: strike N. 70° E.
					dip 23°, N. 20° W.
					(Samples 3, 4, and 5)
				15	Concealed interval

Position	Distance in feet	Bearing	Slope	Thickness in feet	Remarks
3-4	60	N. 0° W.	5°	3.0	Conglomeratic sandstone Bedding: strike N. 72° E. dip 23°, N. 18° W. (Sample 6)
				10	Concealed interval
4-5	51	N. 0° W.	10°	2.7	Sandstone (Sample 7)
				10	Concealed interval
5-6	54	N. 0° W.	10°	0.5 1.5	Conglomeratic sandstone Conglomerate (Samples 8 and 9)
				15	Concealed interval
6-7	63	N. 0° W.	10°	4.0	Conglomeratic sandstone Bedding: strike N. 69° E. dip 22°, N. 21° W. (Sample 10)
				40	Concealed interval
7-8	179	N. 0° W.	10°	-	No outcrop
8-9	140	N. 70° E.	-	3.5	Conglomeratic sandstone (Sample 11)

Position	Distance in feet	Bearing	Slope	Thickness in feet	Remarks
9-10	164	N. 70° E.	-	0.7 2.5	Conglomerate Sandstone Bedding: strike N. 72° E. dip 22°, N. 18° W. (Samples 12 and 13)
				100	Concealed interval
10-11	Location 7	N. 85° W.	-	0.7 2.5	Conglomerate Sandstone (Samples 14 and 15)
				-	Concealed interval
11-12	93	N. 70° E.	0°	0.8	Conglomerate Joints: N. 50° E., vertical (Sample 16)
				10	Concealed interval
12-13	36	N. 0° W.	5°	0.8 5.5	Conglomerate Conglomeratic sandstone (Samples 17 and 18)
				-	Concealed interval
13-14	190	N. 70° E.	0°	2.5	Conglomeratic sandstone (Sample 19)
				-	Concealed interval

Position	Distance in feet	Bearing	Slope	Thickness in feet	Remarks
14-15	130	N. 70° E.	0°	6.0	Conglomeratic sandstone cut by quartz veins, trending N. 49° W., up to four inches thick (Samples 20, 21, 22, and 23)
				10	Concealed interval
15-16	69	N. 0° W.	15°	1.6	Sandstone (Sample 24)
				10	Concealed interval
16-17	150	N. 0° W.	20°	4.0	Conglomeratic sandstone cut by quartz veins, trending N. 45° W. (Sample 25)
				13	Concealed interval
17-18	90	N. 0° W.	15°	4.5	Sandstone cut by quartz veins, trending N. 5° W., N. 15° E., and N. 60° E. (Sample 26)
				10	Concealed interval
18-19	168	N. 0° W.	20°	2.0	Sandstone Bedding: strike N. 69° E. dip 21°, N. 21° W. (Sample 27)
				20	Concealed interval

Position	Distance in feet	Bearing	Slope	Thickness in feet	Remarks
19-20	152	N. 0° W.	15°	4.5	Sandstone Brecciated zone 3.5 feet thick, vertical, trends N. 8° W., 35 feet exposed (Samples 28 and 29)
				5	Concealed interval
20-21	111	N. 0° W.	20°	3.0	Sandstone, cut by irregular quartz veins (Sample 30)
				5	Concealed interval
21-22	92	N. 0° W.	20°	1.5	Conglomeratic sandstone Bedding: strike N. 70° E. dip 22°, N. 20° W. (Sample 31)
				4	Concealed interval
22-23	60	N. 0° W.	20°	2.5	Sandstone Bedding: strike N. 70° E. dip 23°, N. 20° W. (Sample 32)
				8	Concealed interval
23-24	147	N. 0° W.	20°	2.5	Conglomeratic sandstone
				1.5	Conglomerate
				2.0	Conglomeratic sandstone (Samples 33, 34, and 35)
				6	Concealed interval

Position	Distance in feet	Bearing	Slope	Thickness in feet	Remarks
24-25	123	N. 0° W.	20°	2.0	Conglomeratic sandstone, crossbedded (Sample 36)
				6	Concealed interval
25-26	90	N. 0° W.	20°	3.2	Sandstone Bedding: strike N. 68° E. dip 25°, N. 22° W. (Sample 37)
				4	Concealed interval
26-27	65	N. 0° W.	20°	1.0	Conglomerate (Sample 38)
				4	Concealed interval
27-28	60	N. 0° W.	20°	2.2	Sandstone (Sample 39)
				6	Concealed interval
28-29	92	N. 0° W.	20°	3.7	Sandstone Bedding: strike N. 72° E. dip 24°, N. 18° W. (Sample 40)
				180	Concealed interval
29-30	Location 8	N. 0° W.	0°	-	Outcrops of conglomeratic sandstone 25 feet off shore

Section IV

Section IV extends from Location 9 on the shore of Lake Superior to Location 10, and thence in a S. 25° E. direction as shown on Map 2.

Following is a tabulated record of the pace and compass traverse along Section IV:

Position	Distance in feet	Bearing	Slope	Thickness in feet	Remarks
1	Location 9	-	-	3.0	Sandstone, cross-bedded
				1.0	Conglomeratic sandstone, ripple marks
				1.0	Conglomerate
					Joints: N. 50° W., vertical
					N. 50° W., dip 75°, N. 40° E.
					Bedding: strike N. 66° E.
					dip 25°, N. 24° W.
					(Samples 1 to 5)
				750	Concealed interval
1-2	Location 10	S. 25° E.	-	2.2	Sandstone
					Bedding: strike N. 66° E.
					dip 24°, N. 24° W.
					(Sample 6)
				4	Concealed interval
2-3	50	S. 25° E.	20°	3.5	Sandstone
					(Sample 7)
				5	Concealed interval

Position	Distance in feet	Bearing	Slope	Thickness in feet	Remarks
3-4	64	S. 25° E.	20°	2.6	Conglomeratic sandstone (Sample 8)
				8	Concealed interval
4-5	53	S. 25° E.	15°	1.5	Conglomeratic sandstone (Sample 9)
				20	Concealed interval
5-6	116	S. 25° E.	15°	3.0	Conglomeratic sandstone Joints: N. 65° W., vertical (Sample 10)
				35	Concealed interval
6-7	216	S. 25° E.	15°	2.0	Conglomeratic sandstone Bedding: strike N. 65° E. dip 23°, N. 25° W. (Sample 11)
				30	Concealed interval
7-8	198	S. 25° E.	15°	1.7	Conglomeratic sandstone, cross-bedded (Sample 12)
				100	Concealed interval

Position	Distance in feet	Bearing	Slope	Thickness in feet	Remarks
8-9	450	S. 25° E.	10°	4.1	Conglomeratic sandstone Bedding: strike N. 67° E. dip 23°, N. 23° W. (Sample 13)
				25	Concealed interval
9-10	165	S. 25° E.	15°	2.8	Conglomeratic sandstone (Sample 14)
				-	Concealed interval

Section V

Section V extends from Location 11 on the shore of Lake Superior to Location 16 as shown on Map 2.

Following is a tabulated record of the pace and compass traverse along Section V:

Position	Distance in feet	Bearing	Slope	Thickness in feet	Remarks
1	Location 11	-	-	1.6 1.2 0.5	Conglomeratic sandstone Sandstone, cross-bedded Conglomerate Joints: N. 50° W., vertical N. 10° W., vertical S. 80° W., vertical (Samples 5, 6, and 7)
1-2	100	S. 65° W.	-	3.1	Conglomeratic sandstone Joints: N. 20° E., dip 75°, N. 70° W. N. 45° W., vertical (Sample 4)
2-3	50	S. 65° W.	-	2.5 1.8	Sandstone Conglomeratic sandstone Joints: N. 45° W., vertical (Samples 2 and 3)
3-4	50	S. 65° W.	-	4.5	Sandstone, parallel and cross-bedding Bedding: strike N. 68° E. dip 22°, N. 22° W. (Sample 1)

Position	Distance in feet	Bearing	Slope	Thickness in feet	Remarks
				30	Concealed interval
1-5	100	N. 65° E. of Location 11	5°	2.0	Sandstone
				1.0	Conglomerate
					Joints: N. 50° W., vertical
					N. 10° E., vertical
					S. 80° W., vertical
					(Samples 8 and 9)
				950	Concealed interval
5-6	Location 12	S. 25° E.	15°	3.2	Sandstone
				2.4	Conglomeratic sandstone
				0.5	Conglomerate
				1.2	Conglomeratic sandstone
					(Samples 10, 11, 12, and 13)
				15	Concealed interval
6-7	75	S. 25° E.	15°	2.7	Sandstone
					Bedding: strike N. 68° E. dip 27°, N. 22° W.
					(Sample 14)
				25	Concealed interval
7-8	90	S. 25° E.	10°	2.0	Conglomeratic sandstone (Sample 15)
				20	Concealed interval
8-9	84	S. 25° E.	15°	2.5	Conglomeratic sandstone (Sample 16)

Position	Distance in feet	Bearing	Slope	Thickness in feet	Remarks
				20	Concealed interval
9-10	69	S. 25° E.	10°	2.9	Conglomeratic sandstone (Sample 17)
				40	Concealed interval
10-11	309	S. 25° E.	20°	1.7	Conglomeratic sandstone Bedding: strike N. 69° E. dip 28°, N. 21° W. (Sample 18)
				5	Concealed interval
11-12	44	S. 25° E.	20°	1.5	Conglomerate Joints: N. 50° W., vertical S. 80° W., vertical (Samples 19 and 20)
				5	Concealed interval
12-13	39	S. 25° E.	22°	1.2 2.0	Conglomeratic sandstone Conglomerate Bedding: strike N. 65° E. dip 24°, N. 25° W. Joints: N. 60° W., vertical N. 20° E., vertical (Samples 21 and 22)
				70	Concealed interval

Position	Distance in feet	Bearing	Slope	Thickness in feet	Remarks
13-14	345	S. 25° E.	15°	1.5	Sandstone
				0.9	Conglomerate (Samples 23 and 24)
				10	Concealed interval
14-15	25	S. 25° E.	5°	2.5	Sandstone Bedding: strike N. 65° E. dip 29°, N. 25° E. (Sample 25)
				20	Concealed interval
15-16	Location 13	S. 25° E.	20°	2.0	Conglomerate (Samples 26, 27, 28, and 29)
				210	Concealed interval
16-17	Location 14	S. 25° E.	-	14.0	Conglomerate (Samples 30, 31, 32, and 33)
				1.0	Conglomeratic sandstone Bedding: strike N. 64° E. dip 28°, N. 26° W. (Sample 34)
				150	Concealed interval
17-18	Location 15	S. 25° E.	-	13.0	Conglomerate (Sample 35)
				3.2	Sandstone Bedding: strike N. 62° E. dip 27°, N. 28° W. (Sample 36)

Position	Distance in feet	Bearing	Slope	Thickness in feet	Remarks
				140	Concealed interval
18-19	Location 16	S. 25° E.	-	11.0	Conglomerate, boulders up to 1.0 feet (Samples 37, 38, 39, and 40)
				-	Concealed interval

Section VI

Section VI extends from Location 17 on the shore of Lake Superior, to Location 18, thence to Location 23 as shown on Map 2.

Following is a tabulated record of the pace and compass traverse along Section VI:

Position	Distance in feet	Bearing	Slope	Thickness in feet	Remarks
1	Location 17	-	-	-	Sandstone, brecciated zone, trends N. 12° W., 10 feet thick (east-west) (Sample 1)
				23.5	Conglomeratic sandstone Bedding: strike N. 57° E. dip 27°, N. 33° W. Joints: N. 15° W., vertical N. 45° W., vertical S. 85° W., vertical (Samples 2 and 3)
				-	Concealed interval
1-2	Location 18	-	-	14.5	Conglomeratic sandstone, parallel and cross-bedding Bedding: strike N. 56° E. dip 27°, N. 34° W. Joints: N. 40° E., vertical N. 55° W., vertical (Sample 4)
				1,250	Concealed interval

Position	Distance in feet	Bearing	Slope	Thickness in feet	Remarks
2-3	Location 19	S. 35° E.	-	6.0	Conglomeratic sandstone Bedding: strike N. 55° E. dip 26°, N. 35° W. (Sample 5)
				260	Concealed interval
3-4	Location 20	S. 35° E.	-	7.5	Conglomeratic sandstone (Sample 6)
				150	Concealed interval
4-5	Location 21	S. 35° E.	-	6.5	Conglomerate
				4.0	Conglomeratic sandstone Bedding: strike N. 56° E. dip 27°, N. 34° W. (Samples 7, 8, and 9)
				100	Concealed interval
5-6	Location 22	S. 35° E.	-	16.0	Conglomerate (Samples 10,11, and 12)
				125	Concealed interval
6-7	Location 23	S. 35° E.	-	9.0	Conglomerate Joints: N. 27° W., vertical (Samples 13 and 14)

General Statement

Following is a general description of the rock outcrops along the sections (traverses):

1. Lithologic types
   a. Conglomeratic sandstone: These are exposed along all the sections, and constitute the majority of the outcrops. They exhibit mainly parallel bedding, although some zones are massive. They vary in color from brick red to dark brown, and in grain size range from fine to coarse. Pebbles disseminated throughout the body of the sandstones do not compose more than ten per cent of the total volume of the rock. The sandstones grade into non-conglomeratic phases along both the strike and dip.
   b. Non-conglomeratic sandstone: These are exposed along all the sections. In abundance they are next to the conglomeratic sandstone. The sandstones mainly exhibit parallel bedding, but some zones are massive. They vary in color from brick red to brown, and in grain size range from fine to coarse. The non-conglomeratic sandstones grade into conglomeratic phases along both the strike and dip.
   c. Coarse conglomerate: These are exposed along all the sections, but constitute a minority of the outcrops. Their thickness varies from a few inches to 18 feet. The conglomerates are brown and are composed of well rounded, poorly sorted pebbles with an average diameter

of three inches, but some boulders of over one foot in diameter were observed. The conglomerate zones are more abundant in Sections V and VI than in the other sections. This indicates that there is a change in lithology from a sandy to a coarse conglomerate phase westwards along the strike of the formation; but even in these two westerly sections, the conglomerate zones are subordinate to the sandstones.

d. Basic lava flows: These are exposed only in the southern part of Section I. They are dark greenish gray in color and are mostly amygdaloidal. The amygdules are filled with epidote. These rocks represent the upper section of the Lake Shore Traps formation. A concealed interval of 29 feet obscures their actual contact with the sandstone.

2. Structural features

A. Strike and dip: Strike and dip measurements were taken on zones of sandstones and conglomeratic sandstones exhibiting parallel bedding. Following is a tabulated record of the average strikes and dips along each of the six sections:

Section number	Average strike	Average dip
I	N. 88° E.	24°, N. 2° W.
II	N. 70° E.	26°, N. 20° W.
III	N. 70° E.	23°, N. 20° W.
IV	N. 65° E.	24°, N. 25° W.
V	N. 65° E.	24°, N. 25° W.
VI	N. 56° E.	27°, N. 34° W.

The regional strike of the outcrops in the area is approximately parallel to the shore of Lake Superior (Map 2); i.e., it swings northwards to the southwest. The dip increases to the southwest.

B. Fractures:

1. Faults: Evidences of cross faulting occur along Sections III and VI in the form of brecciated zones (Map 2), but no actual displacement of beds was observed. In their geologic map of the Porcupine Mountains, F.E. Wright and A.C. Lane show many cross faults cutting the Lake Shore Traps formation (Map 2). These probably extend into the sandstone to the north.

2. Joints: The outcrops of conglomeratic sandstones, sandstones, and conglomerates are jointed in places (See descriptions of sections). The majority of the joints are vertical; a few possess steep dips ranging from 75 to 85 degrees. There are three main joint systems with trends respectively:

    a. Oblique joints that trend in a northeast-southwest direction.

    b. Oblique joints that trend in a northwest-southeast direction.

    c. Dip joints that trend in an approximate north-south direction.

    It seems very logical that the joints are closely related to the faulting reported in this area.

If this is true, the joints would be classified as feather joints; i.e., tension fractures. This is only an inferred classification, and more extensive field study is necessary before any definite conclusion could be reached regarding the true genetic classification of these joints.

C. Primary features:

a. Cross-bedding: These features are not extensive but occur locally. They are not very well exposed; the tangential parts, if any, and the truncations could not be seen. Thus, it could not be determined whether the cross-bedding was normal or torrential.

b. Ripple marks: These were observed in but a few localities. Most of them are very badly weathered and indistinct, but in places it was determined that they were mainly current ripple marks.

c. Mud cracks: "Horseshoe" type mud cracks were observed in few localities. They vary from a fraction of one inch in extent to about six inches for each "horseshoe".

3. Sand grain, sphericity, and roundness analysis

The average sphericity and roundness of each sandstone sample was determined by the visual methods previously described. From an examination of the results a few significant facts are noted:

a. Coarse grains show the highest roundness value with an average of .6.

b. Medium grains show an average roundness value of .5.

c. Fine grains show an average roundness value of .4 to .5.

d. The sphericity figures are not significant since they vary haphazardly and not according to grain size. They range in value from .69 to .81.

4. Thickness of the sections

The inferred thickness of the concealed and exposed sandstones along each of the sections is reported below. It was calculated by measuring the map distances between the highest and lowest stratigraphic exposed zones perpendicular to the average strike along each section. The average dips (p. 44) were used in the calculation.

Section number	Total thickness in feet
I	1,600
II	1,700
III	1,150
IV	1,050
V	1,650
VI	1,900

The above would be the true thicknesses only if no repetition of beds occur due to faulting.

The thickness of the concealed intervals between outcrops as recorded in the description of the sections (pp. 21-44), was computed by the use of Mertie's* chart. In each case,

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* Mertie, J.B., "Graphic and Mechanical Computation of Thickness of Strata and Distance to a Stratum," United States Geological Survey, Prof. Paper 129-C, plate VI (1921).

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the strike and dip used in the estimation of the thickness is the average of the strikes and dips obtained on the north side and the south side of the concealed section.

5. Secondary inclusions

The sandstone outcrops are cut in places by irregular quartz and calcite veinlets. The thickest calcite veinlet observed is six inches, and the thickest quartz veinlet is four inches. Their exact locations and trends are recorded in the description of the sections (pp. 21-44).

MINERALOGY AND PETROGRAPHY

1. The Sandstones

Eight thin sections of the sandstones were examined:

Section I

Sample 1. Sandstone (Orthoquartzite)

Megascopic description: The sandstone is brown, medium grained, and bedded. The grains are well sorted. Quartz and feldspars are visible to the eye.

Microscopic description: Clastic, well sorted, angular, and sub-angular grains.

Stable "primary" minerals*	Stable "secondary" minerals*	Precipitates* "cement"	Minor constituents
Quartz-80%	Sericite	Calcite	Magnetite-2%
Oligoclase-10%	Chlorite	Hematite	Zircon
Orthoclase-3%			
Muscovite			

* Pettijohn, F.J., Sedimentary Rocks, p. 86 (1940).

Sample 14. Arkose

Megascopic description: The arkose is brown. Poorly sorted, coarse quartz and feldspar grains are visible to the eye.

Microscopic description: Clastic, poorly sorted, subangular and rounded grains. The arkose contains about five per cent of igneous rock fragments. These are mainly composed of microlitic feldspars possessing a felty texture.

Stable "primary" minerals*	Stable "secondary" minerals*	Precipitates* "cement"	Minor constituents
Quartz-40%	Chlorite	Calcite-10%	Epidote
Oligoclase-30%	Kaolin-5%	Hematite	Magnetite-3%
Orthoclase-5%			
Biotite			
Muscovite			

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* Pettijohn, F.J., Sedimentary Rocks, p. 86 (1940).

Section II

Sample 1. Sandstone (Orthoquartzite)

Megascopic description: The sandstone is brown, fine grained, and is cut by calcite veinlets. Quartz, feldspars, and mica are visible to the eye.

Microscopic description: Clastic, well sorted, angular and sub-angular grains.

Stable "primary" minerals*	Stable "secondary" minerals*	Precipitates* "cement"	Minor constituents
Quartz-85%	Kaolin	Calcite	Magnetite-2%
Oligoclase-10%	Chlorite	Hematite	Epidote
Muscovite	Sericite		

* Pettijohn, F.J., Sedimentary Rocks, p. 86 (1940).

Sample 17. Arkosic sandstone

Megascopic description: The sandstone is brown, medium grained, and bedded. The grains are poorly sorted. Brick red, parallel, platy, discontinuous zones about 0.5 millimeters thick (ferruginous clay zones?) are found.

Microscopic description: Clastic, poorly sorted, angular and sub-angular grains. The sandstone contains five per cent of igneous rock fragments. These are mainly composed of microlitic feldspars, and possess a felty texture.

Stable "primary" minerals*	Stable "secondary" minerals*	Precipitates* "cement"	Minor constituents
Quartz-70%	Chlorite	Calcite	Magnetite-2%
Oligoclase-15%	Kaolin	Hematite	
Microcline-20%			
Perthite-3%			
Muscovite			

* Pettijohn, F.J., Sedimentary Rocks, p. 86 (1940).

Section III

Sample 28. Sandstone (Orthoquartzite)

Megascopic description: The sandstone is brown, fine grained, and brecciated.

Microscopic description: Clastic, well sorted, angular and sub-angular grains. The spaces between the brecciated fragments are filled with cryptocrystalline quartz.

Stable "primary" minerals*	Stable "secondary" minerals*	Precipitates* "cement"	Minor constituents
Quartz-90%	Chlorite	Calcite	Magnetite-1%
Oligoclase-5%	Kaolin	Hematite	Epidote
Biotite			Zircon

* Pettijohn, F.J., Sedimentary Rocks, p. 86 (1940).

Section IV

Sample 3. Arkosic sandstone

Megascopic description: The sandstone is brown, medium grained, bedded, and cut by calcite and quartz veinlets.

Microscopic description: Clastic, poorly sorted, angular and sub-angular grains. The sandstone contains about five per cent of igneous rock fragments. These are mainly composed of microlitic feldspars, and possess a felty texture.

Stable "primary" minerals*	Stable "secondary" minerals*	Precipitates* "cement"	Minor constituents
Quartz-75%	Kaolin	Calcite-2%	Zircon
Oligoclase-15%	Chlorite	Hematite	Epidote
Microcline-3%	Sericite		Magnetite
Orthoclase-2%			
Muscovite			
Biotite			

* Pettijohn, F.J., Sedimentary Rocks, p. 86 (1940).

Section V

Sample 14. Sandstone (Orthoquartzite)

Megascopic description: The sandstone is brown and fine grained. It is bedded and micaceous.

Microscopic description: Clastic, well sorted, angular and sub-angular grains.

Stable "primary" minerals*	Stable "secondary" minerals*	Precipitates* "cement"	Minor constituents
Quartz-85%	Kaolin	Calcite	Magnetite-2%
Oligoclase-10%	Chlorite	Hematite	
Microcline-2%			
Muscovite			
Biotite			

* Pettijohn, F.J., Sedimentary Rocks, p. 86 (1940).

Section VI

Sample 3. Sandstone (Orthoquartzite)

Megascopic description: The sandstone is brown and fine grained.

Microscopic description: Clastic, well sorted, angular and sub-angular grains.

Stable "primary" minerals*	Stable "secondary" minerals*	Precipitates* "cement"	Minor constituents
Quartz-90%	Chlorite	Calcite	Magnetite-3%
Oligoclase-5%	Sericite	Hematite	
Orthoclase			
Biotite			
Muscovite			

* Pettijohn, F.J., Sedimentary Rocks, p. 86 (1940).

2. The Igneous Pebbles

Six thin sections of type samples of the igneous pebbles from the coarse conglomerates and the conglomeratic sandstones were examined.

Pebble 1. Rhyolite

Megascopic description: Reddish brown, fine grained, and aphanitic. Quartz and feldspars are identified with a hand lens.

Microscopic description: Holocrystalline, hypautomorphic--granular texture.

Primary minerals	Secondary minerals	Alterations
Quartz-35%	Hornblende-5%	Sericite
Oligoclase-15%	Zircon	Kaolinite-10%
Perthite-30%	Magnetite	
	Epidote	

Pebble 2. Basalt

Megascopic description: Greenish gray, very fine grained, and aphanitic.

Microscopic description: Holocrystalline, diabasic texture.

Primary minerals	Secondary minerals	Alterations
Labradorite-60%	Magnetite-7%	Chlorite-3%
Augite-30%	Epidote	
	Hornblende	

Pebble 3. Amygdaloidal basalt

Megascopic description: Greenish gray, very fine grained, aphanitic, and amygdaloidal.

Microscopic description: Holocrystalline, diabasic texture. Most of the amygdules are filled with cryptocrystalline quartz. One amygdule is filled with skeleton hematite crystals.

Primary minerals	Secondary minerals	Alterations
Labradorite-60%	Magnetite-5%	Chlorite-4%
Augite-30%	Epidote	
	Biotite	
	Apatite	

Pebble 4. Trachyte porphyry

Megascopic description: Light brown, very fine grained, and porphyritic. The phenocrysts are composed of feldspars.

Microscopic description: Hypocrystalline, microlitic texture, and trachitic structure. The phenocrysts are subhedral.

Primary minerals	Secondary minerals	Alterations
Phenocrysts:	Quartz-5%	Kaolinite
Albite-5%	Magnetite-2%	Chlorite
Orthoclase-15%	Biotite shreds-3%	
Microlites:		
Orthoclase(?)-60%		
Glassy matrix-10%		

Pebble 5. Trachyte porphyry

Megascopic description: Light brown, very fine grained, and porphyritic. The phenocrysts are composed of feldspars.

Microscopic description: Hypocrystalline, microlitic texture, and trachitic structure. The phenocrysts are subhedral.

Primary minerals	Secondary minerals	Alterations
Phenocrysts:	Quartz-5%	Chlorite
Albite-3%	Magnetite	
Orthoclase-20%	Epidote	
Microlites:		
Orthoclase(?)-60%		
Glassy matrix-10%		

Pebble 6. Rhyolite porphyry

Megascopic description: Reddish brown, very fine grained, and porphyritic. The phenocrysts are composed of feldspar and quartz. The pebble is fractured.

Microscopic description: Hypocrystalline texture. The phenocrysts are subhedral. The fractures in the pebble are filled with cryptocrystalline quartz.

Pebble 6 (cont.)

Primary minerals	Secondary minerals	Alterations
Phenocrysts:		Kaolinite
Quartz-5%		
Perthite-8%		
Orthoclase-3%		
Sanidine-2%		
Glassy matrix:		
Feldspars and quartz-82%		

3. General Statement

A. The Sandstones

The sandstones along all of the sections show a very similar mineralogy and petrography. This is an indication that they have come from the same source or sources.

The fine grained sandstones are mostly orthoquartzites, the medium grained are arkosic sandstones, and the coarse grained are arkoses with more than 25 per cent of feldspars. As most of the outcrops are medium grained, it is inferred that the Porcupine Mountains Sandstone in the area studied, is mainly a conglomeratic arkosic sandstone with lenses of fine and coarse grained sandstone and arkose.

The cement of the orthoquartzites, arkosic sandstones, and arkoses is composed of secondary calcite and hematite. The latter is the mineral from which the sandstones derive their characteristic reddish brown color.

B. The Igneous Pebbles

A total of one hundred and eighty-eight pebbles were collected from the different outcrops of coarse conglomerates and conglomeratic sandstone. These are classified into four main groups:

1. Trachyte porphyry: Seventy-eight pebbles of this group were collected.
2. Rhyolite porphyry: Forty-three pebbles of this group were collected.
3. Basalt: Thirty-four pebbles of this group were collected. Some are amygdaloidal.
4. Rhyolite: Sixteen pebbles of this group were collected.

The remaining seventeen pebbles are classified into two additional minor groups:

5. Quartz: Ten pebbles of this group were collected. One pebble showed typical agate zoning.
6. Granite: Seven pebbles of this group were collected. One pebble showed gneissic banding.

The above described pebbles were found to have a roundness value of .6 to .9, and a sphericity of .67 to .87 (See appendix).

The average size of the pebbles is about three inches, but a few boulders of more than one foot in diameter were observed. The pebbles are poorly sorted in their respective zones (Figures 1 and 5).

The majority of the pebbles composing the conglomerate zones are acidic and intermediate igneous rocks, which can be classified generally as felsites. This is in conformity with the character of most of the pebbles of the Keweenawan conglomerates that outcrop in the Keweenaw Peninsula and along the Black River southwest of the Porcupine Mountains.

It is inferred that the felsite pebbles which make up most of the material of the conglomerate zones of the Porcupine Mountains sandstone in the area studied, were derived from the lower Keweenawan rocks. Gordon* believes that these rocks were the only possible source of felsites. Other pebbles found, such as granites, quartz, and agates were most probably derived from the pre-Keweenawan rocks, which include the Huronian and the Archeozoic.

* Gordon, W.C., and Lane, A.C., "A Geological Section From Bessemer Down Black River," Michigan Geological Survey Rept. for 1906, p. 429 (1907).

CORRELATIONS

Correlation of the outcrops from one section to another was attempted by the following methods:

1. By lithology: The outcrops in the area are composed of conglomeratic sandstones, sandstones, and thin conglomerate zones. The first two lithologic types do not occur in distinct zones, but grade into each other along both the strike and dip, making it impossible to trace any particular zone from one section to another. The only zones that possess distinct lithology and sharp contacts are those of the coarse conglomerates. Along Sections I, II, III, and IV, all of the conglomerate zones observed were very thin and irregular; but along Section V and VI, relatively large conglomerate zones outcrop in the form of prominent ridges. Along Section V, these outcrop at Locations 14, 15, and 16; and along Section VI, similar ridges occur at Locations 21, 22, and 23 (Map 2).

   The topographic expression of the area of Sections V and VI indicates that these conglomerate ridges described above are a part of one large conglomerate zone that extends from Sections V to VI (Plate 1). It is not known whether this zone extends to the east, or pinches out somewhere in the area between Sections IV and V. The area west of Section VI was not traversed, and it could not be determined if the conglomerate zone extends to the west.

   In an unpublished paper describing outcrops along the

Carp and Little Carp Rivers in the Porcupine Mountains, southwest of Section VI, Hornstein* reported the existence

* Hornstein, O.M., "A Field and Petrographic Study of Some Extrusive and Sedimentary Rocks Along the Carp and Little Carp Rivers in Ontonagon and Gogebic Counties, Michigan." Unpublished Master's thesis, Department of Geology and Geography, Michigan State College, 1950.

of conglomerate zones of very similar character stratigraphically above the Lake Shore Traps formation. It is very probable that one of these zones may be directly related to the conglomerate zone along Sections V and VI.

On a map of the area the regional strike of the Porcupine Mountains sandstone was projected from the position of the conglomerate zone of Section V and VI, to the area of the Little Carp and Carp Rivers. At the locations where this projection cuts the two river courses, Hornstein*

* Ibid.

reported that outcrops of poorly sorted, coarse, felsite conglomerate occur, demonstrating the very probable relation existing between these zones.

It is not within the scope of this investigation to correlate between the area described in this paper, and the area of the Little Carp and Carp Rivers. Nevertheless, it has been shown that relations do exist, both on the basis of lithology and stratigraphic position. More detailed field work in the area between the Little Carp and Carp Rivers and Section VI is, however, necessary before any definite correlations can be established.

2. By the sphericity and roundness of the sand grains and pebbles: Correlation by this method is not possible, because no distinct zones with a constant sphericity and roundness were noted. On the contrary, variations in sphericity and roundness figures were observed along the strike and dip of the sandstones. This is primarily due to variations in the grain size along the strike and dip.

Correlation by this method would have been possible if distinct zones of constant grain sizes occurred. In this case, the sandstone grains would have a constant roundness. This assumption is based on results demonstrated by this investigation; namely, that equal-sized grains of the sandstones in the area studied, possess equal roundness.

Upon inspection of the roundness and sphericity figures of the pebbles from the different conglomerate zones, it can be seen that they possess a very similar sphericity and roundness, regardless of the zone from which they came (See appendix). Thus, these figures could not be used as a means of correlating conglomerate zones.

CONCLUSION

The rocks that outcrop along the six sections traversed are composed mainly of conglomeratic sandstones that exhibit parallel bedding with local cross-bedding (Map 2). Some zones of non-conglomeratic sandstone and coarse conglomerate also occur, probably as lenses. The rocks vary in color from brick red to dark brown, and range in grain size from fine to coarse. They are jointed, possibly faulted, and are cut by irregular veinlets of quartz and calcite.

Attempts to correlate the outcrops:

1. By lithology: Correlation was only possible between the conglomerate zones along Sections V and VI (Plate 1).
2. By the sphericity and roundness of the sand grains and pebbles: Correlation was not possible.

The sandstones are composed essentially of quartz with minor amounts of oligoclase. Most of the pebbles are composed of intermediate and acidic igneous rocks with minor amounts of basic igneous pebbles. This indicates that the main source of the sediments was an area of outcrops of intermediate and acidic igneous rocks. The most likely area in the vicinity from which these sediments could have been derived is the main Red Rock area in the heart of the Porcupine Mountains.

The basalt pebbles found in the conglomerate zones and the conglomeratic sandstones indicate that not all of the sediments were derived from acidic and intermediate igneous rocks. In the vicinity of the Porcupine Mountains there are large areas where basaltic flows are located*. These are probably

* Wright, F.E., and Lane, A.C., "Preliminary Geological Map of the Porcupine Mountains and Vicinity," Michigan Geological Survey Rept. for 1908, pl. 1 (1909).

the source rocks from which these basic igneous pebbles were derived.

The pebbles of the conglomerates and the conglomeratic sandstones are well rounded indicating that they are water-worn. The writer is of the opinion that these sandstones and conglomerates are stream deposits for the following reasons:

1. Thin conglomerate zones are repeated haphazardly through more than 1,500 feet of sandstone.
2. The sandstones are poorly sorted and feldspathic.
3. Ferruginous clay zones are found in the sandstone.
4. Mud cracks are present.

Figure 3. Location 17. In the foreground is the brecciated sandstone zone crisscrossed by calcite veinlets. In the background is Lone Island.

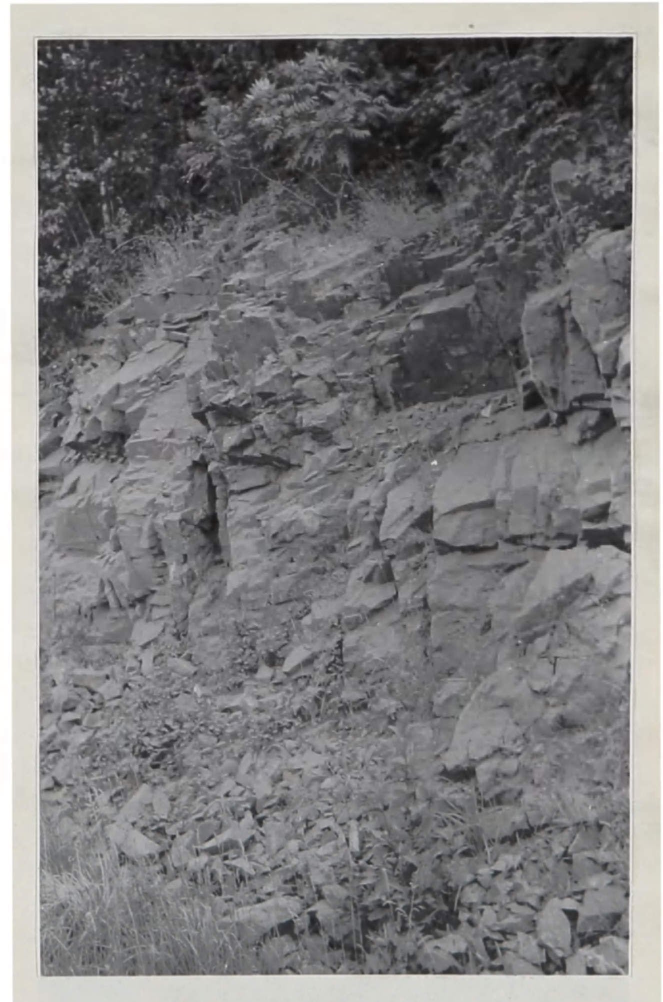
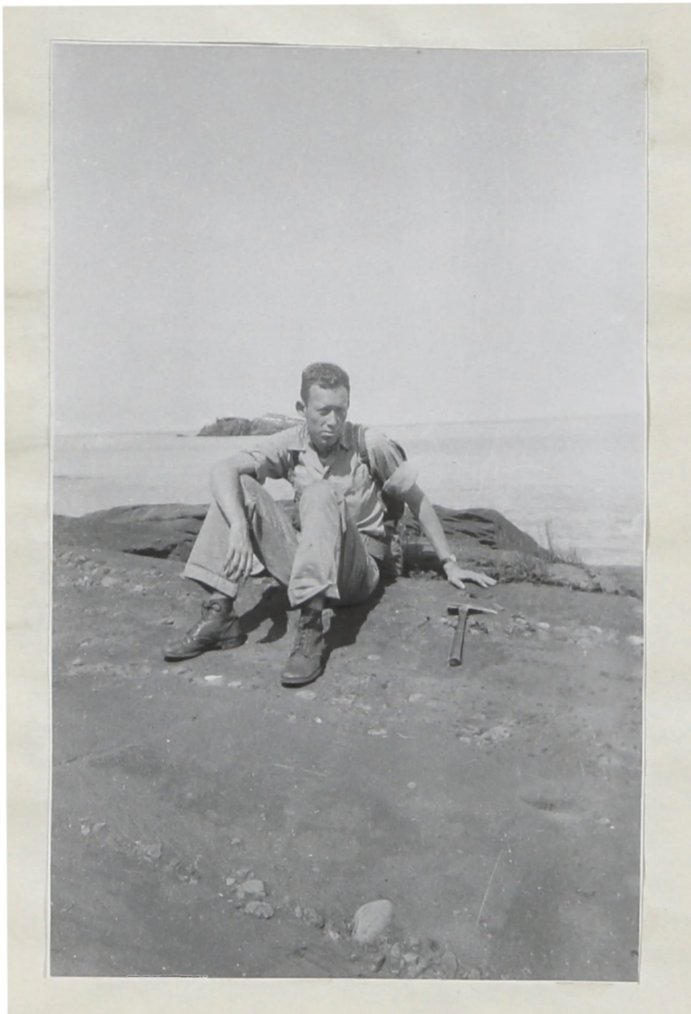


Figure 4. Location 3. Roadcut in fine grained, jointed sandstone.



<u>Figure 5</u>. Conglomeratic sandstone with thin, interfingering, conglomerate zones. Lone Island is in the background.

<u>Figure 6</u>. Outcrop of conglomeratic sandstone offshore in Lake Superior.

APPENDIX

DESCRIPTION OF SAMPLES OF SECTION I

Sample number	Lithologic type	Color	Grain size	Average sphericity	Average roundness	Average sorting	Other characteristics
1	Sandstone	Brown	Medium	.75	.6	Good	Bedded
2	Sandstone	Reddish brown	Medium	.73	.6	Good	Micaceous
3	Sandstone	Reddish brown	Fine	.81	.5	Good	Bedded
4	Sandstone	Reddish	Medium	.73	.5	Good	Bedded
5							
Pebble	Rhyolite porphyry	Reddish brown	Very fine	.81	.8	-	Quartz phenocrysts
6	Sandstone	Reddish brown	Medium	.77	.5	Good	Bedded, mud cracks, micaceous
7	Sandstone	Reddish brown	Medium	.75	.5	Good	Bedded, micaceous
8	Sandstone	Brown	Medium	.77	.4	Good	Bedded, platy discontinuous zones 2-6 inches thick

Sample number	Lithologic type	Color	Grain size	Average sphericity	Average roundness	Average sorting	Other characteristics
9	Sandstone	Brown	Medium	.77	.5	Good	Bedded
10	Conglomerate	Brown	-	-	-	Good	Average size of pebbles 3 inches
Pebble	Basalt	Greenish gray	Very fine	.79	.8	-	-
11	Basalt	Greenish gray	Very fine	-	-	-	Epidote amygdules
12	Basalt	Greenish gray	Very fine	-	-	-	Epidote amygdules
13	Basalt	Greenish gray	Very fine	-	-	-	Epidote amygdules
14	Sandstone	Reddish brown	Coarse	.75	.5	Good	Bedded, micaceous
15	Conglomerate	Brown	-	-	-	-	Pebbles up to 1.0 inches
16	Conglomeratic sandstone	Brown	Medium	.77	.5	Good	Bedded

Sample number	Lithologic type	Color	Grain size	Average sphericity	Average roundness	Average sorting	Other characteristics
Pebble	Basalt	Greenish gray	Very fine	.75	.8	-	-
Pebble	Rhyolite	Reddish brown	Very fine	.83	.7	-	Vesicular
17	Conglomeratic sandstone	Brown	Medium	.83	.4	Poor	Bedded, micaceous
18	Conglomeratic sandstone	Brown	Medium	.75	.5	Good	Pebbles up to 0.4 inches
19	Conglomeratic sandstone	Reddish brown	Medium	.77	.5	Good	Cross-bedded, micaceous
20	Conglomerate	-	-	-	-	Good	Pebbles up to 8 inches
Pebble	Rhyolite porphyry	Reddish brown	Very fine	.77	.8	-	Quartz phenocrysts
Pebble	Basalt	Greenish gray	Very fine	.75	.8	-	Epidote amygdules

Sample number	Lithologic type	Color	Grain size	Average sphericity	Average roundness	Average sorting	Other characteristics
Pebble	Basalt	Greenish gray	Very fine	.65	.9	-	-
Pebble	Rhyolite	Reddish brown	Fine	.81	.8	-	-
Pebble	Rhyolite porphyry	Reddish brown	Very fine	.63	.8	-	Quartz phenocrysts
21	Conglomeratic sandstone	Brown	Medium	.75	.6	Poor	Bedded, micaceous

DESCRIPTION OF SAMPLES OF SECTION II

Sample number	Lithologic type	Color	Grain size	Average sphericity	Average roundness	Average sorting	Other characteristics
1	Sandstone	Brown	Fine	.77	.4	Good	Bedded, cut by calcite veinlets
2	Conglomeratic sandstone	Brown	Fine	.83	.4	Good	Bedded, micaceous
3	Conglomeratic sandstone	Reddish brown	Fine	.79	.4	Good	Bedding indistinct, cut by calcite veins
4	Conglomeratic sandstone	Brown	Fine	.83	.5	Good	Leaching in irregular zones
5	Sandstone	Brown	Medium	.79	.5	Poor	Bedded
6	Sandstone	Reddish brown	Coarse	.81	.6	Poor	Bedded
7	Conglomeratic sandstone	Brown	Coarse	.79	.6	Poor	Indistinct bedding
8	Conglomerate	-	-	-	-	Poor	Average size of pebbles 3 inches

Sample number	Lithologic type	Color	Grain size	Average sphericity	Average roundness	Average sorting	Other characteristics
Pebble	Rhyolite	Reddish brown	Fine	.65	.8	-	-
Pebble	Rhyolite porphyry	Reddish brown	Very fine	.79	.7	-	Quartz phenocrysts
Pebble	Basalt	Greenish gray	Very fine	.81	.9	-	-
9	Sandstone	Reddish brown	Fine	.83	.4	Good	Bedded, micaceous
10	Sandstone	Dark brown	Medium	.81	.5	Good	Bedded, micaceous
11	Sandstone	Dark brown	Medium	.83	.5	Poor	Massive
12	Conglomeratic sandstone	Dark brown	Coarse	.77	.6	Poor	Bedded
Pebble	Basalt	Greenish gray	Very fine	.77	.7	-	-
13	Sandstone	Reddish brown	Medium	.79	.6	Poor	Bedded

Sample number	Lithologic type	Color	Grain size	Average sphericity	Average roundness	Average sorting	Other characteristics
14	Conglomeratic sandstone	Brown	Coarse	.73	.6	Poor	Bedded
15	Conglomeratic sandstone	Brown	Medium	.77	.5	Good	Bedded, micaceous
16	Sandstone	Reddish brown	Fine	.81	.4	Good	Massive, cut by calcite veinlets
17	Sandstone	Brown	Medium	.77	.4	Poor	Bedded, platy discontinuous zones 2-6 inches thick
18	Sandstone	Brown	Medium	.77	.5	Poor	Bedded, micaceous
19	Sandstone	Reddish brown	Medium	.75	.5	Good	Massive, cut by calcite veinlets
20	Sandstone	Brown	Medium	.77	.5	Poor	Bedded, micaceous, exhibits mud cracks

Sample number	Lithologic type	Color	Grain size	Average sphericity	Average roundness	Average sorting	Other characteristics
21	Calcite vein in sandstone	White	-	-	-	-	Vein 6 inches thick, trends S. 16° E., vertical
22	Sandstone	Brown	Medium	.79	.5	Poor	Bedded, micaceous
23	Sandstone	Brown	Medium	.79	.5	Poor	Bedded, micaceous
24	Sandstone	Brown	Fine	.73	.4	Good	Mud cracks, ripple marks
25	Sandstone	Brown	Fine	.83	.5	Good	Bedded

DESCRIPTION OF SAMPLES OF SECTION III

Sample number	Lithologic type	Color	Grain size	Average sphericity	Average roundness	Average sorting	Other characteristics
1	Sandstone	Reddish brown	Medium	.75	.4	Good	Bedded, micaceous
2	Conglomeratic sandstone	Dark brown	Coarse	.77	.6	Poor	Pebbles up to 3 inches
Pebble	Rhyolite porphyry	Reddish brown	-	.75	.8	-	-
3	Sandstone	Reddish brown	Medium	.81	.5	Good	Bedded, micaceous
4	Conglomerate	Brown	-	-	-	Poor	Pebbles up to 4 inches
Pebble	Basalt	Greenish gray	Very fine	.73	.8	-	-
Pebble	Basalt	Greenish gray	Very fine	.75	.8	-	-
Pebble	Rhyolite	Reddish brown	Fine	.79	.8	-	-

Sample number	Lithologic type	Color	Grain size	Average sphericity	Average roundness	Average sorting	Other characteristics
Pebble	Rhyolite porphyry	Reddish brown	Very fine	.77	.8	-	Quartz phenocrysts
5	Conglomeratic sandstone	Dark brown	Coarse	.75	.6	Poor	Pebbles up to 4 inches
Pebble	Trachyte porphyry	Light brown	Very fine	.79	.7	-	Vesicular, feldspar phenocrysts
Pebble	Rhyolite	Reddish brown	Fine	.75	.8	-	-
6	Conglomeratic sandstone	Dark brown	Coarse	.75	.6	Poor	Bedded, pebbles up to 1.0 inch
Pebble	Trachyte porphyry	Light brown	Very fine	.73	.8	-	Feldspar phenocrysts
Pebble	Rhyolite	Reddish brown	Fine	.73	.7	-	-
7	Sandstone	Reddish brown	Medium	.83	.6	Good	Bedded, micaceous
8	Conglomerate	Brown	-	-	-	Poor	Average size of pebbles 3-4 in.

Sample number	Lithologic type	Color	Grain size	Average sphericity	Average roundness	Average sorting	Other characteristics
Pebble	Trachyte porphyry	Light brown	Very fine	.73	.8	-	Feldspar phenocrysts
Pebble	Rhyolite	Red-dish brown	Fine	.71	.8	-	-
Pebble	Rhyolite	Red-dish brown	Fine	.73	.8	-	-
Pebble	Basalt	Green-ish gray	Very fine	.75	.8	-	-
9	Sandstone	Brown	Medium	.73	.5	Good	Bedded
10	Sandstone	Dark brown	Coarse	.73	.6	Poor	Bedded
11	Sandstone	Dark brown	Medium	.75	.5	Poor	Indistinct bedding
12	Conglom-erate	Brown	-	-	-	Poor	Pebbles up to 5 inches
Pebble	Basalt	Green-ish gray	Very fine	.73	.9	-	-
Pebble	Trachyte porphyry	Light brown	Very fine	.73	.9	-	Feldspar phenocrysts

Sample number	Lithologic type	Color	Grain size	Average sphericity	Average roundness	Average sorting	Other characteristics
Pebble	Trachyte porphyry	Light brown	Very fine	.69	.9	-	Feldspar phenocrysts
Pebble	Trachyte porphyry	Light brown	Very fine	.71	.9	-	Feldspar phenocrysts
13	Sandstone	Brown	Coarse	.69	.6	Poor	Bedded
14	Conglomerate	Brown	-	-	-	Poor	Pebbles up to 5 inches
Pebble	Trachyte porphyry	Light brown	Very fine	.71	.8	-	Vesicular, feldspar phenocrysts
Pebble	Rhyolite	Reddish brown	Fine	.83	.8	-	Vesicular
Pebble	Basalt	Greenish gray	Very fine	.81	.8	-	Vesicular
Pebble	Trachyte porphyry	Light brown	Very fine	.71	.9	-	Feldspar phenocrysts
15	Conglomeratic sandstone	Brown	Coarse	.73	.6	Poor	Bedded, micaceous
16	Sandstone	Brown	Coarse	.73	.5	Poor	Bedded, micaceous

Sample number	Lithologic type	Color	Grain size	Average sphericity	Average roundness	Average sorting	Other characteristics
17	Conglomerate	Brown	-	-	-	Poor	Pebbles up to 6 inches
Pebble	Trachyte porphyry	Light brown	Very fine	.79	.9	-	Feldspar phenocrysts
Pebble	Rhyolite	Reddish brown	Very fine	.75	.9	-	Vesicular
Pebble	Basalt	Greenish gray	Very fine	.69	.8	-	-
Pebble	Trachyte porphyry	Light brown	Very fine	.83	.9	-	Feldspar phenocrysts
18	Conglomeratic sandstone	Brown	Coarse	.69	.6	Poor	Cross-bedded
19	Conglomeratic sandstone	Reddish brown	Medium	.79	.5	Good	Bedded, micaceous
Pebble	Trachyte porphyry	Light brown	-	.83	.7	-	Feldspar phenocrysts
20	Sandstone	Reddish brown	Fine	.79	.5	Good	Bedded, cut by quartz veins .5-1.5 inches
21	Conglomerate	Brown	-	-	-	Poor	Cut by quartz veins up to 4 inches thick

Sample number	Lithologic type	Color	Grain size	Average sphericity	Average roundness	Average sorting	Other characteristics
Pebble	Trachyte porphyry	Light brown	Very fine	.79	.9	-	Feldspar phenocrysts
Pebble	Rhyolite	Reddish brown	Fine	.81	.9	-	Vesicular
22	Sandstone	Brown	Coarse	.73	.6	Poor	Bedded
23	Quartz vein	Light gray	Coarse	-	-	-	4 inches, vertical, trends N. 49° W.
24	Sandstone	Reddish brown	Medium	.81	.5	Good	Bedded
25	Sandstone	Reddish brown	Fine	.79	.5	Good	Bedded
26	Sandstone	Reddish brown	Fine	-	-	Good	Bedded, cut by quartz veinlets
27	Sandstone	Brown	Medium	.79	.5	Poor	Bedded
28	Sandstone	Reddish brown	Fine	-	-	Good	Brecciated zone

Sample number	Lithologic type	Color	Grain size	Average sphericity	Average roundness	Average sorting	Other characteristics
29	Sandstone	Reddish brown	Fine	-	-	Good	Brecciated zone, cut by quartz veinlets
30	Sandstone	Reddish brown	Fine	-	-	Good	Massive, cut by quartz veinlets
31	Conglomeratic sandstone	Brown	Medium	.81	.4	Poor	Pebbles up to 3 feet
32	Sandstone	Reddish brown	Medium	.79	.5	Good	Bedded, micaceous
33	Conglomeratic sandstone	Reddish brown	Medium	.75	.5	Poor	Bedded, pebbles up to 4 inches
34	Conglomerate	Brown	-	-	-	Poor	Pebbles up to 6 inches
Pebble	Trachyte porphyry	Light brown	Very fine	.77	.7	-	Feldspar phenocrysts
Pebble	Basalt	Greenish gray	Very fine	.79	.8	-	-
Pebble	Rhyolite porphyry	Reddish brown	Very fine	.79	.7	-	Quartz phenocrysts

Sample number	Lithologic type	Color	Grain size	Average sphericity	Average roundness	Average sorting	Other characteristics
35	Conglomeratic sandstone	Brown	Coarse	.77	.6	Poor	Pebbles up to 0.4 inches
36	Sandstone	Brown	Coarse	.73	.5	Poor	Cross-bedded
37	Sandstone	Reddish brown	Medium	.79	.5	Good	Bedded
38	Conglomerate	Brown	-	-	-	Poor	Average pebble size 3-4 inches
Pebble	Rhyolite porphyry	Reddish brown	Very fine	.87	.9	-	Quartz phenocrysts
Pebble	Rhyolite porphyry	Reddish brown	Very fine	.73	.7	-	Quartz phenocrysts
Pebble	Basalt	Greenish gray	Very fine	.71	.9	-	-
Pebble	Rhyolite	Reddish brown	Fine	.85	.7	-	-

Sample number	Lithologic type	Color	Grain size	Average sphericity	Average roundness	Average sorting	Other characteristics
39	Sandstone	Reddish brown	Medium	.81	.5	Good	Bedded
40	Sandstone	Reddish brown	Medium	.77	.5	Poor	Bedded

DESCRIPTION OF SAMPLES OF SECTION IV

Sample number	Lithologic type	Color	Grain size	Average sphericity	Average roundness	Average sorting	Other characteristics
1	Sandstone	Brown	Coarse	.75	.6	Poor	Cross-bedded, micaceous
2	Sandstone	Brown	Medium	.83	.5	Poor	Cross-bedded, ripple marks
3	Sandstone	Brown	Medium	.81	.5	Poor	Massive, cut by calcite veins 0.1-1.0 inches
4	Sandstone	Brown	Coarse	.75	.6	Poor	Cross-bedded
5	Conglomerate	Brown	-	-	-	Poor	Pebbles up to 5 inches
Pebble	Granite	Light	Medium	-	-	-	-
Pebble	Rhyolite porphyry	Reddish brown	Very fine	.85	.9	-	Quartz phenocrysts
Pebble	Trachyte porphyry	Light brown	Very fine	.75	.9	-	Feldspar phenocrysts
6	Sandstone	Brown	Medium	.77	.5	Good	Bedded
7	Sandstone	Reddish brown	Medium	.75	.5	Poor	Bedded

Sample number	Lithologic type	Color	Grain size	Average sphericity	Average roundness	Average sorting	Other characteristics
8	Conglomeratic sandstone	Brown	Coarse	.71	.6	Poor	Bedded, pebbles up to 6 inches
Pebble	Trachyte porphyry	Light brown	Very fine	.73	.7	-	Feldspar phenocrysts
9	Conglomeratic sandstone	Reddish brown	Medium	.81	.5	Good	Bedded
10	Conglomeratic sandstone	Brown	Coarse	.75	.6	Poor	Bedded
Pebble	Trachyte porphyry	Light brown	Very fine	.77	.9	-	Feldspar phenocrysts
Pebble	Trachyte porphyry	Light brown	Very fine	.85	.9	-	Feldspar phenocrysts
11	Conglomeratic sandstone	Brown	Coarse	.75	.6	Poor	Massive
12	Conglomeratic sandstone	Brown	Coarse	.73	.6	Poor	Cross-bedded
Pebble	Trachyte porphyry	Light brown	Very fine	.73	.8	-	Feldspar phenocrysts
Pebble	Trachyte porphyry	Light brown	Very fine	.85	.9	-	Feldspar phenocrysts

Sample number	Lithologic type	Color	Grain size	Average sphericity	Average roundness	Average sorting	Other characteristics
Pebble	Trachyte porphyry	Light brown	Very fine	.83	.9	-	Feldspar phenocrysts
13	Conglomeratic sandstone	Brown	Coarse	.73	.6	Poor	Bedded
14	Conglomeratic sandstone	Brown	Coarse	.75	.6	Poor	Bedded

DESCRIPTION OF SAMPLES OF SECTION V

Sample number	Lithologic type	Color	Grain size	Average sphericity	Average roundness	Average sorting	Other characteristics
1	Sandstone	Brown	Coarse	.79	.5	Poor	Cross-bedded, micaceous
2	Conglomeratic sandstone	Brown	Medium	.75	.5	Poor	Pebbles up to 0.7 inches
3	Sandstone	Brown	Medium	.75	.5	Poor	Bedded, micaceous
4	Conglomeratic sandstone	Brown	Medium	.77	.5	Poor	Micaceous
Pebble	Trachyte porphyry	Light brown	Very fine	.85	.7	-	Vesicular, feldspar phenocrysts
Pebble	Trachyte porphyry	Light brown	Very fine	.73	.8	-	Feldspar phenocrysts
5	Conglomeratic sandstone	Brown	Medium	.75	.5	Poor	Pebbles up to 0.7 inches
Pebble	Basalt	Greenish gray	Very fine	.77	.8	-	-

Sample number	Lithologic type	Color	Grain size	Average sphericity	Average roundness	Average sorting	Other characteristics
Pebble	Rhyolite porphyry	Reddish brown	Very fine	.77	.8	-	Quartz phenocrysts
6	Sandstone	Brown	Coarse	.77	.6	Poor	Cross-bedded
7	Conglomerate	Brown	-	-	-	Poor	Pebbles up to 5 inches
Pebble	Granite	Light	Medium	-	-	-	-
Pebble	Trachyte porphyry	Light brown	Very fine	.87	.9	-	Feldspar phenocrysts
Pebble	Trachyte porphyry	Light brown	Very fine	.75	.7	-	Feldspar phenocrysts
Pebble	Trachyte porphyry	Light brown	Very fine	.71	.7	-	Feldspar phenocrysts
Pebble	Rhyolite porphyry	Reddish brown	Very fine	.75	.8	-	Feldspar and quartz phenocrysts
8	Sandstone	Brown	Coarse	.77	.6	Poor	Bedded
9	Conglomerate	Brown	-	-	-	Poor	Pebbles up to 4 inches
Pebble	Basalt	Greenish gray	Very fine	-	-	-	Epidote amygdules

Sample number	Lithologic type	Color	Grain size	Average sphericity	Average roundness	Average sorting	Other characteristics
Pebble	Trachyte porphyry	Light brown	Very fine	.77	.8	-	Feldspar phenocrysts
Pebble	Granite	Light	Medium	-	-	-	-
Pebble	Basalt	Greenish gray	Very fine	.81	.8	-	Epidote amygdules
10	Sandstone	Brown	Coarse	.75	.6	Poor	Bedded
11	Conglomeratic sandstone	Brown	Coarse	.73	.6	Poor	Cross-bedded
12	Conglomerate	Brown	-	-	-	Poor	Pebbles up to 4 inches
Pebble	Trachyte porphyry	Light brown	Very fine	.73	.8	-	Vesicular, feldspar phenocrysts
Pebble	Trachyte porphyry	Light brown	Very fine	.71	.8	-	Feldspar phenocrysts
Pebble	Granite	Light	Medium	-	-	-	-
Pebble	Trachyte porphyry	Light brown	Very fine	.75	.6	-	Feldspar phenocrysts
Pebble	Rhyolite porphyry	Reddish brown	Very fine	-	-	-	Quartz phenocrysts

Sample number	Lithologic type	Color	Grain size	Average sphericity	Average roundness	Average sorting	Other characteristics
13	Conglomeratic sandstone	Brown	Medium	.75	.5	Poor	Bedded
14	Sandstone	Brown	Fine	.79	.4	Good	Bedded, micaceous
15	Conglomeratic sandstone	Brown	Medium	.79	.5	Good	Indistinct bedding
Pebble	Trachyte porphyry	Light brown	Very fine	.81	.8	-	Feldspar phenocrysts
17	Conglomeratic sandstone	Brown	Coarse	.73	.6	Poor	Pebbles up to 2 inches
Pebble	Basalt	Greenish gray	Very fine	.71	.7	-	-
Pebble	Trachyte porphyry	Light brown	Very fine	.71	.7	-	Feldspar phenocrysts
Pebble	Trachyte porphyry	Light brown	Very fine	.83	.8	-	Vesicular, feldspar phenocrysts
18	Conglomeratic sandstone	Brown	Coarse	.77	.6	Poor	Bedded

Sample number	Lithologic type	Color	Grain size	Average sphericity	Average roundness	Average sorting	Other characteristics
Pebble	Rhyolite porphyry	Reddish brown	Very fine	.83	.8	-	Quartz phenocrysts
Pebble	Rhyolite porphyry	Reddish brown	Very fine	.73	.8	-	Quartz and feldspar phenocrysts
Pebble	Rhyolite	Reddish brown	Fine	.71	.6	-	-
19	Conglomerate	Brown	-	-	-	Poor	Pebbles up to 5 inches
Pebble	Trachyte porphyry	Light brown	Very fine	.79	.7	-	Feldspar phenocrysts
Pebble	Trachyte porphyry	Light brown	Very fine	.77	.8	-	Feldspar phenocrysts
Pebble	Trachyte porphyry	Light brown	Very fine	.83	.8	-	Feldspar phenocrysts
Pebble	Rhyolite porphyry	Reddish brown	Very fine	.81	.8	-	Quartz and feldspar phenocrysts
Pebble	Rhyolite	Reddish brown	Fine	.75	.7	-	-
Pebble	Trachyte porphyry	Light brown	Very fine	.75	.8	-	Feldspar phenocrysts

Sample number	Lithologic type	Color	Grain size	Average sphericity	Average roundness	Average sorting	Other characteristics
20	Conglomerate	Brown	-	-	-	Poor	Pebbles up to 5 inches
Pebble	Rhyolite porphyry	Reddish brown	Very fine	.79	.6	-	Quartz and feldspar phenocrysts
Pebble	Granite	Light	Medium	-	-	-	-
Pebble	Trachyte porphyry	Light brown	Very fine	.71	.9	-	Feldspar phenocrysts
Pebble	Quartz	Light	Fine	-	-	-	Agate zoning
21	Conglom-	Brown	-	-	-	Poor	Pebbles up to 5 inches
Pebble	Rhyolite porphyry	Reddish brown	Very fine	.73	.7	-	Quartz and feldspar phenocrysts
Pebble	Rhyolite porphyry	Reddish brown	Very fine	.79	.8	-	Quartz and feldspar phenocrysts
Pebble	Trachyte porphyry	Light brown	Very fine	-	-	-	Feldspar phenocrysts
Pebble	Trachyte porphyry	Light brown	Very fine	-	-	-	Feldspar phenocrysts
22	Conglomerate	Brown	-	-	-	Poor	Pebbles up to 4 inches

Sample number	Lithologic type	Color	Grain size	Average sphericity	Average roundness	Average sorting	Other characteristics
Pebble	Basalt	Greenish gray	Very fine	.77	.8	-	-
Pebble	Trachyte porphyry	Light brown	Very fine	.71	.7	-	Feldspar phenocrysts
Pebble	Rhyolite porphyry	Reddish brown	Very fine	.71	.7	-	Quartz phenocrysts
23	Sandstone	Brown	Coarse	.73	.6	Poor	Bedded
24	Conglomerate	Brown	-	-	-	Poor	Pebbles up to 5 inches
Pebble	Rhyolite porphyry	Reddish brown	Very fine	.79	.7	-	Quartz phenocrysts
Pebble	Rhyolite porphyry	Reddish brown	Very fine	.73	.8	-	Quartz and feldspar phenocrysts
Pebble	Rhyolite porphyry	Reddish brown	Very fine	.75	.8	-	Quartz and feldspar phenocrysts
Pebble	Basalt	Greenish gray	Very fine	.81	.7	-	-

Sample number	Lithologic type	Color	Grain size	Average sphericity	Average roundness	Average sorting	Other characteristics
25	Conglomeratic sandstone	Brown	Medium	.75	.5	Poor	Bedded, micaceous
26	Conglomerate	Brown	-	-	-	Poor	Average size of pebbles 4 inches
Pebble	Rhyolite	Reddish brown	Fine	-	-	-	Vesicular
Pebble	Rhyolite porphyry	Reddish brown	Very fine	.73	.8	-	Quartz and feldspar phenocrysts
Pebble	Trachyte porphyry	Light brown	Very fine	.85	.9	-	Feldspar phenocrysts
Pebble	Trachyte porphyry	Light brown	Very fine	.81	.9	-	Feldspar phenocrysts
Pebble	Basalt	Greenish gray	Very fine	.77	.8	-	-
27	Conglomerate	Brown	-	-	-	Poor	Average size of pebbles 4 inches
Pebble	Granite	Light	Medium	.65	.8	-	-
Pebble	Trachyte porphyry	Light brown	Very fine	-	-	-	Feldspar phenocrysts

Sample number	Lithologic type	Color	Grain size	Average sphericity	Average roundness	Average sorting	Other characteristics
Pebble	Trachyte porphyry	Light brown	Very fine	.81	.9	-	Feldspar phenocrysts
28	Conglomerate	Brown	-	-	-	Poor	Average size of pebbles 4 inches
Pebble	Trachyte	Light brown	Very fine	-	-	-	Vesicular
Pebble	Granite	Light	Medium	.76	.8	-	-
Pebble	Basalt	Greenish gray	Very fine	-	-	-	-
Pebble	Quartz	Light gray	Fine	-	-	-	Quartzite(?)
29	Conglomerate	Brown	-	-	-	Poor	Average size of pebbles 4 inches
Pebble	Trachyte porphyry	Light brown	Very fine	.74	.8	-	Feldspar phenocrysts
Pebble	Basalt	Greenish gray	Very fine	.73	.7	-	-
Pebble	Trachyte porphyry	Light brown	Very fine	-	-	-	Feldspar phenocrysts
30	Conglomerate	Brown	-	-	-	Poor	Pebbles up to 1.0 feet

Sample number	Lithologic type	Color	Grain size	Average sphericity	Average roundness	Average sorting	Other characteristics
Pebble	Trachyte porphyry	Light brown	Very fine	.74	.8	-	Feldspar phenocrysts
Pebble	Rhyolite porphyry	Red-dish brown	Very fine	.81	.6	-	Quartz and feldspar phenocrysts
Pebble	Quartz	White	Fine	-	-	-	Vein quartz
Pebble	Basalt	Green-ish gray	Very fine	.73	.7	-	-
31	Conglom-erate	Brown	-	-	-	Poor	Average size of pebbles 5 inches
Pebble	Trachyte porphyry	Light brown	Very fine	.77	.8	-	Feldspar phenocrysts
Pebble	Basalt	Green-ish gray	Very fine	.79	.8	-	-
Pebble	Trachyte porphyry	Light brown	Very fine	.73	.7	-	Feldspar phenocrysts
32	Conglom-erate	Brown	-	-	-	Poor	Average size of pebbles 5 inches
Pebble	Basalt	Green-ish gray	Very fine	.81	.8	-	-

Sample number	Lithologic type	Color	Grain size	Average sphericity	Average roundness	Average sorting	Other characteristics
Pebble	Trachyte porphyry	Light brown	Very fine	.77	.6	-	Feldspar phenocrysts
Pebble	Rhyolite porphyry	Reddish brown	Very fine	.73	.7	-	Quartz and feldspar phenocrysts
Pebble	Trachyte porphyry	Light brown	Very fine	.79	.8	-	Feldspar phenocrysts
Pebble	Trachyte	Light brown	Very fine	.77	.9	-	Vesicular
33	Conglomerate	Brown	-	-	-	Poor	Average size of pebbles 5 inches
Pebble	Trachyte porphyry	Light brown	Very fine	.81	.8	-	Feldspar phenocrysts
Pebble	Basalt	Greenish gray	Very fine	.73	.9	-	-
Pebble	Trachyte porphyry	Light brown	Very fine	-	-	-	Feldspar phenocrysts
Pebble	Quartz	White	Fine	-	-	-	Vein quartz(?)
Pebble	Trachyte porphyry	Light brown	Very fine	.73	.8	-	Feldspar phenocrysts

Sample number	Lithologic type	Color	Grain size	Average sphericity	Average roundness	Average sorting	Other characteristics
34	Conglomeratic sandstone	Reddish brown	Coarse	.73	.6	Poor	Bedded
35	Conglomerate	Brown	-	-	-	Poor	Average size of pebbles 3 inches
Pebble	Trachyte porphyry	Light brown	Very fine	.77	.8	-	Feldspar phenocrysts
Pebble	Trachyte porphyry	Light brown	Very fine	.73	.7	-	Feldspar phenocrysts
Pebble	Basalt	Greenish gray	Very fine	.71	.7	-	-
Pebble	Rhyolite porphyry	Reddish brown	Very fine	-	-	-	Quartz phenocrysts
36	Sandstone	Brown	Coarse	.77	.6	Poor	Bedded
37	Conglomerate	Brown	-	-	-	Poor	Average size of pebbles 3 inches
Pebble	Quartz	Light green	Fine	-	-	-	Vein quartz(?)
Pebble	Trachyte porphyry	Light brown	Very fine	.71	.8	-	Feldspar phenocrysts

Sample number	Lithologic type	Color	Grain size	Average sphericity	Average roundness	Average sorting	Other characteristics
Pebble	Rhyolite porphyry	Reddish brown	Very fine	.65	.8	-	Quartz phenocrysts
38	Conglomerate	Brown	-	-	-	Poor	Average size of pebbles 3-4 inches
Pebble	Trachyte porphyry	Light brown	Very fine	.81	.9	-	Feldspar phenocrysts
Pebble	Rhyolite porphyry	Reddish brown	Very fine	.73	.7	-	Quartz phenocrysts
Pebble	Trachyte porphyry	Light brown	Very fine	.75	.6	-	Feldspar phenocrysts
39	Conglomerate	Brown	-	-	-	Poor	Average size of pebbles 3-4 inches
Pebble	Basalt	Greenish gray	Very fine	.73	.9	-	Epidote amygdules
Pebble	Rhyolite porphyry	Reddish brown	Very fine	-	-	-	Quartz phenocrysts
Pebble	Trachyte porphyry	Light brown	Very fine	.73	.9	-	Feldspar phenocrysts

Sample number	Lithologic type	Color	Grain size	Average sphericity	Average roundness	Average sorting	Other characteristics
40	Conglomerate	Brown	-	-	-	Poor	Average size of pebbles 3-4 inches
Pebble	Rhyolite porphyry	Reddish brown	Very fine	.73	.8	-	Feldspar and quartz phenocrysts
Pebble	Rhyolite porphyry	Reddish brown	Very fine	.71	.8	-	Feldspar and quartz phenocrysts
Pebble	Granite gneiss	Light	Medium	-	-	-	Banded dark minerals
Pebble	Trachyte	Light brown	Very fine	-	-	-	Parallel flow lines

DESCRIPTION OF SAMPLES OF SECTION VI

Sample number	Lithologic type	Color	Grain size	Average sphericity	Average roundness	Average sorting	Other characteristics
1	Sandstone	Reddish brown	Fine	-	-	Good	Brecciated, cut by calcite veinlets. Massive
2	Conglomeratic sandstone	Brown	Coarse	.73	.6	-	Bedded
Pebble	Trachyte porphyry	Light brown	Very fine	.71	.7	-	Feldspar phenocrysts
Pebble	Basalt	Greenish gray	Very fine	-	-	-	-
Pebble	Trachyte porphyry	Light gray	Very fine	.71	.7	-	Feldspar phenocrysts
Pebble	Rhyolite porphyry	Reddish brown	Very fine	.75	.6	-	Quartz phenocrysts
3	Sandstone	Brown	Fine	.73	.5	Good	Bedded
Pebble	Trachyte porphyry	Light brown	Very fine	.75	.7	-	Feldspar phenocrysts

Sample number	Lithologic type	Color	Grain size	Average sphericity	Average roundness	Average sorting	Other characteristics
Pebble	Rhyolite porphyry	Reddish brown	Very fine	.77	.9	-	Quartz phenocrysts
4	Conglomeratic sandstone	Brown	Coarse	.73	.6	Poor	Cross-bedded
Pebble	Trachyte porphyry	Light brown	Very fine	.79	.7	-	Feldspar phenocrysts
Pebble	Basalt	Greenish gray	Very fine	.77	.7	-	-
5	Conglomeratic sandstone	Brown	Medium	.73	.5	Poor	Cross-bedded, micaceous
Pebble	Rhyolite porphyry	Reddish brown	Very fine	.77	.7	-	Quartz phenocrysts
Pebble	Trachyte porphyry	Reddish brown	Very fine	.81	.8	-	Feldspar phenocrysts
6	Conglomeratic sandstone	Brown	Coarse	.71	.6	Poor	Indistinct bedding
Pebble	Rhyolite porphyry	Reddish brown	Very fine	.71	.8	-	Quartz phenocrysts

Sample number	Lithologic type	Color	Grain size	Average sphericity	Average roundness	Average sorting	Other characteristics
Pebble	Rhyolite porphyry	Reddish brown	Very fine	.79	.8	-	Quartz and feldspar phenocrysts
7	Conglomeratic sandstone	Brown	Medium	.77	.5	Poor	Bedded
8	Conglomerate	Brown	-	-	-	Poor	Average size of pebbles 2-3 in.
Pebble	Basalt	Greenish gray	Very fine	-	-	-	-
Pebble	Trachyte porphyry	Light brown	Very fine	.87	.8	-	Feldspar phenocrysts
9	Conglomerate	Brown	-	-	-	Poor	Average size of pebbles 2 inches
Pebble	Quartz	Milky white	Very fine	.79	.7	-	Vein quartz(?)
Pebble	Rhyolite porphyry	Reddish brown	Very fine	.77	.7	-	Feldspar and quartz phenocrysts
Pebble	Basalt	Greenish gray	Very fine	.73	.7	-	-
10	Conglomerate	Brown	-	-	-	Poor	Average size of pebbles 3-4 in.

Sample number	Lithologic type	Color	Grain size	Average sphericity	Average roundness	Average sorting	Other characteristics
Pebble	Trachyte porphyry	Light brown	Very fine	.67	.7	-	Feldspar phenocrysts
Pebble	Basalt	Greenish gray	Very fine	.71	.8	-	-
Pebble	Rhyolite porphyry	Reddish brown	Very fine	.73	.7	-	Feldspar and quartz phenocrysts
11	Conglomerate	Brown	-	-	-	Poor	Average size of pebbles 3-4 in.
Pebble	Quartz	Light gray	Very fine	.71	.6	-	Vein quartz(?)
Pebble	Trachyte porphyry	Light brown	Very fine	.87	.7	-	Feldspar phenocrysts
Pebble	Rhyolite porphyry	Reddish brown	Very fine	.83	.8	-	Quartz phenocrysts. Flow lines
12	Conglomerate	Brown	-	-	-	Poor	Average size of pebbles 3-4 in.
Pebble	Trachyte porphyry	Light brown	Very fine	.71	.7	-	Feldspar phenocrysts
Pebble	Rhyolite porphyry	Reddish brown	Very fine	.77	.9	-	Feldspar and quartz phenocrysts

Sample number	Lithologic type	Color	Grain size	Average sphericity	Average roundness	Average sorting	Other characteristics
Pebble	Trachyte porphyry	Light brown	Very fine	.83	.8	-	Feldspar phenocrysts
13	Conglom-erate	Brown	-	-	-	Poor	Average size of pebbles 4-5 in.
Pebble	Trachyte porphyry	Light brown	Very fine	.75	.8	-	Feldspar phenocrysts
Pebble	Rhyolite porphyry	Red-dish brown	Very fine	.73	.8	-	Quartz phenocrysts
Pebble	Quartz	Light gray	Very fine	-	-	-	Agate zoning
Pebble	Basalt	Green-ish gray	Very fine	.67	.8	-	-
14	Conglom-erate	Brown	-	-	-	Poor	Average size of pebbles 4-5 in.
Pebble	Trachyte porphyry	Light brown	Very fine	.81	.7	-	Feldspar phenocrysts
Pebble	Trachyte porphyry	Light brown	Very fine	-	-	-	Feldspar phenocrysts
Pebble	Rhyolite porphyry	Red-dish brown	Very fine	.79	.7	-	Feldspar and quartz phenocrysts

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LEGEND

KEWEENAWAN

PORCUPINE MOUNTAINS SANDSTONE

Pkpm — Conglomeratic sandstone

Pkpm — Conglomerate

LAKE SHORE TRAPS

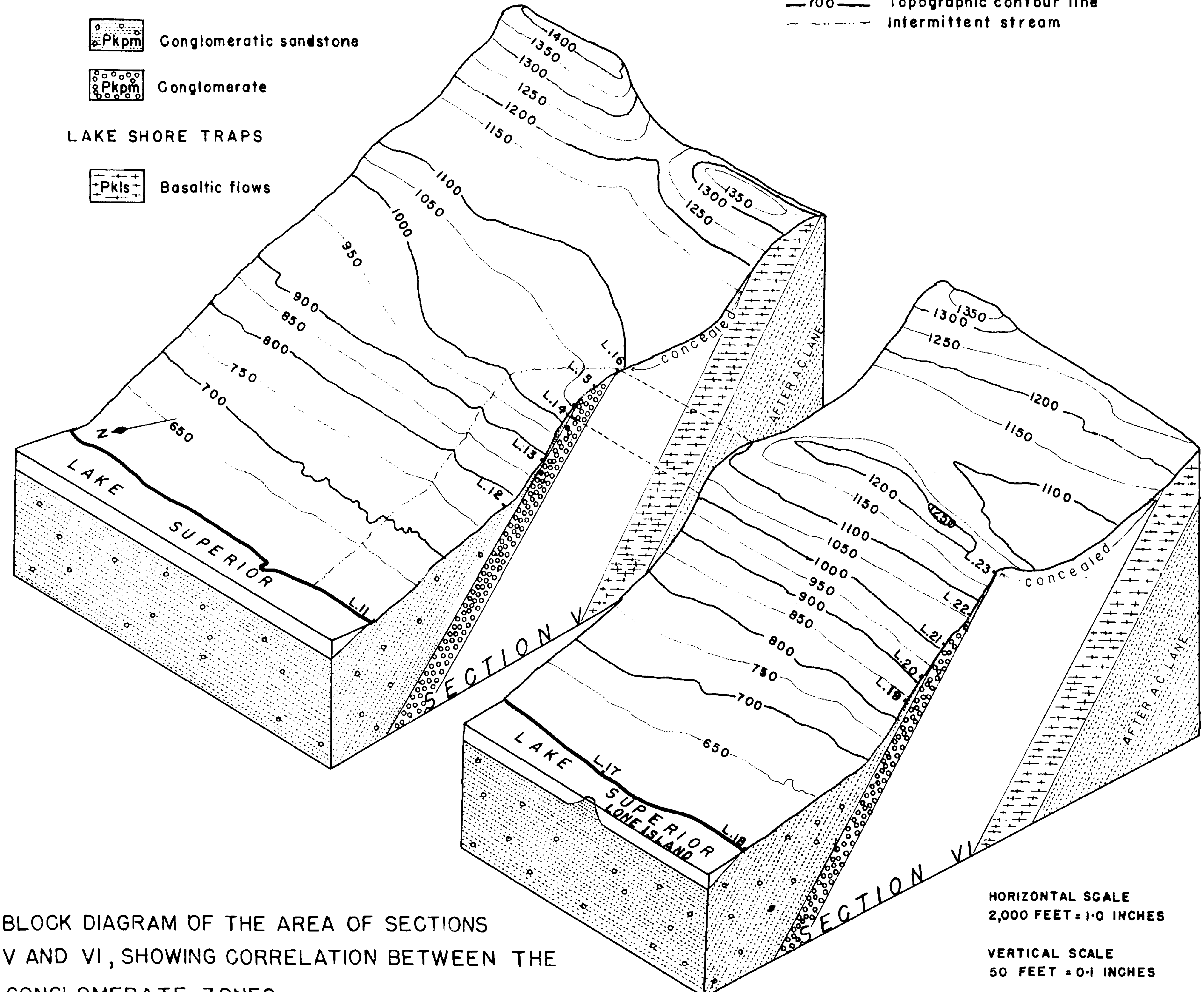
Pkls — Basaltic flows

EXPLANATION

L.15 — Location number

—700— Topographic contour line

— — Intermittent stream



BLOCK DIAGRAM OF THE AREA OF SECTIONS V AND VI, SHOWING CORRELATION BETWEEN THE CONGLOMERATE ZONES

HORIZONTAL SCALE
2,000 FEET = 1·0 INCHES

VERTICAL SCALE
50 FEET = 0·1 INCHES

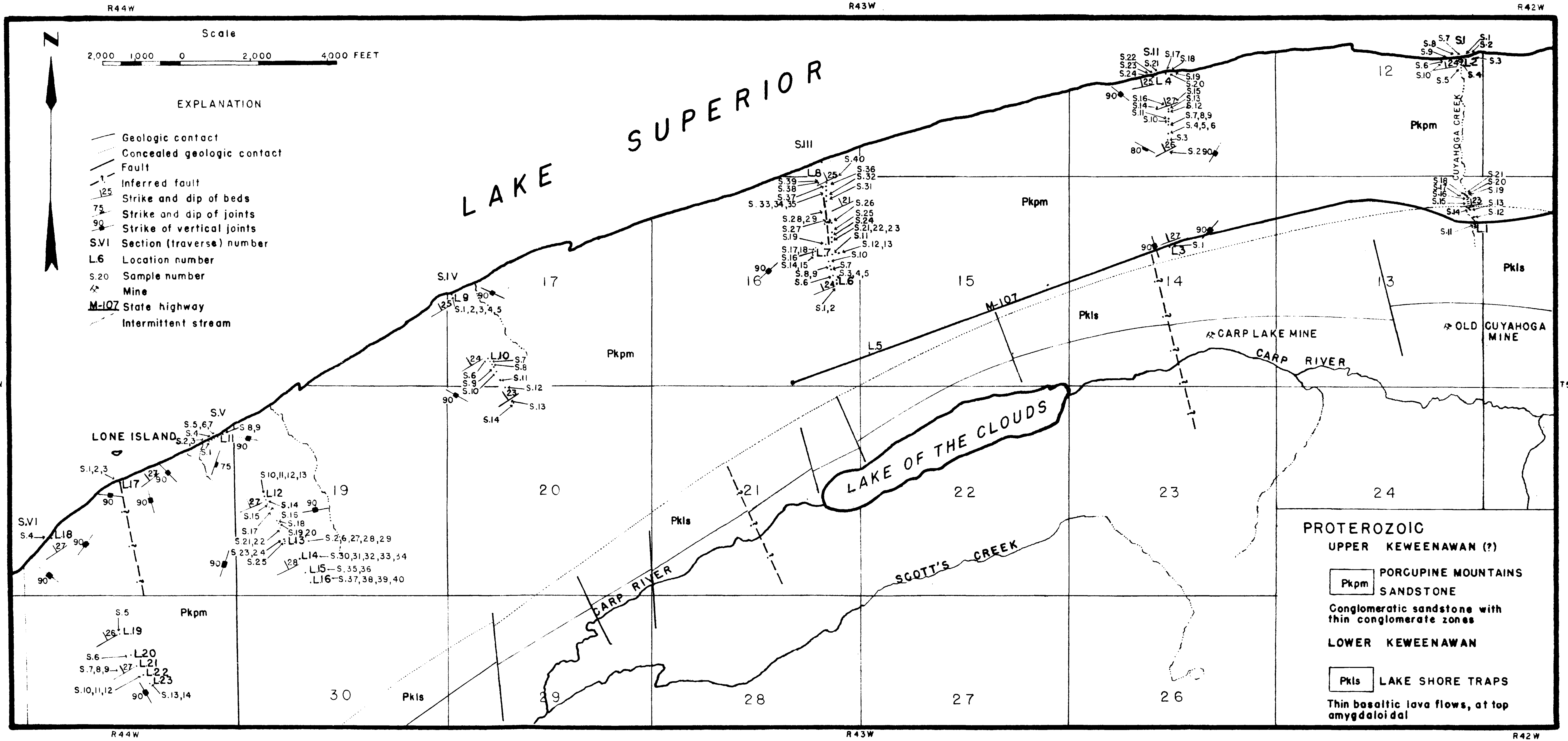
CONTOUR INTERVAL
50 FEET

TOPOGRAPHY AND BASE MAP AFTER W.A. KELLY

LAKE SHORE TRAPS AFTER R.D. IRVING AND F.E. WRIGHT

PLATE I

HATEM EL-KHALIDI 1950



MAP OF THE NORTHERN PART OF THE PORCUPINE MOUNTAINS, ONTONAGON COUNTY, MICHIGAN

SHOWING THE AREAL DISTRIBUTION OF THE LAKE SHORE TRAPS, CROSS FAULTS, THE LOCATION OF TRAVERSES AND THE POSITION OF SAMPLES

BASE MAP AFTER W.A. KELLY

LAKE SHORE TRAPS AFTER R.D. IRVING AND F.E. WRIGHT

MAP 2

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