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LETTERS

VOLUME XXII

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PAPERS OF THE MICHIGAN ACADEMY OF
SCIENCE ARTS AND LETTERS

EDITORS

EUGENE S. McCARTNEY
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VOLUME XXII

“Pusilla res mundus est nisi in illo
quod quaerat omnis mundus habeat.”
—SENECA, *Naturales Quaestiones*

Ann Arbor

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RECOGNITION

IN THE spring of 1931 there applied for a position in my office a young woman who had had no professional training or experience in the handling of manuscripts and the making of books, but who did have boundless enthusiasm for such work. I gave her the position because of her enthusiasm.

Owing to pressure from other sources I was compelled from the very first to entrust to her a great deal of the responsibility for the Academy Papers and other volumes, a burden which she capably bore. Her powers grew from year to year, and she became a big help in removing the editorial briers of my workaday world.

The editing of books composed by many hands is exacting and requires unremitting vigilance. Each Academy volume contains some fifty articles, in which eight or ten widely different fields of investigation are represented. Only a person who has threaded his way through a similar maze of manuscripts and the proof can realize what unceasing demands a volume makes upon one's time, energy, patience, tact, and resourcefulness. With unflinching courage and cheerfulness my assistant, Mrs. Hilda J. Straw, dedicated herself to her work, and it would be ungracious for me to allow to go unrecorded the contribution of one who has bound in eight Academy volumes so much loyalty and ability. Since Mrs. Straw has given up her work at the University and is now making her home in Tennessee I take pleasure in paying her a tribute as lasting as the final volume upon which she worked. I am sure that authors will join with me in

regretting her departure and in wishing her lasting joy and happiness.

I avail myself of this opportunity to express in print the appreciation of the Academy and the University for the continued interest and coöperation of the Plimpton Press. The pride which each member of the staff seems to feel in helping to make the volumes first class has been a constant source of encouragement and has served, not infrequently, to renew flagging spirits.

E. S. McC.

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NOTES ON INDIAN TRADE SILVER ORNAMENTS IN MICHIGAN

GEORGE I. QUIMBY, JR.

THIS study of Indian trade silver ornaments is based upon a detailed examination of two collections, one at the Kent Scientific Museum, Grand Rapids, and the other at the Museum of Anthropology, University of Michigan, Ann Arbor. These ornaments were excavated from Indian village sites and cemeteries of the historic period and from intrusive burials in prehistoric mounds. Occasional ornaments were surface finds.

There were selected for study 119 ornaments of the type commonly stamped with the identifying marks of the silversmiths who made them. Data on type of site and locale of find accompanied them. Characteristic of these ornaments were single- and double-barred crosses, crescent-shaped and circular gorgets, plain circular brooches, ornate circular brooches, star brooches, single-heart brooches, harp-shaped brooches, hair plates, arm bands, wristbands, bracelets, spoon lockets, and animal effigies.

On 27 of these ornaments the touch marks were missing, owing mostly to breakage and corrosion, although a few seem to have been unmarked. But certainly 62 articles of silver, probably 75, were

manufactured in Montreal by late eighteenth- and early nineteenth-century silversmiths. Since the area of distribution of ornaments upon which the marks are missing coincides with that of identified Canadian silver in Michigan, it might be valid to assume that at least half of this silver is also of Canadian manufacture, which would increase the total of Canadian ornaments to 89 (see Table I).

Of the ornaments remaining, one was manufactured in London and two were made in the United States. Fourteen bear touch marks which are unidentified. Thus it is apparent that at least half, if not considerably more, of the silver ornaments excavated from sites in Michigan are of British origin.

Although the brass and the copper crosses given to converts by the Jesuits were church symbols, the silver crosses brought into the fur country at a later time by traders and government agents had little religious significance. Both the Florentine or double-barred cross and the Latin or single-barred cross were common trade items. The head and the foot of the shank, as well as the ends of the cross bars, were foliated. In all the double-barred crosses studied the lower crossbars were longer than the upper. Crosses of both types were pierced at the head to allow the insertion of a ring for suspension.

TABLE I
DISTRIBUTION OF ORNAMENTS BY COUNTY IN MICHIGAN

Mark	Emmet	Ionia	Kent	Lenawee	Mackinac	Marquette	Presque Isle	Unknown
R.C.*	25	3	3	4	..	..	..	1
MONTREAL*	8	1	2	..	..	..	1	..
C.A.*	5	..	..	1	..	2	..	1
P.H.*	3	..	1	..	..	..	..	..
JH*	1	..	..	..	..	..	..	..
JO†	..	1	..	..	..	..	..	1
IS†	8	..	..	2	1	..	..	..
XIII	3	..	..	..	..	..	..	..
Lion passant	2	..	..	..	..	..	..	..
AS(?)	..	..	..	2	..	..	..	..
B.L, etc.	1	..	..	..	..	..	..	..
CG	..	..	1	..	..	..	..	..
JD	1	..	..	..	..	..	..	..
JK	1	..	..	..	..	..	..	..
JT	1	..	..	..	..	..	..	..
P.J.D.	1	..	..	..	..	..	..	..
P.J.D. BP	..	1	..	..	..	..	..	..
SH	1	..	..	..	..	..	..	..
W	1	..	..	..	..	..	..	..
WC	1	..	..	..	..	..	..	..
No marks	16	1	3	..	..	..	7	..
TOTALS	79	7	10	9	1	2	8	3

* Touch marks of Montreal silversmiths.
† Probably the touch mark of a Montreal silversmith.

The crescent-shaped gorget is convex in cross section. The decoration occurs upon the convex side, and means for suspension are provided by bosses or buttons at the points of the crescent.

The circular gorget is a concave disk, with the ornamentation on the concave surface. Means for suspension are provided by two buttons or bosses on the upper part. Both the circular and the crescent-shaped gorgets were worn suspended from the neck by a band or a cord.

Hair plates appear as flat silver disks punched in various patterns, so that the perforations leave a tracery of geometric design enclosed within a circular rim. The whole ornament is approximately symmetrical. There are no means of attachment.

Plain circular brooches are convex disks with a central, circular opening or mouth. A hinged clasp or pin crosses this opening upon the convex side of the ornament, and this brooch, like all the others, is held in place on the garment by pulling a portion of the cloth through the opening, so that the hinged pin may be inserted. The tension of the cloth on the pin prevents the ornament from becoming unfastened.

The decoration, if there is any, appears on the convex side. The portion of the ornament from the mouth circumference to the rim is a solid surface and is not perforated.

The ornate circular brooch is similar to the plain circular brooch in that it also is a convex disk with a central opening or mouth, but, unlike it, is ornamented with a symmetrical arrangement in a circle of oval, triangular, diamond-shaped or crescent-shaped perforations. The decoration appears upon the convex side, and consists of various kinds of engraved lines on the solid parts of the brooch between the perforations. The rim may or may not be crenulated.

The harp-shaped brooch, of which there is only one among the collections studied, is similar in form to an Irish harp. It is perfectly flat, and bears no engraved decoration.

Heart-shaped brooches are in the form of a single heart, and generally are surmounted by a cross, a crown, or some other decorative form.

As their name indicates, star brooches are in the form of a star, although not necessarily a five-pointed one. They are slightly convex in cross section. The decoration, if present, appears upon the convex side. The various points of the star may or may not be enclosed within a rim.

Spoon lockets are spoon-shaped, with ovoid, flat covers. There is a ring for suspension at the base of the locket. Usually the covers which are attached to the locket at the base by a hinge are the only decorated portions of the ornaments.

Arm bands are similar to bracelets, but are much wider in proportion to their length. Like the bracelets, they are not complete circles. Rather, there is a break between the ends of the band to allow for variation in the size of the arm or the leg, upon either of which they were worn. Longitudinal ridges are often present at the edges of the arm band. Decoration consists of stamped designs, engravings of animals, and geometric patterns.

Bracelets have longitudinal ridges, which are parallel to one another and run the entire width instead of being at either edge like arm bands. As a rule, the bracelets are

not decorated with engraving or stamped design of any kind.

The only animal effigy represented among the Michigan collections is a bear. It is of silver and is hollow. The mouth has a ring for suspension. These various types are illustrated in Plate III.¹

The decoration upon the various types of silver ornaments consists of stamped or engraved design. A characteristic stamped design is illustrated by Figure 1 K. This type usually occurs at the margins of arm bands, just inside the longitudinal ridges at either side. Another type of stamped design is the small circle, which is similar to the design stamped upon pottery with a hollow reed. This is illustrated by Figure 1 J.

Engraved designs may be straight line, curvilinear, roulette, and rocker. The upper parts of Figure 1 L illustrate the rocker type, and the lower part is representative of the roulette type. These various types of engraving appear in any number of combinations and, in addition, may have spurs or dots associated with them.

A tentative identification of the possible totemic decorations, Figures 1A-I, engraved upon these ornaments seems to indicate that they were owned by the Ojibwa or Chippewa, the Ottawa, and the Potawatomi Indians. These Indians were British allies; thus it is not surprising that so large a proportion of Canadian silver should be found in this region.

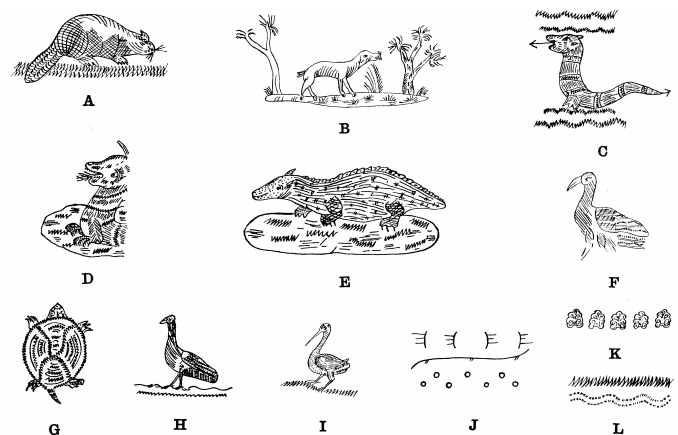


FIG. 1. Design elements and pictures engraved upon Indian silver ornaments

At the beginning of the war between the United States and England in 1776 both the Americans and the British made great efforts to secure the support of the Indians. Nevertheless the Indians in general favored the British, perhaps because of the active work of their agents in distributing presents among them. So thorough were the efforts of these agents and traders that the influence of the English lasted until after the War of 1812.

In Volume 10 of the Knox Papers, which are in the Clements Library at the University of Michigan, there is a communication from Captain Knox to General Haldimand dated April 7, 1781. Included in the presents for Indians at Niagara were the following ornaments:²

- 50 large silver Medals with the King's Bust on one side, the other arms.
- 100 smaller ditto — on one side the kings bust; the other Lion, Wolf, Si^a
- 500 Silver arm bands with King's arms and supporters, Si^a engraved on them.
- 500 Wrist bands
- 100 Silver Gorgets engraved with the King's arms and supporters Si^a
- 1000 Silver shirt buckles (brooches) sorted.
- 500 pairs Silver earrings with drops, sorted.

In the *Michigan Pioneer and Historical Collections*, 15: 606-607, there is a "Recapitulation of Indian Presents &c shipped for the Post of Michilimackinac in the Brigade of Canoes which Left Lachine (Montreal) the 9th of July 1814 in charge of Capt. J. M. LaMothe & Consigned to Lieut. Col. McDonall." Among a considerable variety of trade goods and supplies these articles of silver are found:

- 5000 Ear Bobs
- 60 Pairs Arm Bands
- 3640 Common Silver Broaches [probably miniature round, brooches]
- 50 Silver gorgets

An "Invoice of Sundry Indian Stores delivered (to) Robert Dickson Esqr. Agent & Superintendent of the Western Nations by order of Lieut. Coin. McDonall Comdg Michilimackinac," signed "Jno Askin, Indian Department Michilimackinac 29th Octr. 1814" appears on page 655 of the volume already cited. The silver ornaments which are listed therein are:

- 30 Pairs of Arm Bands
- 1874 Brooches
- 1250 Pairs of Ear Bobs
- 40 Gorgets

Thus on the basis of the documentary evidence it is apparent that the British were presenting and trading silver ornaments in the Great Lakes region and in Michigan during the period from 1776 to 1814.

Further evidence that the silver ornaments studied belong to this period is brought out by the identification of the touch marks and the makers.

In some regions the Indians themselves took over the art of silver-smithing after it had been introduced into their territories by white men.³ The Iroquois of New York are a notable example of this. But from the appearance of the ornaments and the fact that most of them bear touch marks, it does not seem that the Indians of this region manufactured much of the silver found here.

Robert Cruickshanks of Montreal was the ranking silversmith with regard to quantity of production for the fur trade in Michigan and vicinity. His touch mark, the script letters 'R.C' enclosed in a curvilinear cartouche, appears upon 36 of the 119 ornaments. After learning

his trade in London Cruickshanks⁴ emigrated to Boston about 1768, where he worked as a silversmith. According to the accounts of Colonel Daniel Claus, silver ornaments were supplied for the Indians by Cruickshanks in 1779. (He should not be confused with the Robert Cruickshanks of London who completed his apprenticeship to Alexander Johnson in 1776 and worked in that city until 1806 or later.)

Being a Loyalist, Cruickshanks fled to Montreal in the opening years of the American Revolution and is there listed as a merchant in 1781. For a while he was in partnership with Charles Arnoldi, but this was terminated in October, 1784. In the records of the Church of Lacadie Cruickshanks' name appears under the dates 1787, 1788, and 1789. The Government House in Montreal bought cutlery of Cruickshanks in 1789. Robert Cruickshanks died suddenly on board the ship *Eweretta* on April 16, 1809, at Spithead.

Another Montreal silversmith, Charles Arnoldi,⁵ a onetime partner of Cruickshanks, is probably responsible for eight of the ornaments studied. His touch mark consisted of the script letters 'C.A' in a curvilinear cartouche. Records pertaining to him are dated 1784, 1788, and 1810. At the last date he was established at 16 Notre Dame Street in Montreal. In his later years he was associated with a silversmith named Comens.

There is a possibility that the touch mark consisting of the Roman capitals 'P.H' in an oblong cartouche is that of Henri Polonceau,⁶ a silversmith of Laprairie, who entered business in Montreal in 1806. However, the reversal of the initials in the touch mark is entirely without precedent. The last known record of Polonceau is dated 1810. In the two collections there are four ornaments with this mark.

Although the silversmith who used the Roman capitals 'IS' in a square cartouche is unknown, evidence of his work is found in Canada. In the Bishop's Palace at Quebec there is nineteenth-century silver cutlery which bears this mark.⁷ This fact and the comparatively high percentage of silver ornaments bearing 'IS' in the collections studied might lead one to conjecture a Canadian origin for it.

Two of the ornaments in the collections studied bear the Roman capitals 'JO' in a square cartouche. This touch mark is probably that of John Oaks,⁸ a Montreal silversmith and onetime associate of Charles Arnoldi.

One ornament, a silver gorget incised with the Royal Arms of England, was manufactured in 1781 by Benjamin Laver, Bond Street, London. The marks on it are: (1) 'B.L,' in thick letters, in an oblong cartouche; (2) the small letter 'V' in a square cartouche; (3) a lion passant in an oblong cartouche; and (4) a crowned leopard in a shield-shaped cartouche.⁹

Upon a harp-shaped brooch from Emmet County appears the mark of an unknown Montreal silversmith. It consists of the script letters 'JH' in a curvilinear

cartouche, which in addition is stamped "Montreal" in small Roman capitals.

Twelve varied ornaments are merely stamped with the word "Montreal," in small Roman capitals. These pieces bear no other mark.

Only two of the 119 ornaments bear touch marks of United States silversmiths; one was manufactured by either John David, Jr., or John Dupuy, both of Philadelphia, and the other by John Kinzie of Michigan. The David, Jr., or Dupuy mark¹⁰ consists of the capitals 'JD' in an oblong cartouche. Since the mark of John David, Jr., is known to appear in an oval cartouche, it is more likely that the one in question is that of Dupuy, who was working in Philadelphia from 1769 to 1803. This mark is stamped upon a double-barred cross. John Kinzie's mark,¹¹ consisting of the script letters 'JK' in an oblong cartouche, is stamped upon a large double-barred cross from Emmet County. Kinzie, who received his training as a silversmith in Montreal, was working in the Michigan region from about 1800 to 1815 or later.

The touch marks of unknown silversmiths which appear upon Indian silver ornaments in Michigan are as follows: the Roman numerals 'XIII' in an oblong cartouche, on three objects; the Roman capitals 'AS' in an oblong cartouche, on two; 'CG' in a square cartouche, on one cross; a lion passant in an oblong cartouche, on two bracelets; 'JT' in an oblong cartouche, on one brooch. Other unknown marks are: 'P.J.D.' in an oblong cartouche with serrated edges; the same letters in an oblong cartouche with straight edges and accompanied by the stamped letters 'BP' in a square cartouche; and the letter 'W' in an oblong cartouche. The initials 'BP' in the square cartouche might be the mark of Benjamin Price of Philadelphia, although it is certainly incongruous to find them on the same ornament with another touch mark. One gorget is stamped with the Roman capitals 'SH' in an oblong cartouche and one brooch is marked with the script letters 'WC,' or possibly 'JM,' in an oblong cartouche.

SUMMARY

On the basis of the touch marks identified and of documentary evidence, it would seem that Indian silver ornaments were brought into Michigan during the period from the American Revolution to the War of 1812. More than half are British in origin; a large number came from Montreal, most of which were made by Robert Cruickshanks. In some places the Indians took over the art of silversmithing, but the Indians of this region do not seem to have done so, although they may be responsible for some of the decoration. Possible archaeological applications of the study of trade silver are the dating of historic sites and the identification of the tribe which occupied a given site and of the peoples on the basis of their governmental affiliations as revealed by the silver.

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¹ For more detailed explanation and description of types of silver ornaments see Beauchamp (1).

² The list is reproduced here as it occurs in the original.

³ Harrington (2) and Parker (5).

⁴ This and subsequent tentative identifications, unless otherwise stated, were made by means of rough sketches of the touch marks sent to various scholars, who communicated their opinions to me by letter. For the identification of the touch mark and for the information concerning Cruickshanks I am indebted to the historian E. Alfred Jones, London, England; Professor Ramsay Traquair, head of the School of Architecture, McGill University, Montreal; Dr. Amos W. Butler, Indianapolis, Indiana; E. Z. Massicotte, archivist, Old Court House, Montreal; Dr. James F. Kenney, acting dominion archivist, Ottawa; John Marshall Phillips, Gallery of Fine Arts, Yale University, New Haven, Connecticut.

⁵ The information concerning Arnoldi was supplied by Professor Ramsay Traquair and Mr. E. Z. Massicotte.

⁶ According to Professor Ramsay Traquair.

⁷ According to Professor Ramsay Traquair.

⁸ According to E. Z. Massicotte.

⁹ Identified in *Old London Silver* (4).

¹⁰ According to Harrold E. Gillingham, Germantown, Philadelphia, and John Marshall Phillips.

¹¹ According to John Marshall Phillips.

PLATE III

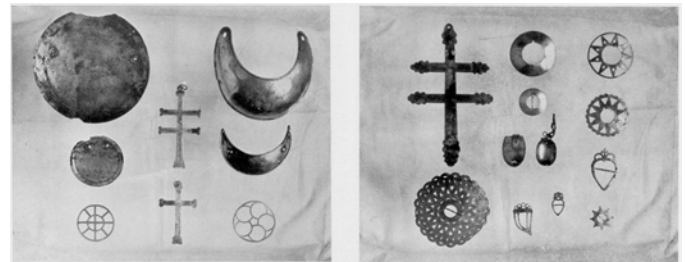


FIG. 1. From top to bottom: Row 1, large circular gorget, small circular gorget, hair plate; Row 2, double-barred cross, single-barred cross; Row 3, large crescent-shaped gorget, small crescent-shaped gorget, hair plate

FIG. 2. From top to bottom: Row 1, large double-barred cross, circular ornate brooch; Row 2, plain circular brooch, small circular brooch, turtle or spoon locket, small heart brooch, harp brooch; Row 3, star brooch, star brooch, large heart brooch, small star brooch

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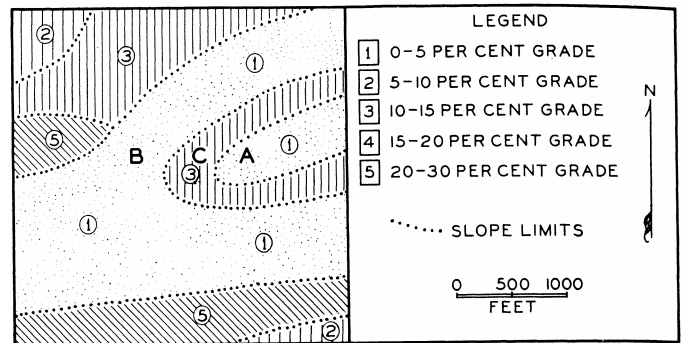
THE SLOPE AND SLOPE-DIRECTION MAP

ROBERT M. GLENDINNING

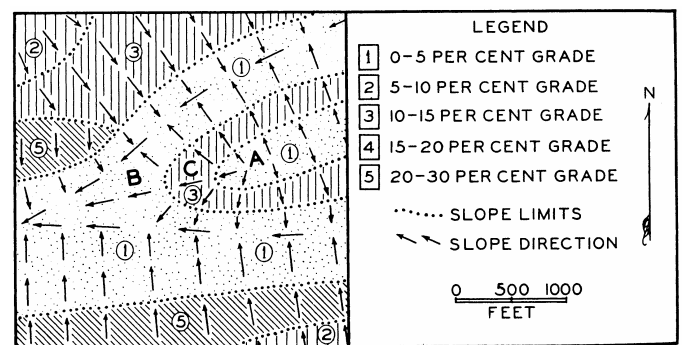
WHETHER one is interested in the purely academic or in the so-called practical aspects of geography, there is usually need for a method or a tool which will adequately reproduce the surface configuration of the portion of the earth being studied — a need for some device that will properly portray the essence of the "mold," or the "lay," of the land. There are many devices of this kind. They vary from such tools as the contour map and the physiographic diagram to aerial photographs examined stereoscopically. It is the purpose of this paper merely to indicate how a map made by combining a slope map and a slope-direction map may serve, at least in the larger scales, as one of such tools. In addition, it is proposed to indicate how such a slope and slope-direction map may be combined with other maps to "point up" the intricate relationships which exist between surface conditions and other landscape elements. This twofold objective may be best accomplished through the presentation of maps dealing with conditions of slope alone, and also with slope conditions related to certain other geographic items. An exemplary, rather than an exhaustive, treatment will be given.

Map 8 is an ordinary slope map of a sample area. It presents the area divided into its several slope classes or categories. The steepness of slope for each portion of the area is expressed in percentage of grade, that is, in terms of so many feet of vertical change for every hundred feet of horizontal distance. In the part of the area labeled A the slope ranges from 0 to 5 per cent grade. The same condition is found in the portion labeled B. In terms of the legend, both these portions have a number 1 slope. The part of the area labeled C has a slope of 10-15 per cent grade, or, in terms of the legend, a number 3 slope. A total of four slope classes is recognized in the entire area, the steepest of these being located in the southern and in the west-central portions, in which the slope is from 20 to 30 per cent grade. Map 8 thus presents the areal relationships of land facets according to their steepness. However, this map in no way indicates the relative altitudinal positions of the several slope areas. For example, areas A and B have the same steepness; yet there is no indication as to which possesses the greater elevation. All that is known is that one is higher than the other, as indicated by the relatively steep area C which separates them. Area A is

either a ridge top which drains across area C to area B, or a valley bottom which receives its drainage from areas B and C. It is in just this respect that the ordinary slope map fails to give an adequate picturization of the land surface.



MAP 8. Slope



MAP 9. Slope and slope direction

Map 9 presents the same slope map as shown in Map 8, but to it have been added arrows which indicate the direction of slope. It thus constitutes a slope and slope-direction map. The addition of the arrows brings out the mold, or form, of the land and injects the item of relative altitude into the picture of the surface conditions. Now it is possible to see, by taking the example given above, that area A is a ridge top which slopes from a narrow crest to area C and that area C, in turn, slopes steeply to the bottom lands of area B. Furthermore, it can be seen that the lower parts of area B slope gently in a westerly direction; that area B collects the surface drainage of the entire area shown on the map; and that this surface drainage is concentrated in the western part of area B before draining off to the west. Map 9, by combining steepness of slope and direction of slope, as well as, incidentally, a picturization of the movement of surface drainage, succeeds in reproducing in cartographic form a reasonably adequate portrayal of the surface configuration of the area.

Maps 8 and 9 are concerned only with items pertaining to the "lay-of-the-land." As such they possess, in and of themselves, a certain value from the standpoint of geographic investigation. However, it is when the information which they convey is related to other landscape elements that they take on a more real and more useful significance. Just what relationships to such elements are to be shown will depend upon the nature of

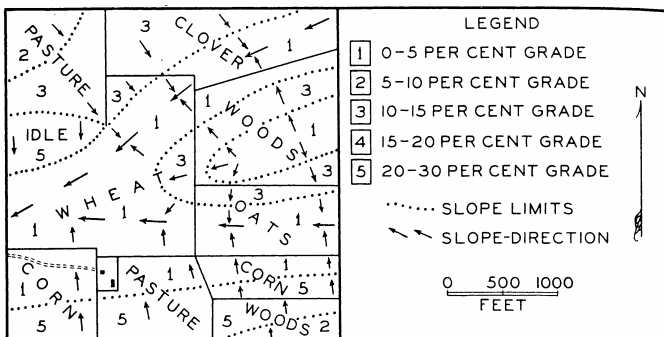
the investigation being conducted. The discussion which follows is based on arbitrarily selected examples.

In Map 10 the information of the first two maps has been combined with land use in order to indicate the relationships existing between surface configuration and the ways in which man is using the area. On this map the boundaries of the slope categories and the slope direction are indicated as before, except that fewer arrows are used to show slope direction; the limits of the several land uses are shown as heavy black lines; and the particular utilization of each use unit is printed within that unit. Inasmuch as a complete interpretation of Map 10 is unnecessary at this juncture, only portions of it will be discussed. To take examples: the cornfield in the southwestern corner of the map is shown to lie on two very different conditions of slope. The northern two thirds occupies a 0-5 per cent slope, while the southern third occupies a 20-30 per cent slope. The arrows indicate that the southern part of the field slopes directly to the northern part and that surface drainage in the former portion must move rapidly, considering the use and the steepness of the land, into the lower, flatter section. In the northwestern part of the map another land use, namely, pasture, likewise spreads across two degrees of slope steepness. The northwestern part of the pasture occupies a 5-10 per cent slope, while the southeastern portion lies on a 10-15 per cent slope. As indicated by the arrows, the slope of this field is toward the southeast. Other examples of the relationships of surface conditions to land use in this area would only indicate further that neither field pattern nor use of the land portrays any uniform adjustments to the surface configuration.

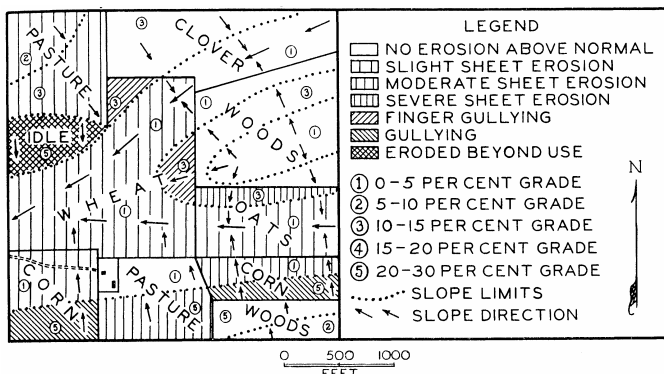
Map 11, again with slope and slope-direction information as a base, indicates the areal relationships of surface forms, land use, and, in addition, erosion conditions. The varying degrees of erosion above normal are indicated by different weights of vertical or oblique lining. Other items shown are expressed as in the preceding maps. If one takes the same examples as above, it will be noted that all the cornfield in the southwestern part of the area is eroding above normal. The lower and flatter portion is marked only by slight sheet erosion, but the higher and steep section is shown to be actively gullying. The pastured field in the northwestern portion of the area is marked throughout by slight sheet erosion, regardless of steepness of slope. Additional illustrations may be taken. The clover field in the northeastern corner shows no erosion above normal, even though part of it lies on a 10-15 per cent slope. On the other hand, the cornfield near the southeastern corner of the area is moderately sheet-eroding on a 0-5 per cent slope and actively gullying on the portion of it which occupies a 20-30 per cent slope. Just to the south, the part of the woods likewise lying on a 20-30 per cent slope shows no erosion above normal. The area of idle land near the west-central part of the map occupies a similar 20-30 per cent slope; it is eroded beyond any possibility of cultivation. Ignoring at this time such factors as soil types, climatic conditions, erosion-control methods, and conditions of exposure, this map indicates that the kind of land use and the steepness of slope are important factors in erosion in this area. It will be noted that all the 20-30 per cent slopes that are not wooded are seriously eroded, whereas more gentle slopes are eroding, or not eroding, depending upon the nature of the land use. One of the major conclusions to be drawn from this map is that, in terms of erosion, there is considerable maladjustment between conditions of slope on the one hand and type of land use on the other.

The four maps just discussed will serve in a limited manner to illustrate the nature and the possibilities of the slope and slope-direction map. Whether it is desired to describe surface conditions in and of themselves, or whether it is desired to show their relationship to other landscape elements as well, this type of map constitutes one sort of useful tool for those interested in describing and analyzing the surface of the earth.

LAND PLANNING AND HOUSING DIVISION
TENNESSEE VALLEY AUTHORITY



MAP 10. Slope, slope direction, and land use



MAP 11. Slope, slope direction, land use, and erosion

THE SURFACE CONFIGURATION OF SOUTH AMERICA

PRESTON E. JAMES

THE accompanying map of the surface configuration of South America (Map 13) recognizes the following categories of surface, each of which is given a somewhat more exact definition than is associated with its title in the lay vocabulary:

Plains. — Plains are areas of relatively slight local relief (less than 500 feet difference between the high and the low points of an area of roughly 25 square miles); they are low-lying with reference to surrounding areas, and are usually, but not in every case, low in altitude.¹

Plateaus. — Plateaus stand distinctly above neighboring areas, at least on one side, and have a considerable part of the surface at or near the summit level. Their local relief may or may not exceed 500 feet. A plateau, from the point of view of its physiographic background, may represent either a youthful land recently uplifted and with a considerable portion of its initial surface still preserved, or an area underlain by horizontal or nearly horizontal layers of stratified rock.

Hilly uplands. — Hilly uplands differ from plateaus in that a considerable part of the surface does not remain near the summit level. Their profiles, therefore, are rounded rather than flat-topped. Not uncommonly such areas are underlain by crystalline rocks forming a so-called crystalline oldland. The hilly upland differs from a plain in degree of local relief, having over 500 feet and less than 1,000 feet.

Low mountains. — Low mountains, it seems, should be distinguished from high mountains. These features are similar to hilly uplands in profile, but have a local relief of more than 1,000 feet and, generally, less than 3,000 feet.

High mountains. — High mountains are similar to the last two categories in that they possess rounded or peaked summits (as opposed to the flat-topped plateaus). A satisfactory working definition to separate them from low mountains calls for sufficient local relief to permit the development of marked vertical zoning of the vegetation cover.²

Intermont basins. — Within the mountain areas there are numerous intermont basins, more or less completely surrounded by higher land. Where such basins lie at a low altitude, perhaps representing only lowland extensions into the mountains, they are included with the plains; but at a higher altitude these basins are distinguished by a special symbol.

In a number of instances these major divisions might well be subdivided. Because of the detailed differences in the landforms, crystalline areas should, if possible, be distinguished from areas with stratified rocks. Glaciated terrain is markedly different from non-glaciated terrain. In the low or the high mountain areas the intermont

basins should be separated from the rougher surfaces. As the area to be treated becomes smaller, the number of such more detailed subdivisions becomes greater.

In any system of generalization the question of boundaries is apt to become troublesome. Should, for example, the foothills of a high mountain system — the marginal cuesta belt, let us say — be included with the mountains or indicated as a separate surface division? For two reasons the author has followed the practice of including such marginal areas with the larger division of which they form a part. In the first place, the data by which the marginal areas might be separated are not in every case available. But even if they were, the question of logic might be raised if an attempt is made to treat the boundary of a generalization too specifically. Therefore, foothills are included with the mountains unless they are essentially different; the dissected (and perhaps no longer flat-topped) edges of plateaus are included with the plateaus; and the low "rolling" surface on the margin of a hilly upland, even if it has a local relief of less than 500 feet, is included with the upland. The attempt is made to identify the critical changes in surface character and here to establish the boundaries rather than to apply any quantitative definition based on relief alone.

The original compilation of the new material on surface configuration was worked on a base with a scale of 1:6,000,000. In the reduction of the map presented here some of the detail has been lost.

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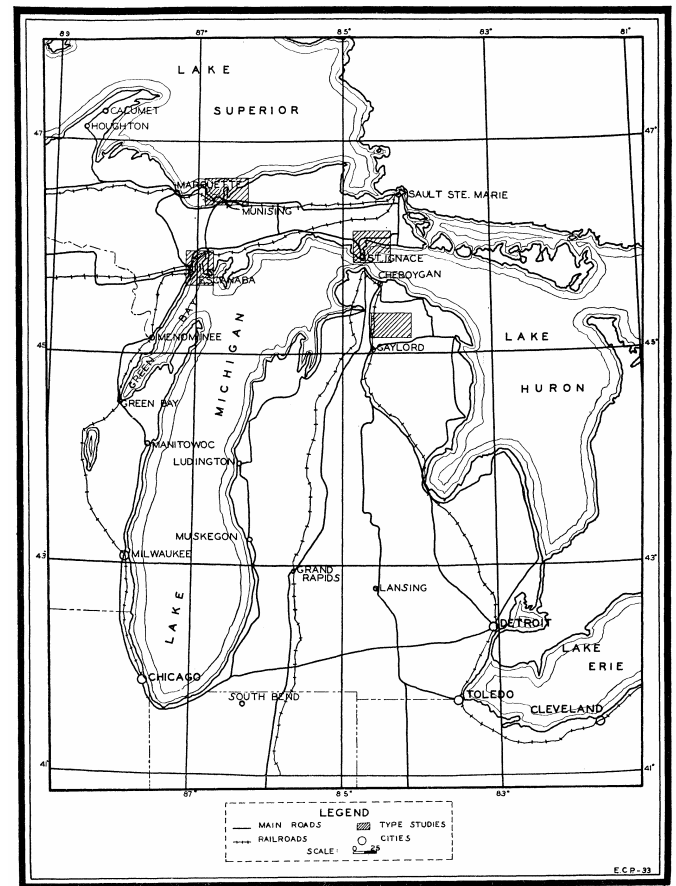
SOME TYPES OF RECREATIONAL LAND USE IN MICHIGAN A SERIES OF TYPE STUDIES

EDWARD C. PROPHET

THE relatively extensive use of northern Michigan lands for recreational purposes is a recent development. It has provided this part of the state with an additional industry, expressing itself largely through increased employment. Unfortunately, up to the present time it has been exploitive rather than constructive, just as are most of the other major human activities of the area, such as lumbering, mining, trapping, and land booming. A movement is now under way to make it constructive and permanent rather than purely exploitive. The people of this area realize, or at least their leaders do, that they must find some source of employment which will continue indefinitely into the future and which does not take something away from the land. Accordingly, they are turning more and more to recreation as their last hope for such an industry. The forest has been cut and burned to such an extent that lumbering is no longer a dependable source of employment to a major portion of the population, as it has been in the past. With the decline of lumbering, farms which furnished supplies to the lumber camps have ceased to be profitable undertakings, and in some localities even the mines are beginning to fail. It is inevitable that the area will be abandoned unless some other source of employment is found. Fortunately, the automobile, which has become more and more important in our civilization during the last twenty years, and good roads, which the automobile has forced on most areas, have made this region readily accessible to about thirty million people. Map 23 shows the major lines of transportation serving the northern part of the Lower Peninsula and the eastern part of the Upper Peninsula. "The North Country," with its sparse population, its lakes and streams, its wild lands, its game, its beautiful scenery, and its cooler climate has proved very attractive to the city dweller who lives just south of it and is likely to become an even more popular vacation land as people find that they have more time for recreation owing to the leisure that is being forced on them by the machine age in which they live.

The map shows four type studies which have been chosen to illustrate various recreational uses of land or resources and also to show the ways in which certain resources function in developing and maintaining this industry.

Motorists, to the number of eight or ten thousand, annually make a tour around Lake Michigan. Incidentally this is a very conservative estimate, made from relatively reliable data obtained by the State Highway Department of Michigan. These cars have an average of three or four passengers each.



MAP 23. The transportation routes shown are the through ones carrying most of the traffic. Other, less-used, routes exist, but have been left off the map to avoid confusion resulting from too much detail. The shaded areas correspond to the areas included on the detailed maps shown later

ESCANABA

The route takes tourists through Escanaba, located at the north end of Green Bay (Map 24). It serves purely as an overnight stopping place for the majority of them. The hinterland is not inviting, since it was lumbered at an early date and is now very badly burned over. At the best it is covered with a poor stand of brush and is a monotonous plains area. No effort has been made to provide cottages on the bay shore for visitors or to develop boating or swimming facilities in the adjoining bodies of water. The cottages east of Gladstone and south of Escanaba, shown on the map, are owned and maintained by local residents of Escanaba for their own use and pleasure and usually are not available for visitors during the summer months. The city has a very large number of tourist lodgings and restaurants, as well as fair hotel accommodations. No effort has been made to keep or delay visitors in this area by providing anything that will interest them, so that their stops are of short duration. Escanaba is merely a stopping point on the route to somewhere else and, accordingly, it behooves the resident to pluck the plumes of the bird of passage (as the tourist really is) while he is

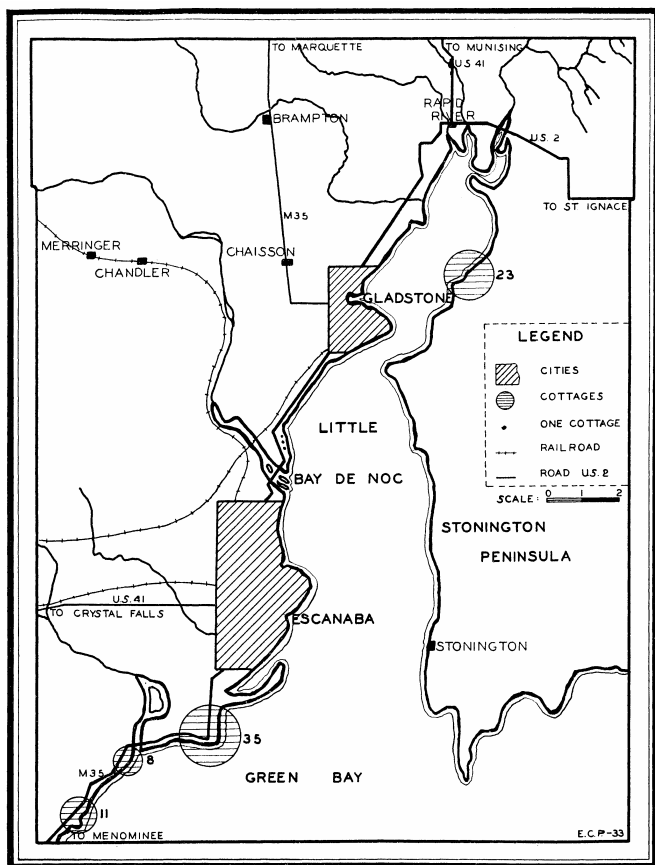
en route. Fortunately, discretion has been used to the extent that the traffic has not been unduly discouraged.

MUNISING

Munising is also a tourist town, but it has a definite resource to attract the tourist (Map 25). The Pictured Rocks, which are reached from this point, serve as a magnet which draws visitors to this area. For many people they are an objective, not merely an incident of a trip. Munising has a very beautiful site. It is located on a magnificent, almost land-locked bay and is backed on the land side by heavily wooded, deeply dissected cliffs. Many people call it the Naples of America. Lodginghouses are numerous, and the spirit of a resort town is not lacking here as it is in Escanaba. The wooded slopes lying back of the town are likely some day to be covered with great summer estates, but much must be done before that will be a reality. One thing that Munising needs and needs badly is a good fire. The chief calamity from such a fire would be the survival of some buildings. If it were possible to get rid of the shacks that disfigure the shore line, then man could rebuild in a way which would not detract from the beauty that nature has here provided. The main attraction is, of course, the Pictured Rocks, the cliffs which border Lake Superior to the east of the town. These cliffs extend for about twenty-five miles, and visitors are shown them from boats. The cliffs are composed of a resistant limestone, which rises sheer from the water's edge. They vary in height from seventy-five to three hundred feet and have been cut by the waves into many fantastic forms. Stacks, caves, arches, and waterfalls, where streams drop from their gorges over the cliffs into Lake Superior, provide a variety of scenery which is very pleasing and interesting to the visitor. Except at Miner's Castle it is almost impossible to see the Pictured Rocks from the land side. The operating of boats to take visitors to see the rocks has proved a very profitable business and employs many of the residents.

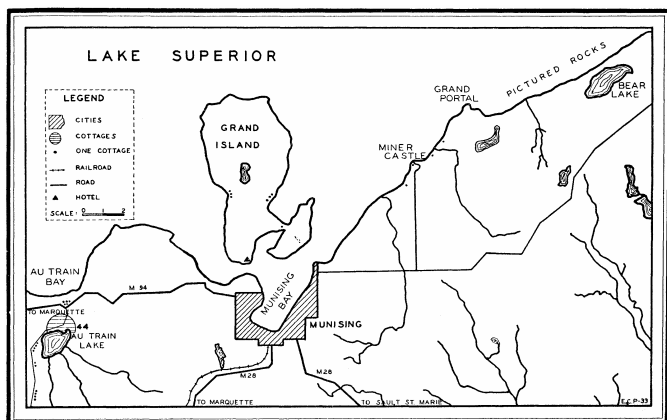
Grand Island, which shuts off Munising Bay from Lake Superior, is a privately owned recreation area. The Cleveland Cliffs Mining and Timber Company, one of the largest employers of labor in the Upper Peninsula, owns the island and maintains it as a summer resort for their office men and for officials of the company. A large resort hotel, the Williams Hotel, is operated by the company for the use of its employees. Hunting is prohibited, and the virgin timber has never been disturbed, making it a wilderness park in the true sense of the word. It may be that this island will be opened up to the public in the near future, since the company has suffered in the depression, as have other concerns, and would like to derive some revenue from its investment on the island.

To the west of Munising, at Au Train Lake, is a very promising summer-resort development. There are now fifty-nine cottages, most of which are rented to summer visitors. With the exception of about a dozen, all have been built during the last five years and the colony is expanding rapidly. The majority are owned by local people and rented to transients, but a few were built by individuals who return to this area every year and want



MAP 24. Escanaba, Delta County

Note the absence of cottages on the Stonington Peninsula except across from Gladstone, and the concentration of cottages along Green Bay south of Escanaba. The latter site is more accessible to Escanaba, which has resulted in its development



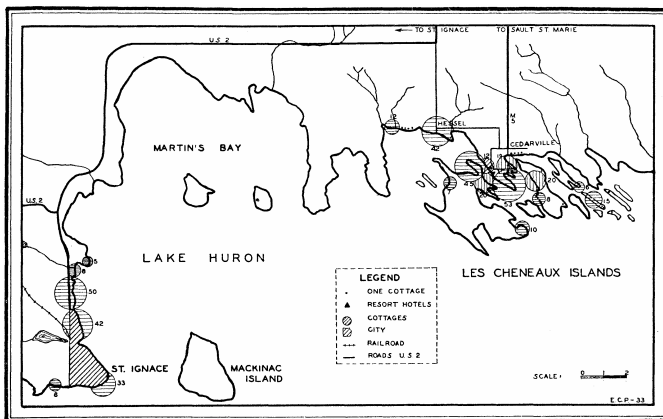
MAP 25. Munising and vicinity, Alger County

to own their own places. An effort is being made to increase this kind of resorter.

LES CHENEAUX ISLANDS AND ST. IGNACE

The third type study discusses two sharply contrasting developments in the southeastern part of the Upper Peninsula. These two areas are Les Cheneaux Islands and St. Ignace (Map 26).

St. Ignace is the eastern entrance to the Upper Peninsula. Its function is much like that of Escanaba, being a stopping point for tourists on their way to other localities. During the last eight years a real effort has been made to provide better facilities to take care of resorters, with the result that about one hundred new cottages have been built. Some of these are very fine log cabins, but most of them are used to house overnight visitors. St. Ignace has had a bad reputation for overcharging the tourist, and the practice still persists, in spite of the efforts of some citizens to live it down. The psychology is: "Get what you can from the tourist. You may never see him again." The old exploitation idea is still present in a vicious form.



MAP 26. St. Ignace and Les Cheneaux Islands, Mackinac County

At St. Ignace itself there is little of interest for the visitor, but within easy driving distance there are several features that could be used to entertain him. The land in the immediate vicinity is low and swampy or else composed of limestone outcrops, and the timber has been cut or burned, giving it a desolate, uninviting appearance. Actually, it is depressing to the beholder, so that it does not encourage residence for any length of time. The map shows the relative location of the cottages and the general site of the town. The majority of people who go to the trouble of crossing the "Straits" from the south do not linger long at St. Ignace. Thus its primary function is that of a terminal at the east end of the Upper Peninsula and an entrance to the Peninsula from the rest of the state.

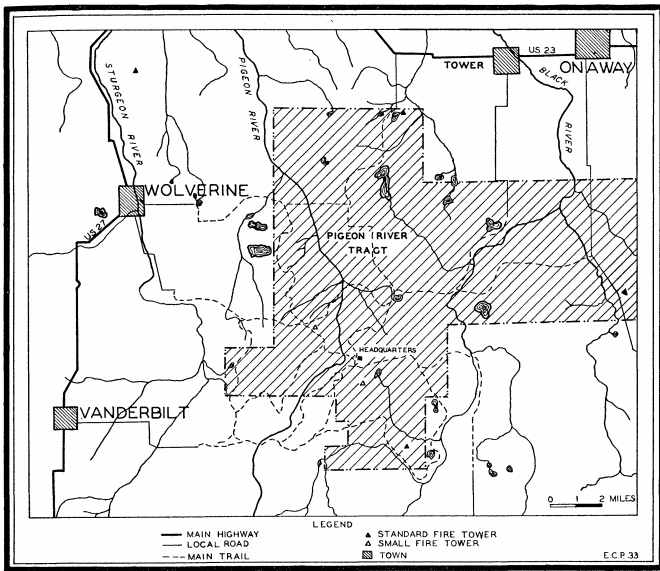
About twenty miles to the northeast lie Les Cheneaux Islands. These islands are the site of one of the finest summer resorts in the state. An outcrop of relatively hard dolomitic limestone, dipping gently to the south and

having a strike running from northwest to southeast, extends obliquely into Lake Huron. The receding glacial waters cut many channels through this outcrop, and the present lake level is such that the channels are flooded and the outcrop exists as a series of islands. A very thin layer of soil is found here, and the islands are covered with birch trees, from which they have obtained their name, Les Cheneaux. Deep but narrow channels between the wooded islands, which have many bays and coves, provide unexcelled waters for fishing and boating. The natural beauty of the region is very striking, especially when compared to the areas near it, and it attracted resorters at an early date. For a long time visitors came only by boat from Mackinac Island or St. Ignace, which were reached by the large lake passenger boats. For forty or fifty years Les Cheneaux have been a summering place of the socially prominent from the lower lake region. Now that they can be reached overland by road they serve a larger number of people, but they have not lost their atmosphere of refinement and quiet. The islands are still frequented by the exclusive class, and it is almost impossible for newcomers to purchase either summer estates or cottages in the older established clubs. Newcomers have had to content themselves with sites for their summer homes on the mainland or on outlying portions of the islands. The site of this development is as ideal as any in all Michigan for a summer colony and was one of the first chosen for development.

PIGEON RIVER PROJECT

The Pigeon River tract involves a type of land use very different from that of Escanaba and St. Ignace, which are used as overnight stopping places; from that of Munising, where there are special features for sightseers; and from that of Les Cheneaux, which is exclusively a resort development. It lies in the northern part of the Lower Peninsula and can be reached from the main routes of travel to the "Straits" (Map 27). The casual sightseer does not know it is there, since it is isolated from these routes.

The State Department of Conservation fell heir to several thousand acres of this land, owing to the fact that former owners could not afford to keep up the taxes on the land once the timber had been cut off, and there seemed to be no other good economic use for it. The Department has added to its original holdings by purchasing several thousand acres more, so that it now owns outright about four townships. Two state forests, a game preserve, and a large area of public hunting land have been established in this tract. Much time, thought, money, and labor have been poured into these projects, which have resulted in the tract becoming one of the major projects of the Department.



MAP 27. The Pigeon River tract in Otsego and Cheboygan counties

The area is composed of sharply defined moraines, a little till plain, and a great deal of outwash plain. Two large rivers drain through it, and many kettle and pit lakes are in it. The streams are excellent trout water, and the improvements that have been made on them will bring about an even better habitat for trout. During the trout season many fishermen come to this tract and set up camp. Deer and small game abound, especially on the borders of the game preserve. The area has been lumbered, but since it has not suffered greatly from fire, the second-growth cover develops unusually well. In some sections, where fires have destroyed the cover, plantings have been made, and the present plan is to manage the tract in such a way that in the course of time it not only will have a good stand of timber but also will be a wilderness park serving hunters and fishermen as well as attracting those who wish to camp in the wilds and study nature. In a number of states the aesthetic value of our wild lands has been largely overlooked in the conservation movement, but in Michigan some attention is being paid to it. It has been found that a live deer which a tourist can see in its native habitat is a great attraction and draws city dwellers to the wild lands for their vacations. If these visitors can see some wild animals in their native habitats, the trip is a success, and they come again. If vistas are cut in the forests, the tourist can see the lay of the land better, and the monotony of continuous forest or brush is avoided, making his trip more interesting. These are some of the things that are now making the Pigeon River tract inviting to tourists. It is already starting to function as a magnet to draw people north, just as the Pictured Rocks do, and thus it serves several functions.

Projects of this sort are absorbing several hundred thousand acres of the so-called waste lands of the state. They are not really "waste lands," but merely "idle lands," and are gradually being converted into use by the recreational industry. The aesthetic use of wild land

does not interfere with its use for forest products or for by-products like game, fishing, and nature study.

SUMMARY

This study is an attempt to present briefly several phases of the recreation industry as it is developing in Michigan. The types chosen are not all-inclusive but merely representative. Escanaba and St. Ignace serve the tourist exclusively; Munising acts as a magnet to draw people north and also serves the tourist as well as the resorter; Les Cheneaux are a resort region with relatively little tourist trade; and the Pigeon River tract is an example of the extensive use of idle land for a wilderness park, comprising timber growing, hunting, fishing, and other outdoor recreation. These are only types, since there are dozens of other localities which are functioning in a similar manner.

Land and resources that would otherwise be idle are being put to work through the recreational industry and are providing employment for thousands of local residents who would otherwise have to move away and seek employment elsewhere.

Not one of these resources is unusual or exceptional, and the writer has no idea of suggesting that Michigan is better equipped for recreation than are other states or that the state has anything to boast of in this line, but the intent is to show how very ordinary resources can be put to use and provide employment and thus allow an area to develop.

MICHIGAN STATE COLLEGE
EAST LANSING, MICHIGAN

FUNCTIONAL AREAS OF DETROIT, 1890-1933*

LEONARD S. WILSON

THIS study of the growth and change in the functional areas of the city of Detroit presents a portion of the uncompleted story of the growth of the city. In preparing the material plotted on the accompanying maps an attempt was made to relate the evolution of the various divisions of Detroit to the data of the United States censuses. The procedure outlined below might well be followed in constructing functional maps in the historical growth of any city.

METHOD

The technique followed in working out this series of maps combines the discipline of the historian with that of the geographer. Since all the functional maps present landscapes which are at least ten years old, the entire work of delimiting the divisions of the city was related to the available documentary evidence on its growth.

The most important single source of information was the city directories for the years under consideration.¹ These publications, compiled during the years discussed, present material which accurately lists all the buildings in the city, with the address and the use of each. From these sources, checked through the office of the city engineer, it was possible to locate within a block the entire structure of Detroit. However, with the exception of the manufacturing and commercial buildings, the Polk directories gave no clue to the function of the individual structure in relation to the city as a whole. Consequently, it was necessary to consult records of dwellings as they existed in the period under consideration.

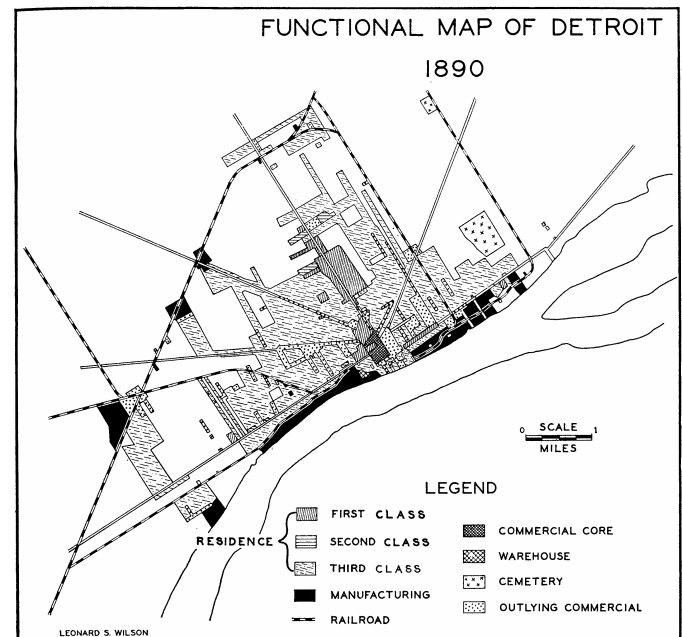
Aside from the purely physical information contained in the directories, other historical sources pertaining to the city were investigated to learn the location of each class of dwelling. Among the more important historical papers dealing with this subject are the various local histories.² First- and second-class residences were plotted from sources similar to those mentioned above, and court calendars, newspapers, and police items tended to indicate the location of the poorer residential areas.³ From these sources an accurate picture of the history of the city could be had. By the correlation of this history with the information previously mentioned as to the buildings of Detroit, the accompanying series of functional maps was prepared. As an explanation of the growth of the city, a brief account of the historical development of the urban area is included with the description of each map. This account describes the changes in the functional areas.

MAP FOR 1890

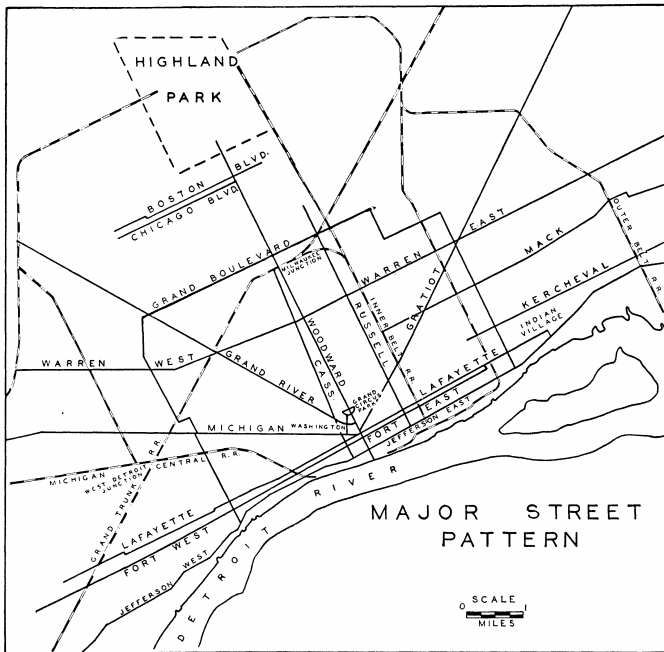
(Map 28)

Prior to 1890 the city of Detroit was primarily a one-industry town. The copper and the iron deposits in the Upper Peninsula of Michigan had been worked, and the smelting industry was of fundamental importance. This industry, combined with a smaller amount of lumbering and commerce, was the main source of employment in the city. By 1890 these industries, augmented by the addition of several small manufacturing plants, had developed the following pattern.

Industry was located within the city in a long narrow zone, interrupted only by Woodward Avenue, along the Detroit River. The Inner Belt Railroad had been built during the previous decade and the beginning of industrial replacement begun. Apparently the crossing of the Michigan Central Railroad and the Grand Trunk Railroad produced a satellite core beyond the city proper. The development, known as West Detroit, grew around a large stockyard located here. Shortly afterwards, several industries, formerly situated around the river front, moved into this new center because of congestion in the downtown area. Other beginnings were made on West Jefferson Avenue, the Milwaukee Junction section, and at the crossing of the main roads and the railways. These functional units in turn attracted associated groups. Small stores serving local needs followed the industrial development and in turn attracted small areas of third-class residences. Thus small independent areas composed of the three functional units mentioned above were established beyond the limits of the city proper.



MAP 28



MAP 29

The commercial areas, which, on the basis of function, may be divided into commercial core and outlying commercial, were located along the five main radial streets (see Map 29).⁴ The commercial core was bounded by Woodward, Jefferson, Cass, and Michigan avenues. On the southern and the eastern sides an area of outlying commercial development was established in several blocks between Jefferson and Gratiot avenues. The beginning of the important role played by the five radial streets appeared. Commercial development took place on Jefferson, Michigan, Grand River, Woodward, and Gratiot avenues, the attraction being the establishment of city markets at the limits of the town. Secondary commercial streets became apparent chiefly in the area east of Woodward Avenue, which had formerly been the site of first-class residences. The ribbon pattern of commercial development followed the extension of these streets, which were drawn north during the decade 1880-90 by the increase in the importance of Milwaukee Junction. Other important locations were found along north-south streets between Michigan and Jefferson avenues on the west side and between Jefferson and Gratiot avenues on the east side of the commercial core. One more commercial area was started on north Woodward Avenue in the vicinity of the present-day Grand Boulevard.

First-class residences were confined to the blocks on either side of Woodward Avenue north of Grand Circus Park, the area around Washington Boulevard, West Fort Street, and Jefferson Avenue, east of Woodward Avenue. A few people were beginning to move into the vicinity of the old race track, where the Indian Village development of today is located.

Second-class residences were practically nonexistent, being confined to a small area near the junction of Grand

Boulevard and Jefferson Avenue. Another small area was on the Boulevard near the junction with Woodward Avenue.

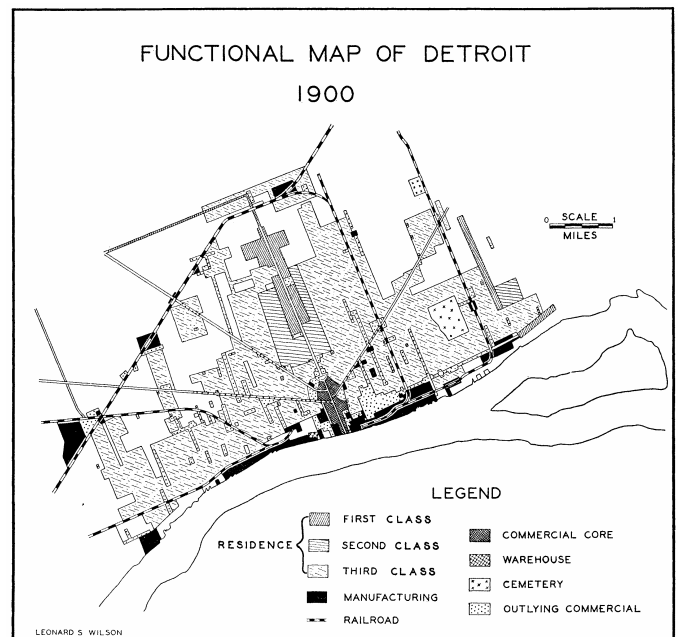
Third-class residences made up the major portion of the city. In outlying districts these dwellings were composed of one- and two-story frame buildings. In the center, near the commercial core, and especially west of Woodward Avenue and south of Michigan Avenue, were old second-class residences. It is probable that this section may have been the slum area of the 1890's.

MAP FOR 1900

(Map 30)

During the 1890's the automobile industry started. At first the process was merely an assembly of parts manufactured in plants which normally dealt with portions of the machine, such as motor castings and wagon bodies. The motor blocks, for example, were manufactured under contract by the several iron foundries and smelters associated with the earlier concentration on ores from the Upper Peninsula. Bodies were furnished by the wagon companies already established, so that during the infancy of the industry no radical changes in the manufacturing section were made. The automobile industry merely occupied structures abandoned by other industries.

In 1900 the manufacturing developments remained closely allied with the transportation systems. The majority of these plants were along the bank of the river south of Jefferson Avenue. There was, apparently, a continued growth in the direction of the railroads, with a slight increase in areal extent indicated in all sections. The satellites at Milwaukee Junction and West Detroit continued to grow.



MAP 30

The commercial core had expanded until it reached from the river along Woodward Avenue to the southern border of Grand Circus Park. It is interesting to note that for ten years this small boundary acted as a barrier to northern expansion. This functional unit also occupied the former first-class residential area on Washington Boulevard and had taken over a considerable portion of outlying commercial property between Gratiot and Jefferson avenues, as well as the first-class residences on Fort Street.

This period also saw the further development of the five radial streets along commercial lines. Jefferson Avenue became a commercial street as far east as the Inner Belt Railroad. Russell Street was of secondary importance as a commercial thoroughfare, while the roads between Russell Street and Woodward Avenue as far north as Gratiot Avenue began to show a skeletal structure of commercial buildings.

Residential areas as a whole tended to fill in the unoccupied land within the city. The first-class areas on Woodward Avenue contracted because of the expansion of the commercial areas. Washington Boulevard was entirely given over to commerce, and new concentrations appeared along West Grand Boulevard at Woodward Avenue, on East Grand Boulevard, and on East Jefferson Avenue beyond the Boulevard.

Second-class residences continued to be closely allied with first-class dwellings. They all occupied adjoining areas and tended to act as buffer zones between first- and third-class residential areas.

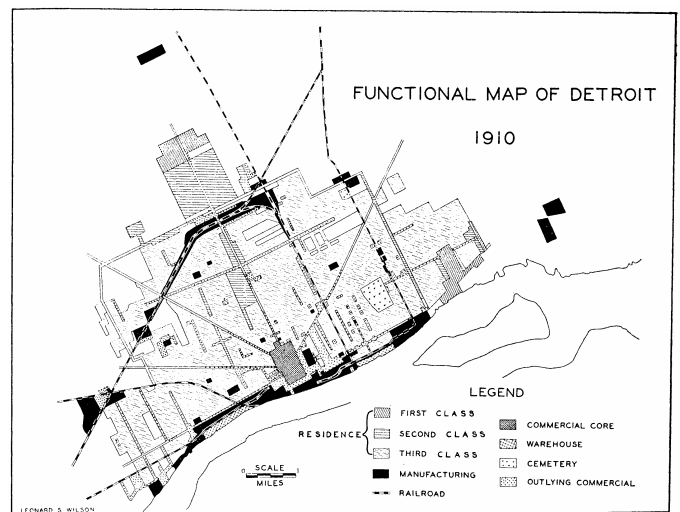
The greatest change occurred in the third-class residential areas. These continued to expand, filling in the vacant areas within the city and making ribbon-like extensions along streets leading to outlying commercial centers and toward the intersections of the five radial streets with the railroads. For the first time in the years studied this type of dwelling succeeded in surrounding the older first- and second-class residential areas.

In 1900 warehouses were scattered for the most part throughout the transportation area, with a heavier concentration along the river than elsewhere. It was during the preceding ten-year period that the trade commodities of the city changed from raw or semiprocessed materials to manufactured articles which had to be protected from the weather.

MAP FOR 1910

(Map 31)

By 1910 motor-car manufacturing had become firmly established in the industrial life of Detroit. As a result the industry began to occupy its own buildings, which, because of the crowding of the downtown river area, had to seek other places of attachment. A comparatively rapid growth took place, an early indication of what was later to develop into one of the most disorganized urban agglomerations in the United States.



MAP 31

Industrial property showed a marked departure from the close formation of the preceding decades. This was caused primarily by the expansion of the automobile industry. Ford built his Highland Park plant in the latter part of the decade. On East Jefferson Avenue, beyond the city limits, Continental Motors, Hudson Motors and Chalmers Motors were established. Automobile factories acted as magnets, drawing the city out toward them. At this time, too, the motor-car industry was plagued by "fly-by-night" concerns which sprang up in less favorable locations. For the most part these were located in abandoned factories near the downtown section. Here one other important change occurred, namely, the retreat of the industrial area served by both the river transports and the railroads; it was invaded by large warehouses, which became an important feature in the industrial scheme of Detroit.

The commercial core had nearly doubled in area. It extended from Jefferson Avenue north along Woodward Avenue to the third block beyond Grand Circus Park. In width it encompassed most of the area between Cass Avenue and Brush Street. A considerable portion of this expansion may be accounted for by the increase of real estate offices and of branch offices of various industries which served the manufacturers of automobiles. In addition, many new stores were opened; theaters and hotels were built in the vicinity of Grand Circus Park, and the trade in the commercial core expanded into new fields of endeavor. The southern limit contracted from the water front to Jefferson Avenue, and in this section was replaced with terminals of the cross-river transportation lines.

Outlying commercial areas continued to expand along the five radial streets, but with less rapidity, especially on Grand River and Woodward avenues. Many small stores that existed on the west side in 1900 had been abandoned by 1910. A more concentrated grouping of these establishments was found on streets connecting the main arteries with the outlying industrial plants. A shifting of the commercial center around Milwaukee Junction was also noticeable. During the period prior to

1910 Warren Avenue began to develop as a business street. A heavy concentration of stores serving the outlying residential areas sprang up and continued at least until 1920. Kerchival Avenue, on the east side, and Mack Avenue also began to expand as commercial roads. The size of the outlying commercial area on the east side of the commercial core declined, possibly because of the increased diversity of products handled in the core proper and the movement of people from the downtown section to the periphery of the city.

Residential classifications became more complex with the beginning of cheap rapid transportation for all. In 1910 the first-class residential districts had moved outward beyond the Boulevard. In the vicinity of Woodward Avenue and Boston Boulevard the major new area of first-class dwellings was established. It was on the very fringe of the city; only the Ford plant in the village of Highland Park was north of this district. Between the first-class dwellings and the Boulevard a large section of second-class dwellings grew up. Another first-class residential area was just east of the Boulevard, on Jefferson Avenue.

Between the first- and the third-class residences sections of second-class dwellings appeared as buffers between the two types of homes already noted. These concentrations were along Boston and Grand boulevards. A minor growth of dwellings in this classification was located in Indian Village and on East Grand Boulevard near Jefferson Avenue.

Expansion in the residential classes was concentrated in third-class areas. Many of the old first- and second-class areas, especially along Woodward and Jefferson avenues, became rooming-house districts. In addition, the automobile industry attracted large numbers of people to the city, and these immigrants tended to locate close to the source of employment. This resulted in the beginning of the spread of subdivisions. Prior to 1920 the city was a compact unit, with major expansions along the five radial streets. The first large unsettled areas within the city proper are of this date. In all cases these are near third-class residential areas and railroads. This might be an indication of land speculation for industrial development.

MAP FOR 1920

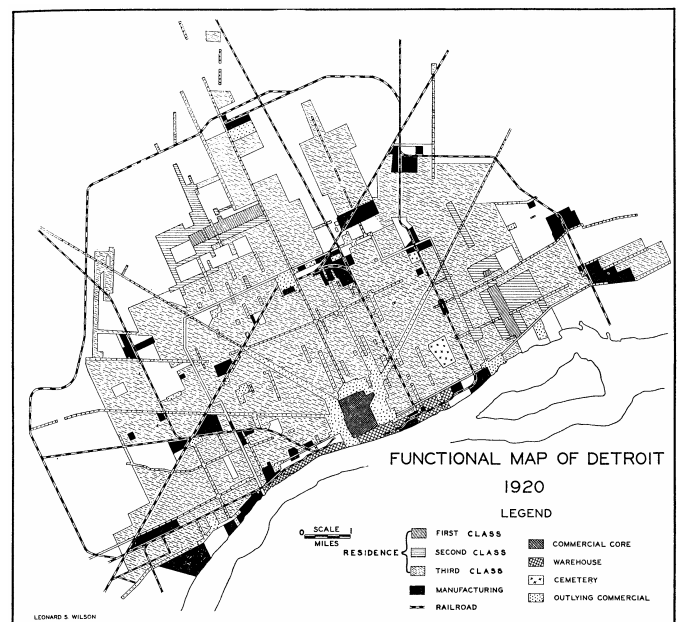
(Map 32)

In 1920 the automobile industry was weathering its first depression; expansion had gone on at a very rapid rate and land values rose to unheard-of prices. Speculation, combined with a rapidly increasing population and cheap quick transportation, began to make its impression on this cultural landscape. There were large blocks of unoccupied land within the city. Commercial streets extended to the limits of the settled areas and beyond.

At this time manufacturing had almost abandoned the river front near the center of the city to warehouses, which had multiplied in number with the expansion of the

motor-car industry. A few establishments connected with the refining of salt remained on the west side of the city. Nearly all others moved out to advantageous sites along the railroads. Notable areas of concentration were those at West Side Junction, formerly West Detroit, Milwaukee Junction, and the crossing of the Outer Belt Railroad. Other sections of the city in this functional class were located on Kerchival and Jefferson avenues.

During the same period the commercial core had expanded to a considerable distance north of Grand Circus Park along Woodward Avenue and had occupied a number of blocks on Michigan and Gratiot avenues, Fort Street, and Lafayette Boulevard. On the east side the boundary had moved outward to include a portion of the commercial area as far as Russell Street. The core proper had not reentered the zone between Jefferson Avenue and the river; it was entirely surrounded by outlying commercial zones.

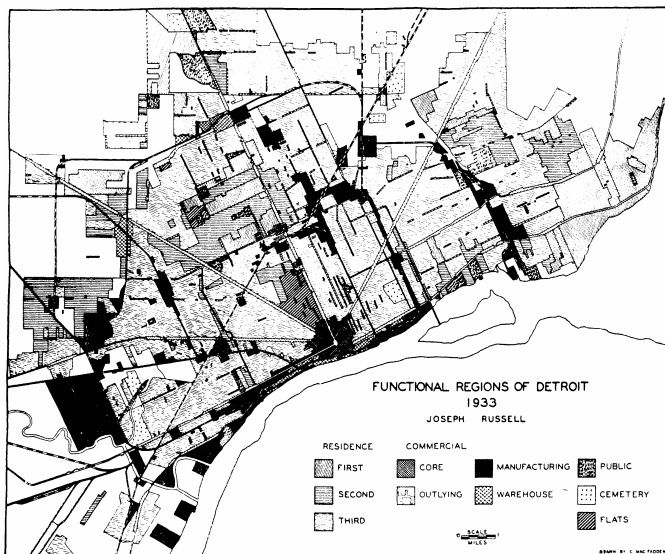


MAP 32

The outlying commercial areas continued to expand along the five radial streets, in many instances beyond the built-up residential areas. Gratiot and Michigan avenues were paralleled by other commercial streets. Satellite centers grew very rapidly, especially those at Grand Boulevard, Woodward and Jefferson avenues, East Grand Boulevard, and Highland Park.

First-class residential areas continued to exist along Chicago Boulevard and in Indian Village, but many of the wealthier citizens had moved either far beyond the city to the small summer resort of Grosse Pointe or into apartment buildings, the area of which was just beginning to expand.

As before, second-class residential areas surrounded the first-class zones. In contrast to the 1890 era these covered more space than did the first-class sections, and growth continued in a northwest direction beyond Chicago Boulevard and north of Indian Village.



MAP 33

Third-class residential areas again showed the greatest change. These tended to follow the precedent started at the outset of the motor-car era, namely, to settle in the vicinity of the factories. Land speculation, combined with the universal use of automobiles, spread the city over a large area, leaving great blocks unoccupied within it.

MAP FOR 1933

(Map 33)

Map 33 indicates that the changes in the city which took place in 1910 and which were shown on the 1920 map as continuing actually did carry on until 1933-34. The only change that has taken place since the construction of this map is the removal of a portion of the outlying commercial area and the commercial core. Apparently, the city is in a static condition so far as growth is concerned. If anything, it is contracting, both because of vacancies in commercial buildings and because of the actual removal of such structures.

CONCLUSION

In conclusion, a few generalizations are here made:

1. Improved transportation may be the cause of the spreading of the city over a larger area than is necessary for the inclusion of all functional units.
2. The reversal of the sequent occupance on major transportation routes is characteristic of modern urban growth. Prior to the motor-car era, outlying commercial development followed the residential occupation of any area. At present it tends to precede it.
3. In competition with industry, commercial developments in satellite areas tend to be forced to relocate, regardless of the favorableness of the site.
4. The circumference of a first- or second-class residential area by third-class dwellings appears to end the growth of the district as a member of either of these

functional groups. Shortly after the enclosure the dwellings decline. The former occupants move to a different location, rooming and apartment houses begin to appear, and the function as an exclusive or a superior residential area ends.

ACKNOWLEDGMENT

Map 33 is reproduced through the courtesy of Mr. J. A. Russell, who constructed it while holding a fellowship under the Earhart Foundation for Research in Metropolitan Detroit. It is included in this paper to supplement the series of maps made by the author.

CARLETON COLLEGE
NORTHFIELD, MINNESOTA

* The field work done in connection with this paper was made possible by the granting of a Fellowship in Geography by the Earhart Foundation for Research in Metropolitan Detroit.

¹ Polk, R. L., *Directory of the City of Detroit*. R. L. Polk, Detroit, Michigan, 1891, 1901, 1911, 1921.

² Histories of the city are best exemplified by Silas Farmer, *History of Detroit*. Farmer and Company, Detroit, 1884.

³ Another important source was the Burton Historical Collection, of the Detroit Public Library.

⁴ The five radial streets referred to are Woodward Avenue, Gratiot Avenue, Grand River Avenue, Michigan Avenue, and Jefferson Avenue.

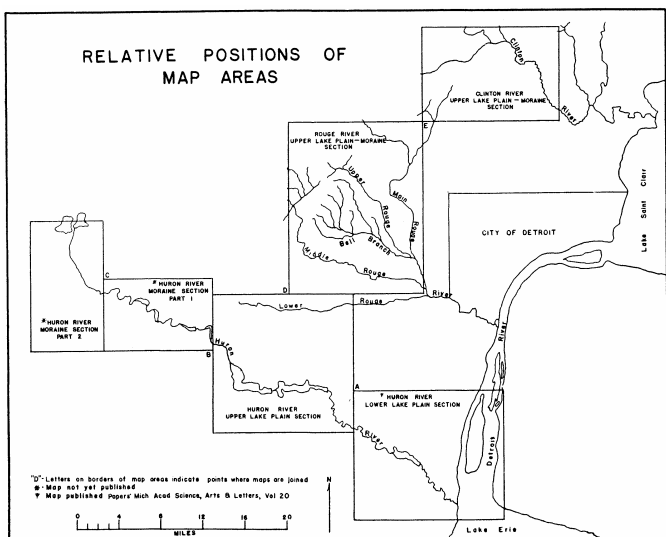
GLACIAL-LAKE LEVELS INDICATED BY TERRACES OF THE HURON, ROUGE, AND CLINTON RIVERS, MICHIGAN

JAMES WILLIAM BAY

INTRODUCTION

THE rivers of southeastern Michigan originated as small streams flowing from the retreating ice front of the Huron-Erie lobe of Wisconsin glaciation. Their courses were at first northwestward to westward away from the ice front, or southwestward along the margin of the glacier.¹ As the glacier withdrew from the area and the series of glacial lakes began, new and lower base levels to the southeast were provided for these streams. By Lake Maumee time the drainage courses had become so altered that all the major streams flowed southeastward as tributaries to the lake. During the lake stages which followed, the valleys of these streams were lengthened at the mouthward end as rapidly as the lake waters lowered and exposed the lake bottom to erosion. As a result of these activities the drainage basins of the present rivers contain portions of the morainal area and of the subsequently formed glacial lake plain of this region.

Into this new terrane of morainal till and the clays, sands, and gravels of the lake plain each river has cut its valley. The unconsolidated materials have made it possible for the rivers to adjust their valleys to changing base levels. Thus, in spite of the relatively short time of each event, a rather complete record of the history is preserved in the terraces of the valleys. This record is of value as a verification or as a contradiction of the history which has been interpreted from the glacial and the glacial-lake features of the area.



MAP 34

PLATE XLIV

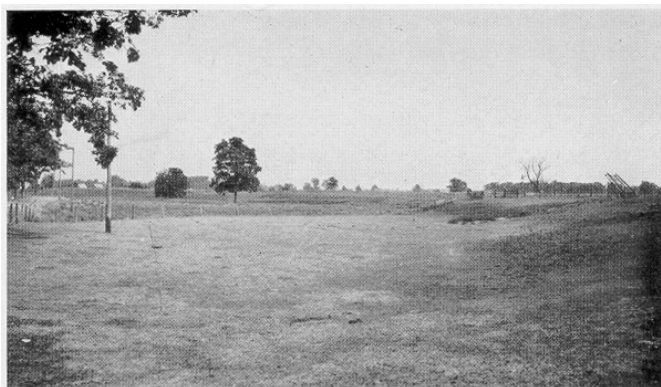


FIG. 1

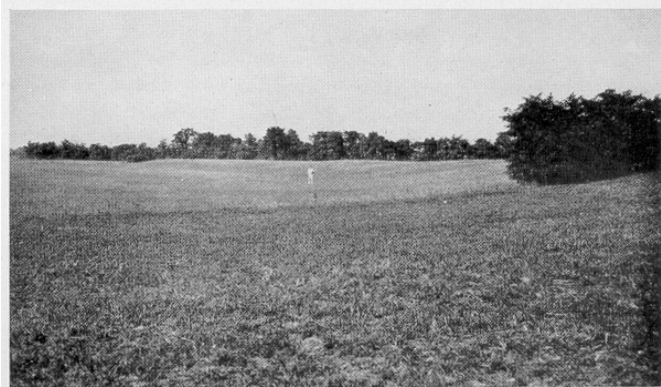


FIG. 2

Views, looking downstream, of terrace of Lake Wayne age cut in delta terrace of Lake Warren age, south side of Huron River valley, one mile west of Belleville (Fig. 1) and two miles west of Belleville (Fig. 2). The back slope of the delta terrace is one half to three quarters of a mile from these locations (see Map 35)

In the valleys of the Huron, Rouge, and Clinton rivers are terraces which mark the flood-plain levels of these streams during the lives of several of the glacial lakes. The most significant of these terraces are found in the Upper Lake Plain section of each stream (Maps 34-37²). The area to be considered here extends about fifty miles along the upper part of the glacial lake plain in a northeast-southwest direction. It is a belt which lies between the moraines at the upper edge of the lake plain and the abandoned shore line of Lake Wayne, which is from six to twelve miles to the southeast. The Huron is the largest and most southerly of the rivers which flow across this belt, and it furnishes the type valley for the study of the terraces.

FEATURES OF THE HURON RIVER VALLEY

Map 35 of the Upper Lake Plain section of the Huron River shows three large terraces which correlate with the lake beaches crossing the valley. Miscellaneous smaller terraces exist downstream from the Wayne shore line, but are not to be considered at present. The oldest of the large terraces extends upstream from and correlates

FEATURES OF THE ROUGE AND CLINTON RIVER VALLEYS

The River Rouge (Map 36) consists of several branches which began as separate streams that extended the mouthward portion of their courses across the lake plain as rapidly as the lake waters left the area. These did not become joined to form one river until Lake Elkton time. The Middle Rouge is the oldest and largest of the branches. The Clinton River (Map 37) is intermediate in size between the Huron and the Middle Rouge.

The maps indicate that there is a terrace of Lake Whittlesey age in the valleys of the Middle Rouge, the Bell Branch of the Rouge in Sections 6 and 7, Livonia Township, and the Clinton. These can be positively identified as being of the same age as the highest of the three Huron River terraces because of their relationship to the Whittlesey beach, which is practically an unbroken ridge over the entire distance. Furthermore, on the Middle Rouge and the Clinton the terrace contains bedded gravels. The absence of a terrace of Lake Whittlesey age on some of the streams suggests that they were too small at that time to adjust themselves to the changing base levels.

A terrace which corresponds to the lowest of the three Huron River terraces is present in the valleys of the Middle Rouge, the Bell Branch of the Rouge in Section 10, Livonia Township, the Upper Rouge, the Main Rouge, and the Clinton. These terraces are recognized by the fact that all of them, including that of the Huron, are at elevations close to 650 feet above sea level and are at or near the front of the large fan-shaped delta which had its origin in Lake Arkona time.

The middle of the series of three terraces is represented in the valleys of the Middle Rouge, the Bell Branch of the Rouge in Section 3, Livonia Township, the Upper Rouge, and the Clinton. These features are considered to be counterparts of the Huron River terrace of Lake Warren age because: (1) by Lake Maumee time the Huron, Rouge, and Clinton were subject to the same lake-shore conditions at their mouths, and therefore the Lake Plain sections of the valleys of each river should show the same number of large terraces; (2) the location is between the Whittlesey beach and the terrace of Lake Wayne age, both of which are easily recognized; and (3) the structure of this feature in the Clinton River valley is the same as that of the Huron. There are no exposures of structure in this terrace on the Rouge.

The relation of the Wayne terrace to the Warren is evident in the valleys of, the streams which have both. The Clinton River furnishes an even more perfect example than the Huron; the terrace of Lake Wayne age extends upstream from Utica as a single unbroken feature one and one-half miles into the Warren. This relationship is also well illustrated in the Middle Rouge valley.

The delta of Lake Arkona age appears on the Rouge River map. On the Clinton River map it is suggested by

with the Whittlesey beach.³ A large portion of the town of Ypsilanti is built on this feature. It consists of bedded gravels, which presumably represent the delta of the Huron River deposited during Lake Whittlesey time in the still waters of an estuary before reaching the lake itself. The estuary had been formed by the Huron River cutting its valley to the low level of Lake Arkona and later becoming drowned when the water rose to the level of Lake Whittlesey. West of Belleville is a large terrace correlating with the Warren shore line,⁴ with upstream remnants cut in the terrace of Lake Whittlesey age. The Warren terrace, like that of Lake Whittlesey age, is a delta terrace and signifies a former lower stage of valley cutting before Lake Warren time. The third terrace begins back of the Wayne beach about two miles south of French Landing and extends upstream through French Landing and Belleville, and portions are cut in the Warren terrace west of Belleville (Pl. XLIV). The identity of the detached remnants of these three large terraces has been established by an extensive series of levels; sea-level elevations were measured along the entire length of each terrace.

Between the Whittlesey beach and that of Lake Wayne the Huron River deposited a large delta of the normal type, which covers an area of over fifty square miles. Most of this is believed to have been built into Lake Arkona. The map indicates that the Arkona, Warren, and Wayne shore lines take an arcuate path around this feature.

REGIONAL HISTORY SUGGESTED

The terraces and the large delta just described suggest the following events in the glacial lake history:

1. A low-water stage in Lake Arkona time existing while the Huron River built a large delta into the lake. The valley of the Huron River was cut to the low-water level of this lake.
2. Rise of the water to the Lake Whittlesey level, which caused the drowning of the Huron River at its mouth and the creation of an estuary in the valley. This was filled by sediments which the river deposited to form the inset delta or delta terrace upstream from the Whittlesey beach.
3. Lowering of the lake to a level at or below the Wayne beach.
4. Rise of the water to the Lake Warren level, which caused the deposition of the second delta terrace in the same manner in which that of Lake Whittlesey age was formed.
5. Lowering of the lake waters to the Lake Wayne level. The river adjusted itself to the new base level and cut the terrace which extends upstream through Belleville and which is cut in the delta terrace of Lake Warren age.

This order of events differs from the accepted history, as determined from the glacial lake shore features, in one important respect. The terraces indicate that Lake Warren was followed by either Lake Wayne or a second stage of Lake Wayne instead of by Lake Grassmere.

the curvature of the shore lines as they approach the valley, but the exact boundaries have not been mapped.

Before proceeding further it should be noted that the correlation of the Whittlesey terrace on the various rivers was based largely upon its relation to a strong beach whose identity could not be mistaken at any point. The Wayne terrace was recognized principally by its elevation. Because of the fragmentary nature of the Arkona and the Warren shore lines and for reasons which will appear in the next section of this paper, neither position with reference to a strong beach nor elevation could be used as a basis for correlating the Warren terrace. Therefore the three points enumerated above were used. This method of correlation brings the terraces of all the rivers into a unified system. In addition, the order of events suggested by the features of the Huron River valley receives the full support of all the facts furnished by the other rivers.

WATER LEVELS OF THE GLACIAL LAKES

It is now possible to examine the record of elevations taken at the most downstream portion of the terraces in order to arrive at a water level for the lakes with which each terrace has been correlated. These elevations should be closer to the actual water levels than any previously determined because the lower sections of the terraces represent the flood plains at the mouths of the rivers tributary to the lakes. In the past, lake levels have been determined largely from crest lines of beaches which have been built up above the levels of the lakes.

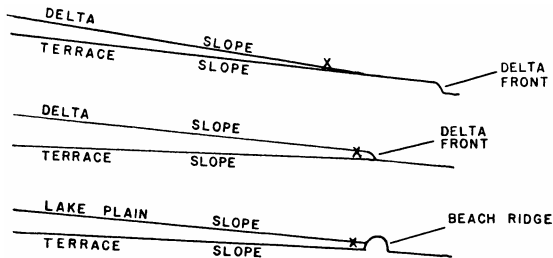


FIG. 11. Typical valley profiles, showing location of former river mouths

Letter x indicates position of river mouth and also water level of lake
 Top: Delta front built into lake below water line
 Center: Delta front at water line
 Bottom: Beach ridge at water line

Table I contains elevations taken at the ancient mouths of the rivers. Most of these elevations are an average of several points on uneroded portions of the terraces at distances so far from the back slope that slope wash has not caused filling. Special care was taken in the field to reach the most downstream portion of each terrace. These points were located by the following method: It was observed that the slope of the lake plain or the lake delta into which each terrace was cut was greater than that of the terrace (Fig. 11). Because of this condition the height of the back slope of the terrace, or the depth to which it was cut in the plain, increases upstream and decreases downstream from any chosen point. An area

for leveling was selected in the field where the terrace merged with the lake plain or where it terminated back of a shore line. These two positions are the old mouths of the rivers, and their elevations should be near the water level of the lake. The elevations of the terraces increase upstream from the abandoned mouths, but are not of interest in determining lake levels.

TABLE I

ELEVATIONS OF TERRACES REPRESENTING FORMER MOUTHS OF SOME RIVERS TRIBUTARY TO LAKES WAYNE, WARREN, AND WHITTLESEY *

Age of Terrace	Huron	Middle Rouge	Bell Branch of Rouge	Upper Rouge	Main Rouge	Clinton
Lake Wayne	650-652	649	.....	647	645	649
Lake Warren	677-679	691	.....	693	...	694
Lake Whittlesey . .	723-725	737-739	735-737	...	...	741

* All elevations are tied to the same sea-level datum except those on the Huron which are subject to a correction of one foot or less. Elevations reported between two limits (thus, 677-679) indicate that there exists a variation to the amount reported.

The table indicates that the water level of Lake Wayne was around 649 feet above the present sea level. This deduction is possible because the terraces seem not to have been disturbed by tilting since their formation.

The levels of Lake Warren and Lake Whittlesey are not so easily determined. The elevations on the terraces of Lake Warren age increase from 677-679 feet above sea level in the Huron River valley to 694 feet at the Clinton River, and most of this is between the Huron and the Middle Rouge. Similarly, the terraces of Lake Whittlesey age increase from 723-725 feet above sea level to 740-741 between the Huron and the Clinton, with the greatest amount of increase again between the Huron and the Middle Rouge. These elevations strongly suggest tilting, with the Whittlesey terraces most affected and the Wayne terraces undisturbed. Before such conclusions can be considered definite, however, studies along the Whittlesey beach are necessary. The crest line of this feature should be a reliable point to which levels can be run because it appears to be about the same height above the lake plain along its entire length. If tilting is displayed by the beaches, the terraces of the Saline and Raisin rivers to the south of the Huron should be mapped in order to determine where the tilting ceases. Should the Huron River prove to be just south of this point, the water level of Lake Whittlesey, to judge from elevations in the Huron River valley, would be about 724 feet above the present sea level, and that of Lake Warren about 677-678 feet.

SUMMARY

The Huron, Rouge, and Clinton rivers have an excellent record of their history preserved in the river terraces and deltas which are associated with these streams in the upper part of the glacial lake plain. These features are of value in studying the history of the glacial lakes that constituted the base levels to which the valleys were cut or filled. According to the method of correlation used here, the main terraces are of three ages: Lake Whittlesey, Lake Warren, and Lake Wayne or a second stage of Lake Wayne. From a study of these features

the following additions or changes in the known glacial lake history of this region are indicated:

1. Lake Wayne or, possibly, a second stage of Lake Wayne followed Lake Warren. It was during the life of this lake that the lowest of the series of three terraces was formed in the river valleys studied.⁵
2. Points along the shore line of this lake are established by the lower extremities of the terraces correlated therewith, because these points represent the mouths of the rivers at that time. These should be an aid in the tracing of the lake boundaries, and the method is applicable wherever fragmentary beaches or tilting exists.
3. The water level of this lake was around 649 feet above the present sea level according to the elevations on the most downstream portions of the terraces.
4. Tilting of the features of Lake Whittlesey and Lake Warren ages, most of which is between the Huron and the Middle Rouge rivers, is suggested by the elevations in Table I. This needs verification from a study of the beaches.
5. Because of this suggested tilting, a determination of water levels for Lake Whittlesey and Lake Warren cannot be definite until a study is made of the terraces of the Saline River and the Raisin River south of the Huron. Water levels of 724 feet above the present sea level for Lake Whittlesey and of 677-678 feet for Lake Warren are temporarily assigned.

WAYNE UNIVERSITY
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¹ The direction of the retreat of the ice in this part of Michigan was southeastward toward the low part of the Erie basin. For a brief discussion of events from the Wisconsin glaciation to the present time see I. C. Russell and Frank Leverett, "Ann Arbor Folio," *Geologic Atlas of the United States*, No. 155: 12-14. 1915.

² The glacial and the glacial-lake features are largely based upon the surface geology maps of the Ann Arbor, Romulus, and Wayne Quadrangles published by the U. S. Geological Survey.

Frank Leverett, of the U. S. Geological Survey, has very kindly consented to the use of certain portions of his manuscript maps of the Pontiac and Rochester Quadrangles and has offered valuable suggestions throughout this study. The writer is indebted to D. U. Gunter, W. G. Moore, and F. E. Stormer for their assistance in the field mapping and leveling work in the valleys of the rivers.

³ The terraces of Lake Whittlesey and Lake Warren ages in the Huron River, valley were first described by Russell and Leverett (*op. cit.*, p. 14), but they stated at the time that "studies of the valley features were not sufficiently detailed to justify the complete mapping of each terrace or its coordination with the lake level to which it corresponds."

⁴ See note 3.

⁵ The lake which immediately preceded Lake Warren has not been determined from a study of the terraces, but the delta terrace of Lake Warren age indicates that it was a low-water stage. Whether this lake was at or below the level of Lake Wayne can be determined by getting elevations at the base of the gravel in the delta terrace and comparing these with that of the Lake Wayne terrace where it is cut in the Warren.

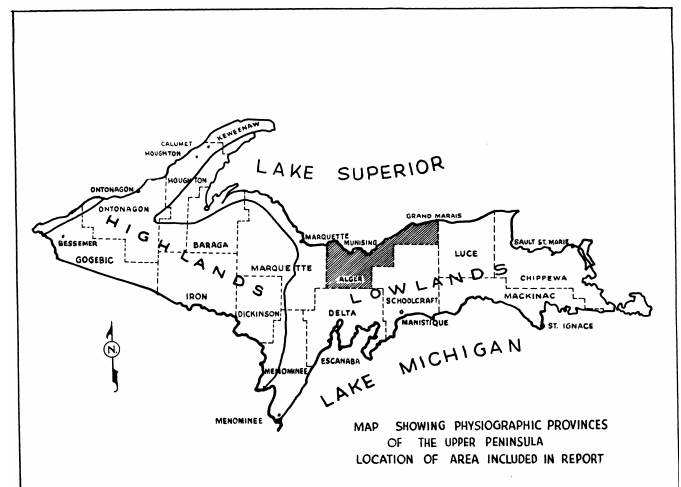
THE CAMBRIAN-OZARKIAN CONTACT IN ALGER COUNTY, MICHIGAN

STANARD G BERGQUIST

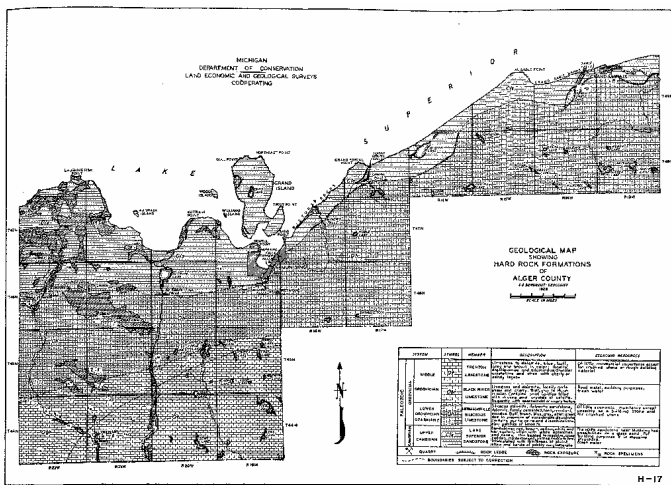
OF THE several counties situated in the Lowlands province in the eastern half of the Northern Peninsula, Alger is outstanding in possessing a wealth of natural scenic resources. This county, comprising an area of approximately 1,000 square miles, has a mainland water front of 83 miles along the south shore of Lake Superior (see Map 38). In this distance, and within a narrow belt extending inland some 8 or 10 miles from the present margin of the lake, numerous waterfalls, steep-walled rock escarpments, and shore cliffs find expression in the landscape.

During the summer of 1928 studies were undertaken of a large number of outcrops and rock exposures in Alger County, in connection with the work of the Land Economic Survey. An effort was made to work out, at least in part, the stratigraphic relationships and to account for the development of the major topographic features, particularly along the rim of the Lake Superior basin. Subsequent trips, together with laboratory studies of numerous rock samples, have made it possible to draw some rather definite conclusions relative to the geology of the area.

The text of this paper is concerned largely with that portion of the county in which the St. Croixan¹ series of the Cambrian system come in contact with the younger Hermansville calcareous formation (Map 39), which in Delta County Ulrich² and Hussey³ have tentatively assigned to the Ozarkian system. In an early report Rominger,⁴ however, classifies this formation, lying between the Cambrian sandstone and the Trenton limestone, as the Calciferosus. The area studied includes rock sections at numerous falls across the county where northward-flowing streams plunge precipitously over an escarpment wall from 50 to 100 feet high as they break into the Lake Superior basin.



MAP 38



MAP 39

Field investigations of the numerous falls in the county seem to bear out the observation that they owe their position in large measure to the presence of a hard, resistant cap rock fairly uniform in structure, but of somewhat variable thickness. Laboratory studies of samples from several sections along the escarpment show that the cap rock ranges in composition from dolomitic sandstone to siliceous dolomite. It rests unconformably upon the more weakly cemented and friable Cambrian sandstone below. The cap rock in the various exposures appears in the field to have somewhat striking physical similarities. Laboratory studies seem to bear this out and to prove without question that the rock composition within the formation is fairly consistent from one locality to another.

In the complete absence of megascopic fossils in the formations of the region it has been necessary to make correlations of the strata chiefly on the basis of lithological and chemical characters. Detailed comparative studies of a relatively large number of rock samples from numerous localities seem to present conclusive evidence that several distinctly different formations are exposed in vertical section along the walls of the escarpment.

The silicocalcareous cap rock is at present confined largely to the area south of the crest of the northward-facing escarpment rim. There is, nevertheless, good evidence to support the view that at an earlier date it covered a much more extensive area, even to the north of the present shore. In the northwest part of Grand Island, Sections 20 and 29, T. 48 N., R. 19 W., one may observe several patches of the cap rock exposed along the crest of the high marginal cliffs (Map 39). These exposures are the highest elevation on the island and appear to have no counterparts in the lower-lying areas. It is evident from these isolated and rather far removed outliers that the so-called Hermansville formation has undergone a great deal of recession by shore-cliff erosion. Much of the early erosional activity which took place in the region was undoubtedly associated with the movement of the Superior ice lobe through the basin in

the Pleistocene epoch, and later still by the shore work of lakes Algonquin and Nipissing.

LAUGHING WHITEFISH FALLS

Laughing Whitefish River (Pl. XLV, Fig. 1), in the western part of the county, plunges over an escarpment to expose a cliff of 90 feet of sandstone in the NE. ¼, NW. ¼, SW. ¼, Sec. 16, T. 46 N., R. 22 W. In this exposure the upper 25 or 30 feet of the sandstone is quite massive in structure, cross-bedded, and grayish, and breaks in a vertical cliff. It is composed essentially of loosely consolidated, clear small grains of subangular and faceted quartz. Below this massive surface ledge the sandstone is thin-bedded and intercalated with laminae of blue shale. Here the slope of the falls becomes less abrupt, but the river has excavated a broad, extensive amphitheater in the formation below the crest of the falls (Pl. XLV, Fig. 2). Numerous water-worn caves have been sculptured in the rock wall some 20 feet below the break of the escarpment at the juncture between the more massive and the thin-bedded sandstones.

The crest of the falls is carved in a friable, easily eroded sandstone, which is being worn back to form a steep-walled gorge. The chemical analysis of a sample of the rock (specimen 34) taken from the upper brink of the falls definitely shows it to be sandstone, with a silica content of 98.97 per cent (see Table I). Lithological studies of the rock samples indicate conclusively that the high percentage of SiO₂ is largely in the form of quartz. The analysis shows a complete absence of calcareous cement.

A study of the surface petrology reveals no cap of hard dolomitic rock at the immediate crest of the falls. As a consequence of sapping the cliff is here retreating quite definitely. In the river bed an eighth of a mile upstream from the lip of the falls, however, may be found the contact between the lower siliceous sandstone and the hard, massive dolomitic sandstone above. The latter is composed of light to dark gray, translucent grains of quartz, cemented in a matrix of firm dolomite in which are also found partly rounded grains of calcareous minerals. The chemical analysis of the sample (specimen 31) shows the silica content reduced to 50.90 per cent. The oxides of calcium and magnesium and the carbon dioxide together make up a total of 49.32 per cent of the composition, thus evidencing a high degree of dolomitization (see Table I).

The Hermansville cap rock in this locality is relatively thin and is being worn back rather rapidly by the swift-flowing waters in the stream above the falls. At one time, in the earlier development of the escarpment, the resistant layer covered the Cambrian sandstone in this area entirely, as may be judged from its mantle occurrence outside of the channel. It must have exerted an important influence in erosional control during the youthful history of the falls.

TABLE 1
SUMMARY OF ROCK ANALYSES

Rock sample	Locality	Position	SiO ₂	Al ₂ O ₃	Fe ₂ O ₃	CaO	Na ₂ O	K ₂ O	MgO	TiO ₂	P ₂ O ₅	CO ₂	SO ₂	Mn ₂ O ₃	R ₂ O ₃	Moist.
31	Laughing Whitefish Falls	Cap rock crest of falls	50.98	None	1.21	15.76	None	None	10.38	Trace	0.21	23.30	Trace	0.18	.....	.....
34			98.70	0.03	0.35	0.80	None	None	0.30	Trace	0.35	None	None	0.01	.....	.....
35	Rock River escarpment	Cap rock - 35 feet	62.13	0.22	1.86	11.58	None	0.92	4.35	0.15	0.30	9.88	Trace	0.13	.....	.....
37			98.15	0.20	0.16	0.50	0.28	None	0.30	Trace	0.20	None	None	0.19	.....	.....
60 (A. T.)	Au Train Falls, upper	Cap rock - 90 feet	33.92	4.90	0.72	10.05	0.24	0.31	13.05	0.02	0.15	29.79	Trace	0.12	.....	.....
11(A. T.)	Au Train Falls, lower	Cap rock - 90 feet	30.65	1.13	1.81	20.35	0.78	0.21	13.62	Trace	0.08	32.10	Trace	0.20	0.21	.....
1 (W. F.)	Wagner Falls	Cap rock - 36 feet	53.52	2.95	2.25	15.75	0.46	1.64	10.78	Trace	Trace	21.40	None	0.24	.....	.....
48 (W. F.)			98.70	None	0.37	0.99	0.27	0.09	None	0.02	0.03	None	None	0.01	.....	.....
48	Tannery Falls	Cap rock	60.68	Trace	1.23	11.05	0.07	0.20	10.18	None	0.27	17.10	None	0.21	.....	.....
69	Munising Falls	Cap rock - 16 feet	61.11	0.60	0.63	11.07	0.27	0.40	7.07	0.04	None	16.40	None	0.13	.....	.....
62	Miner's Falls	Cap rock - 18 feet	86.00	1.87	1.53	18.45	0.27	0.09	11.70	0.13	0.13	30.80	Trace	1.00	0.21	.....
63			90.20	5.48	0.13	0.57	0.46	1.84	0.60	0.02	0.18	None	1.00	0.01	.....	.....
59	Miner's Castle	Cap rock	79.80	12.70	1.28	0.32	2.30	2.40	0.78	0.24	0.18	None	0.55	Trace	.....	.....
C. F. a	Chapel Falls	Cap rock - 15 feet	40.59	0.13	1.61	18.21	0.07	0.15	12.40	Trace	0.05	26.59	0.58	0.29	1.79	0.10
C. F. b			56.82	0.53	0.20	0.04	0.06	0.19	0.28	Trace	0.01	0.006	0.02	Trace	0.74	0.11
56a	Sable Falls	Brink Shore cliff	85.38	None	0.75	2.55	0.42	1.85	2.18	0.07	0.30	3.00	Trace	None	.....	.....
57			50.61	None	2.20	14.00	0.09	None	10.03	0.02	0.30	23.00	Trace	0.27	.....	.....
53	South of Grand Marais	Shore scarp cap	50.16	None	0.30	15.21	None	0.17	2.73	0.63	0.15	21.30	None	0.06	.....	.....
58	Chipmunk Falls	Below cap rock	92.57	1.07	0.64	3.31	None	0.60	2.16	0.05	0.20	None	None	0.01	.....	.....

pyrite are disseminated through the rock section, as has been noted in a previous paper.⁶

At the base of the lower falls, or Power Falls (Pl. XLVI, Fig. 2), directly above the contact with the Cambrian sandstone, the rock is light brown and somewhat weather-banded. It is more friable and less resistant than that which forms the crest of the upper falls. Disseminated pyrite has in part been oxidized into limonite, which is present as a brownish stain throughout the rock mass. The analysis (specimen 1 A. T.) is essentially the same as that for the sample from the upper section (see Table I).

The escarpment at Au Train Falls presents the thickest exposure of Hermansville formation to be observed in the county. The base of the dolomite rests directly upon a brownish, ferruginous sandstone composed essentially of rounded to subangular grains of loosely cemented quartz, the Cambrian, through which the lower gorge has been excavated. As the river leaves the gorge it follows a broadly meandering course across the Nipissing sand plain before finally entering Lake Superior, near Au Train.

In an early report of the Michigan Geological Survey Rominger⁵ described more or less completely the various layers of the Cambrian sandstone in the area of Laughing Whitefish River and Falls. In his report the siliceous sandstone is classed as the Potsdam formation.

ROCK RIVER ESCARPMENT

The escarpment wall which constitutes the south slope of the South Branch of Rock River, in the SW. ¼, NW. ¼, Sec. 17, T. 46 N., R. 21 W., is capped with a hard, resistant dolomitic sandstone which measures 35 feet in thickness. This extremely fine textured rock is composed of minute subangular grains of quartz firmly cemented into a matrix of dense, compact dolomite. It is grayish, with local brown streaks and stains due to the presence of small amounts of weathered iron oxide. It contains 62.13 per cent of SiO₂, mostly in the form of quartz, in addition to appreciable amounts of lime, magnesia, and carbon dioxide (specimen 35; see Table I). The dolomitic sandstone rests directly upon a light-colored siliceous sandstone, which is composed essentially of loosely cemented subangular grains of quartz. The underlying rock is nonresistant and friable and has been extensively undercut by river action. The analysis shows this rock (specimen 37) to be extremely siliceous and to contain no calcareous cement (see Table I).

AU TRAIN FALLS

Au Train Falls (Pl. XLVI, Fig. 1), on Au Train River in the NW. ¼, SE. ¼, Sec. 31, T. 46 N., R. 20 W., exposes a section of siliceous dolomite with an aggregate thickness of approximately 100 feet, as measured from the crest of the upper falls to the base of the lower falls. In this locality the river descends over two abrupt breaks, which are separated by a rather strong cataract. The rock slope of the two falls is steplike in character, owing to differential erosion on the alternate thin beds of dolomite and shale in the formation. Specimen 60 A. T., taken from the crest of the upper falls, has an analysis which characterizes it as siliceous dolomite (see Table I). This rock is more highly dolomitic and contains less silica than the cap rock which is exposed in the river channel above Laughing Whitefish Falls. Much glauconite and

WAGNER FALLS

The section at Wagner Falls (Pl. XLVII, Fig. 1) on Wagner Creek, in the NW. ¼, NE. ¼, Sec. 14, T. 46 N., R. 19 W., exposes 36 feet of upper cap rock varying in composition from siliceous dolomite to dolomitic sandstone. The rock is grayish, hard, and resistant, and contains an abundance of glauconite and some pyritic disseminations. It is composed of subangular grains of quartz firmly cemented in a ground mass of dolomite (see Table I, specimen 1 W. F.). At a depth of 36 feet below the crest of the falls the rock changes abruptly into a sandstone, composed essentially of loosely cemented grains of quartz. The chemical analysis of a sample of this rock (specimen 48 W. F.) shows that it contains 98.70 per cent of silica, with no calcareous cementing material (see Table I). The upper 36 feet of siliceous dolomite which forms the resistant crest rock of Wagner Falls is unquestionably Hermansville of Ozarkian age; the underlying loosely consolidated sandstone belongs to the St. Croixan series of the Cambrian.

TANNERY FALLS

The crest of Tannery Falls (Pl. XLVIII, Fig. 1), near Munising, in the SE. ¼, NW. ¼, Sec. 1, T. 46 N., R. 19 W., exposes a buff-colored, dolomitic sandstone made up largely of subangular grains of quartz embedded in a matrix of dense, firm dolomite. The rock is hard and resistant and forms a section about 12 feet thick, resting directly upon a weak, loosely cemented, and easily weathered sandstone. A steep amphitheater-like gorge has been sculptured in the sandstone for a considerable distance below the falls, and undercutting is still in progress in the weaker formation which underlies the cap rock (Pl. XLVIII, Fig. 2). A sample of the rock (specimen 48), taken from the upper portion of the 12-

foot cap, was found by chemical analysis to contain 60.68 per cent of SiO₂, 11.95 per cent of CaO, 10.18 per cent MgO, and 17.10 per cent CO₂, making it definitely a dolomitic sandstone (see Table I). Although no samples of the lower rock were analyzed chemically, petrologic examination indicated a predominance of quartz, with little or no trace of calcareous substance in the cement. The large amount of gorging which has taken place in this area was probably due to more rapid stream erosion as related to the thinness of the dolomitic cover.

MUNISING FALLS

Munising Falls (Pl. XLVII, Fig. 2), in the NE. ¼, SW. ¼, SE. ¼, Sec. 36, T. 47 N., R. 19 W., owes its existence to a hard, resistant cap rock of dolomitic sandstone which is 15 feet thick. The rock consists of light to dark gray subangular and rounded grains of quartz firmly cemented in a matrix of dolomite. It contains 64.11 per cent of silica and appreciable amounts of calcium and magnesium oxides, as well as carbon dioxide (see Table I). At a depth of 15 feet below the surface the rock breaks into a light brown rather weak sandstone, which has been extensively undercut. This part of the section resembles greatly the lower sandstone which is exposed in the Tannery gorge. The composition (specimen 69) is largely silica, with but very small amounts of lime, magnesia, and carbon dioxide (see Table I). The contact between the upper or Hermansville and the lower or Cambrian formations is distinctly marked at a depth of 15 feet below the crest of the falls, where it may be traced with comparative ease along the ledges of the gorge. Here again, as at Tannery Falls, the surface-resistant layer overhangs the lower undermined weaker sandstone. Numerous potholes, churned out deeply in the sandstone floor at the base of the falls, are expressions of the weak character of that rock.

MINER'S FALLS

A vertical section approximately 100 feet thick is exposed in the falls on Miner's River (Pl. XLIX, Fig. 1), in the SE. ¼, NE. ¼, NE. ¼, Sec. 15, T. 47 N., R. 18 W. The mantle rock at the falls is a firm, resistant, siliceous dolomite and forms a layer 18 feet thick capping the sandstone. It is light to dark gray, fine in texture, and is composed of rounded grains of translucent quartz firmly embedded in a matrix of dolomite cement. It is pitted with small weather pockets and solution cavities, some of which are lined with minute crystals of calcite. Glauconite is disseminated through the basal portion of the dolomite, where it is in contact with the subjacent sandstone, but it constitutes a very small proportion of the rock. The uppermost layer of rock in this area, as represented by an average sample (specimen 62), has a composition which is not much unlike that of the corresponding formation at Au Train Falls (see Table I). The Cambrian sandstone, which directly underlies the dolomite cap, is grayish, weak in structure, and easily eroded. It is composed essentially of very fine grains of subangular quartz set into a siliceous and more or less

argillaceous cement. The sandstone of this section contains a slightly lower percentage of silica, but a relatively higher content of alumina than do the samples of the same horizon in other areas along the escarpment (specimen 63; see Table I).

THE PICTURED ROCKS

One of the most imposing geologic features within the county is that which is known as the Pictured Rocks (Pl. L, Fig. 1).⁷ These formations extend more or less continuously from a point in the SE. ¼, Sec. 17, T. 47 N., R. 18 W., directly east of Munising, eastward for a distance of approximately 13 miles, to the SE. ¼, Sec. 12, T. 48 N., R. 17 W., near Beaver Lake (see Map 39). The rocks rise out of Lake Superior as a range of bold mural cliffs, with sheer walls from 100 to 150 or more feet high. They are sculptured in the St. Croixan formation, which in this area assumes a variety of bright colors and brilliant hues. The dominant shades are red and brown, interspersed with tints of yellow and green. Distributed through the rock are numerous white circular blotches and occasional bleached-out lenses in which the ferruginous coloring matter has been removed. These lighter areas in the variegated and mottled sandstone may have been produced by the bleaching action of hydrogen sulphide, which was generated from included decaying organic matter, sulphate-reducing bacteria, or sulphide waters, according to the theory proposed by Keller,⁸ who states that "the solution of the ferrous iron must take place after reduction, by water and subsequent solutions affected by carbonate waters."

The sandstone of the Pictured Rocks varies in structure from a thin-bedded, cross-laminated, fine-textured variety to a massive, somewhat coarser but, nevertheless, weakly cemented and friable type. Occasional lenses of quartz conglomerate and thin layers of bluish shale are locally intercalated. At the edge of Lake Superior numerous caves have been undercut into the rock cliffs by wave action. The sandstone is divided by vertical joints into a series of close-fitting blocks. In the process of sapping along the joint openings, large sections of rock have been dislodged from the cliffs and heaped along the base of the bluffs, to be churned up by the ever-pounding surf. The cliffs are gradually being cut back in an echelon pattern, but continue to maintain a vertical face in spite of recession. In the districts where the rock wall flanks the water's edge the sandstone has been largely stripped of its former cap rock of resistant dolomitic Hermansville formation, and erosion is gradually reducing the surface relief. The mantle rock can invariably be traced to the higher terraces a short distance back from the cliff face, where it affords a protective surface against excessive wear. Small residual outliers of the original cap have been preserved in the more sheltered areas along the shore, but are usually so small in extent as to be of little or no consequence in the present conditioning of the ledges.

The turrets of Miner's Castle (Pl. L, Fig. 2), which is in the SW. ¼, Sec. 3, T. 47 N., R. 18 W., seem to rise above a beveled promontory which owes its development to the resistant nature of the rock mantle. The "Castle" itself is composed of material which is entirely unlike that of the sandstone in the main façade. It occupies a position which is considerably lower than the average level of the adjacent cliffs and seems to be set into an embayment or reëntrant in the older Cambrian rock mass. The rock in the turrets is tan to gray, and is composed of small rounded grains of quartz set solidly in a matrix of argillaceous cement. It has the appearance of being somewhat oolitic in structure and is resistant to weathering, as may be judged by the erosional remnants. Analysis of the rock (specimen 59) from the turrets shows it to contain 79.8 per cent silica, 12.70 per cent alumina, and but a small trace of calcium and magnesium oxides (see Table I). It will be noted from the analysis that the rock is a highly aluminous, argillaceous sandstone, quite different in composition from the average Cambrian sandstone in the area. On the other hand, it does not contain the calcareous cement which is characteristic of the Hermansville in the various exposures.

Slightly beyond the Grand Portal, and within three miles of the east end of the high cliff section of the Pictured Rocks, stand several water-carved monuments, commonly known as Pulpit Rock and the Chapel. The Chapel is sculptured out of the Cambrian sandstone at a height of 30 or 40 feet above the level of the lake, and was formed at a time when the lake level was higher than at present, probably during the later Algonquin and Nipissing stages. It has an arched roof of sandstone, some 20 feet in thickness, which is supported on four massive columns of rock. From the lakeside the structure presents the appearance of a natural rock-hewn chapel,

CHAPEL FALLS

At the south end of Chapel Lake, in Section 28, T. 48 N., R. 17 W., Chapel Creek breaks over the escarpment rim and plunges in a series of cascades across the Cambrian sandstone into the lake (Pl. LI). The outlet from the lake spills over a succession of low, gently sloping ledges of sandstone and discharges with a slight fall into Lake Superior, just to the west of the Chapel. The position of the upper falls on the escarpment is here, as in the other falls described, under control of the Hermansville cap rock. This formation, however, has been worn back in the river channel for a short distance upstream from the crest of the falls.

The analysis of the sandstone is almost identical with that of the similar formation at Laughing Whitefish Falls, whereas the cap rock approximates in composition that of the corresponding horizon at Wagner Falls (see Table I).

The "Rocks" continue, with gradually diminishing height beyond Grand Portal, for a distance of about 3 miles to

the eastward. At that point they disappear into the sandy, dune-covered lake plain of the Beaver Lake basin. They are conspicuously absent along the shore for a distance of 12 miles beyond, but reappear at Au Sable Point, on the west end of Grand Sable Banks. Here they form a line of relatively low, undercut cliffs, which may be traced for a half mile or more along the shore near the lighthouse.

SABLE FALLS

Sable Creek, the outlet of Grand Sable Lake in the vicinity just west of Grand Marais, plunges over a 75-foot rock escarpment (Pl. XLIX, Fig. 2) before it reaches Lake Superior in Section 2, T. 49 N., R. 14 W. This feature is characterized by a series of cascades which have developed in a section of alternately hard and soft layers in the Cambrian sandstone. Thin beds of soft blue shale and hard pebbly conglomerate are intercalated with the sandstone and contribute to the cascade-like development of the falls.

The rock which forms the crest of Sable Falls is a slightly calcareous, cross-bedded sandstone composed of rounded grains of quartz with a silica content of almost 86 per cent. The formation is brownish, thin-bedded, and friable, and seems to be very susceptible to erosion. Analysis of specimen 56a, taken from the ledge at the brink of the falls, shows a relatively small proportion of calcium, magnesium oxides, and carbon dioxide (see Table I). The relatively high percentage of silica contained in the rock, together with its lithologic characters, seems to preclude its falling into the Hermansville formation. In physical characteristics and features it is related more closely to the Cambrian sandstone. No hard cap rock of siliceous dolomite is present at the immediate crest of the falls, since excessive erosion has caused its retreat upstream. The Hermansville forms the ridge of the Lower and Middle Algonquin shore scarps to the south of the falls, where it is exposed in the cut at the highway crossing in the SW. ¼, SW. ¼, Sec. 1, T. 49 N., R. 14 W.

In this locality the exposed rock is a grayish, firm, resistant, siliceous dolomite, composed essentially of small rounded quartz grains with interspersed pebbles up to one-half inch in diameter. In the outcrops and cliff exposures the rock is severely pitted and seems to have undergone rather effective differential weathering. The composition is radically different from that of the rock which constitutes the crest of the Sable Falls, as may be inferred from the analysis (specimen 57; see Table I). The composition as indicated in the analysis corresponds within very close limits to that which is given for the Hermansville cap rock one eighth of a mile above the crest of Laughing Whitefish Falls, approximately 54 miles to the south and westward.

SHORE ESCARPMENT SOUTH OF GRAND MARAIS

A steep rock escarpment representing the Nipissing shore cliff parallels the highway along the south shore of West Bay near Grand Marais. The rock in the crest of this scarp is exposed along the road about a mile south of the West Bay shore in the center of Section 8, T. 49 N., R. 13 W., and grades from a siliceous dolomite to a dolomitic sandstone. It is light gray, firm and resistant, and fine in texture. It is composed of small spherical to subangular grains of quartz embedded in a matrix cement of dense dolomite. A sample (specimen 53) taken from the highest terrace in the cliff gives by analysis 50.16 per cent of silica and 49.17 per cent of calcium and magnesium oxides and carbon dioxide. Less than a mile north of the crest of the escarpment, or a few hundred rods south of the shore of West Bay, in the NW. ¼, SW. ¼, Sec. 5, T. 49 N., R. 13 W., Chipmunk Creek, flowing a very thin ribbon of water, breaks over the rock ledge to expose a fairly thick section of sandstone. The rock in this formation is grayish, fine in texture, and loose in structure. It is highly siliceous but weakly cemented; hence it is not especially resistant (specimen 58; see Table I). The stratigraphic position of the sandstone here suggests a strong relationship to the Cambrian formation. The contact with the overlying Hermansville dolomite may be observed upslope toward the crest of the escarpment merely a few rods to the south.

The outcrop of Cambrian sandstone in the shore cliff which marks the location of Chipmunk Falls is the most easterly exposure of the formation in Alger County. No evidence of rock ledges is found along the shore of Lake Superior in Luce County to the east. The falls of the Tahquamenon River, 38 miles to the east in Luce and Chippewa counties, reveal the next nearest exposure of Cambrian sandstone of any consequence. These falls have been described in a previous paper involving the glacial geology of Luce County.⁹

SUMMARY AND CONCLUSIONS

The numerous geologic features, expressed in the form of falls and rock cliffs along the south shore of Lake Superior in Alger County, are intimately associated with the stratigraphic relationships which exist between the Cambrian sandstone and the Hermansville siliceous dolomite. The sandstone, which is of Cambrian origin, is in the main highly siliceous and consists essentially of subangular to rounded grains of weakly cemented quartz. It is friable and extensively jointed and, consequently, is readily influenced by weathering activities. The Hermansville formation, which forms an unconformable mantle over the sandstone, is younger and undoubtedly belongs to the Ozarkian. It is a firm, relatively hard rock, composed largely of rounded to subangular, frosted grains of quartz embedded in a matrix of dolomitic cement. It is resistant to erosion and has played an important role in the geologic

development of the escarpment rim which borders the south shore of Lake Superior in Alger County.

Previous to the invasion of Pleistocene glaciation in the Superior basin, the Hermansville formation apparently covered a much more extensive area than at present. This is shown by the presence on Grand Island of isolated outliers which have been preserved from erosional activity. When the Superior lobe advanced through the Superior basin it plowed its way through the then exposed Hermansville formation and gouged deeply into the underlying Cambrian sandstone. Upon retirement of the ice sheet the basin became occupied with waters which in the early development, through the Algonquin and Nipissing stages, stood at decidedly higher levels than does the modern lake.

During the stages of higher lake levels the water in the basin pounded with tremendous force against the face of the rock cliffs. The soft, friable Cambrian sandstone was effectually undercut by wave activity to develop overhanging ledges in the more resistant Hermansville dolomite. The projecting rock cornices were thus left unsupported, and through the influence of penetrating joints were dropped, block by block, to the base of the cliff, where further erosion reduced them to transportable debris. In this manner the cliffs were forced in many places to retreat landward, but the rate of recession was controlled largely by the cover of resistant rock.

When the water level in the Superior basin was depressed as a consequence of the opening up of new and lower outlets, the present lake stage was initiated. The waters retreated from the older shores and in places left the rock cliffs somewhat removed from wave action. At present, except where the cliffs flank the immediate shore, as in the Pictured Rocks section, east of Munising, erosional activity is being accomplished mainly by north-flowing streams and rivers which head in the higher upland areas of the interior. Cliff recession, as linked with modern stream work, is quite localized, and the effects produced are small as compared with the wave work accomplished during Algonquin and Nipissing times. Future recession, if dependent upon stream work and surface erosion alone, will eventually result in the development of deep, narrow gorges in the channels where the falls are slowly retreating upstream.

The chemical analyses of the rocks as listed in Table I of this report were prepared in 1930 and 1931 by O. B. Winter, R. J. Davis, Miss F. Lamb, and Miss L. I. Butler, of the Michigan State College Chemistry Experiment Station.

MICHIGAN STATE COLLEGE
EAST LANSING, MICHIGAN

¹ E. O. Ulrich seems to have good evidence to support the view that the St. Croixan formation of the Wisconsin area extends into the Superior region of Alger County. The so-called Lake Superior sandstone would thus be included as a member of the formation. Personal communication, 1935.

² E. O. Ulrich, personal communications, 1930 and 1935.

³ R. C. Hussey, personal communication, 1930.

⁴ Rominger, C., "Palaeozoic Rocks [of the Upper Peninsula of Michigan]," Part III of *Rep. Geol Surv. Mich.*, 1: 71-79. 1869-73.

⁵ *Op. cit.*, pp. 88-90.

⁶ Bergquist, S. G., "The Occurrence of Glauconite in the Hermansville Formation of Alger County, Michigan," *Pap. Mich. Acad. Sci., Arts and Letters*, 12 (1929): 231-237. 1930.

⁷ A vivid description of the Pictured Rocks, with illustrations, is contained in one of the early volumes dealing with the geology of the state, by J. W. Foster and J. E. Whitney, *U. S. Senate Report of the Lake Superior Land District: Part II, The Iron Region together with the General Geology*, pp. 124-131. 1851.

⁸ Keller, W. D., "Red Bed Bleaching," *Am. Journ. Sci.*, 18: 65-70. 1929.

⁹ Bergquist, S. G., "Surface Geology of Luce County, Michigan," *Pap. Mich. Acad. Sci., Arts and Letters*, 14 (1930): 438-444. 1931.

PLATE XLV

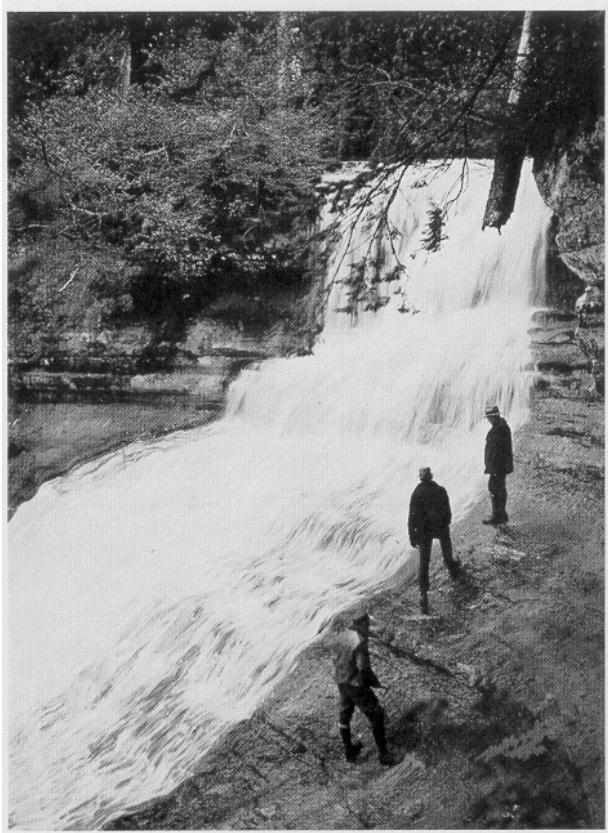


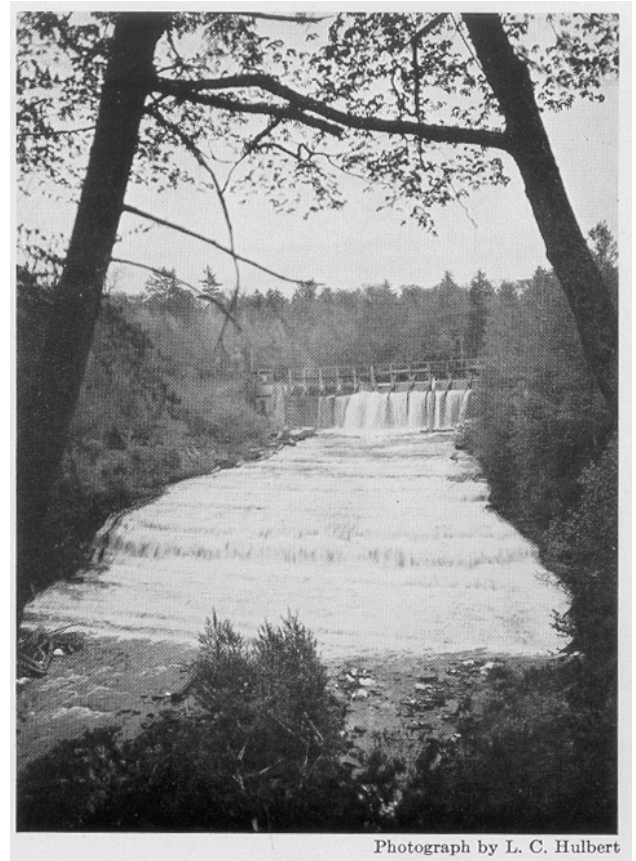
FIG. 1



Photographs by L. C. Hulbert

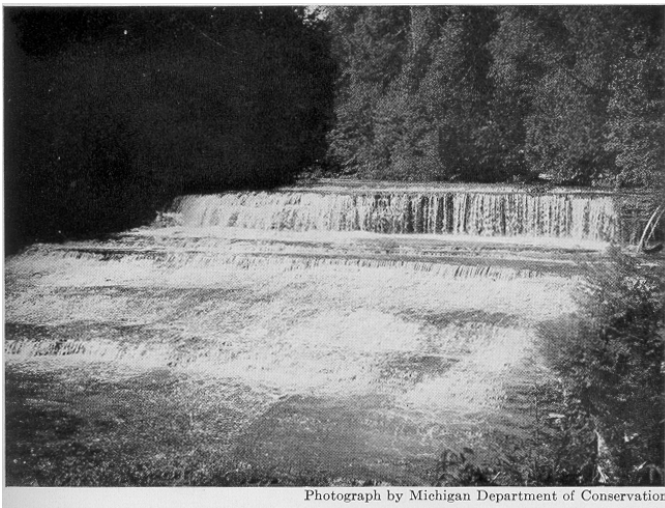
FIG. 2
Laughing Whitefish Falls

PLATE XLVI



Photograph by L. C. Hulbert

FIG. 1. Upper Au Train Falls



Photograph by Michigan Department of Conservation

FIG. 2. Lower Au Train Falls
PLATE XLVII



Photographs by L. C. Hulbert

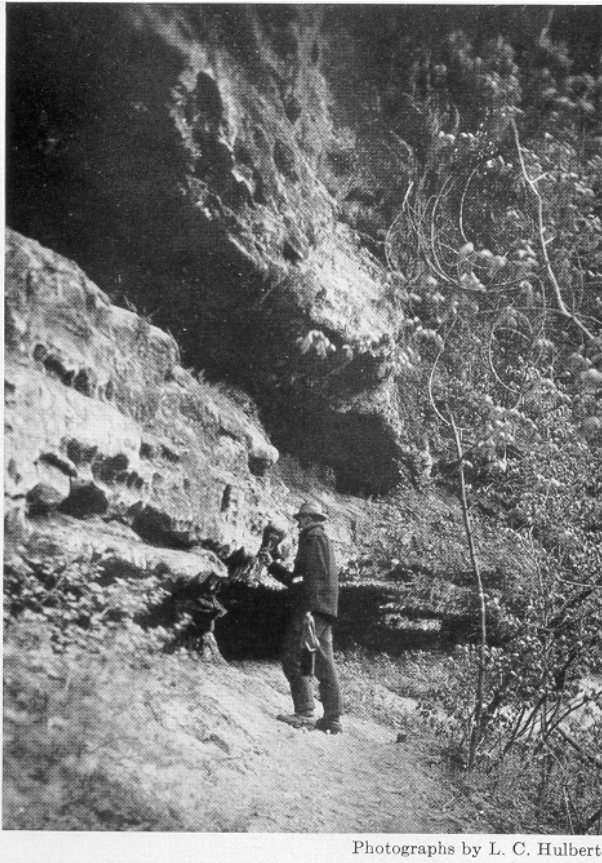
FIG. 2. Munising Falls
PLATE XLVIII



FIG. 1. Wagner Falls



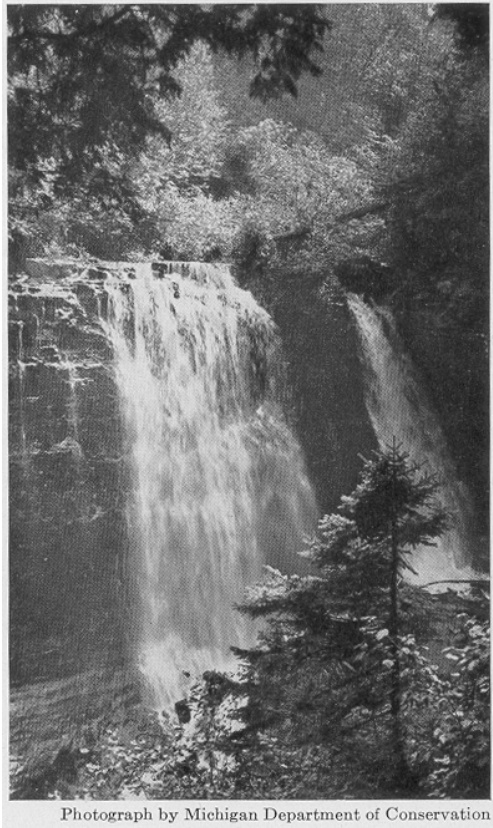
FIG. 1. Tannery Falls



Photographs by L. C. Hulbert

FIG. 2. Base of Tannery Falls (undermined sandstone)

PLATE XLIX



Photograph by Michigan Department of Conservation

FIG. 1. Miner's Falls



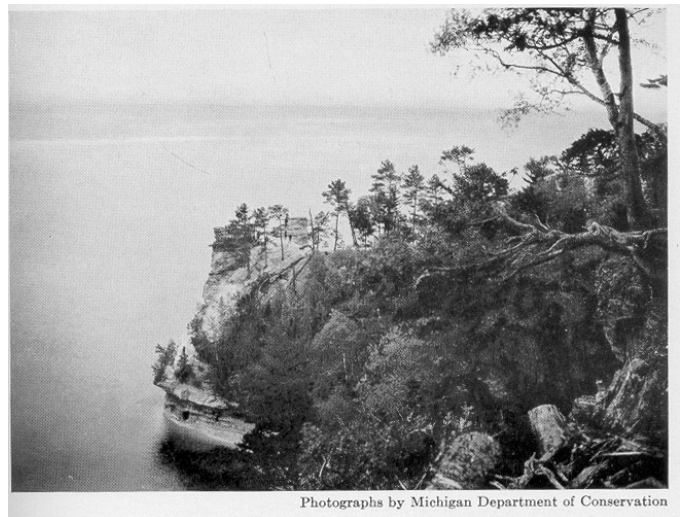
Photograph by L. C. Hulbert

FIG. 2. Sable Falls

PLATE L



FIG. 1. Façade of Pictured Rocks



Photographs by Michigan Department of Conservation

FIG. 2. Miner's Castle (view from land)



Photograph by S. G. Bergquist

Chapel Falls

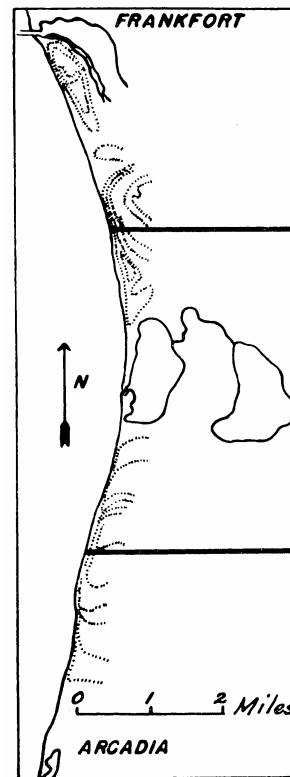
DUNES OF THE HERRING LAKE EMBAYMENT, MICHIGAN

IRVING D. SCOTT AND KENNETH W. DOW

THE Herring Lake embayment is situated in the western portion of Benzie County, Michigan, approximately six miles south of Frankfort and an equal distance north of the town of Arcadia (Map 40). The depression lies within a prominent U-shaped spur of the Manistee Moraine, which was formed probably during the closing stages of Lake Warren. The spur is open to the west, and the end extends to the shore of Lake Michigan to form steep bluffs 300 feet or more in height.¹ The embayment is occupied by two lakes of moderate size; that farthest east, at an elevation of about 13 feet above Lake Michigan, is known as Upper Herring Lake. This lake drains through Heron Creek into Lower Herring Lake to the west, which, being connected by a short outlet, stands at the same level as Lake Michigan. The purpose of this paper is to trace the geologic history of the depression from its inception to the present time, as evidenced by the physiographic forms now existing in

the area. The hinge line, or zero isobase, of the Algonquin beaches runs just to the north of the depression, which, therefore, lies within the area of horizontality.

These studies, carried out during the summers of 1934 and 1935, are illustrated by sketch maps of the dune area made by the junior author. Merely the outlines of the ridges have been shown, which must not be mistaken for contour lines, since the charts are intended solely to show the various forms, with their relative sizes and position. They should not be regarded as accurately scaled maps of the area, but they are believed to be more representative than the incomplete and inaccurate maps available, with the single exception of the United States Lake Survey Coast Chart No. 9, corrected to 1900, which, however, does not include the entire dune area. For convenience in reference, numerals have been assigned to locations of particular importance, ridges, dunes, etc.



MAP 40. General map showing location of the Herring Lake embayment

Inasmuch as the moraine which surrounds the Herring Lake depression is of Warren age, as already stated, the embayment must have been filled by a tongue from the ice lobe which occupied this part of the Michigan basin during the Warren-Chicago stage of the Glacial Great Lakes.

Subsequent melting completely freed the Michigan basin of ice and initiated the Kirkfield stage of Lake Algonquin, the level of which was considerably below that of the present Lake Michigan (possibly fifty to sixty feet).² Because the depth of the Herring Lake depression is relatively shallow, it is believed to have been dry at this

stage. Uplift of the Kirkfield Outlet raised the waters to the three-outlet or main Algonquin stage, twenty-five feet above present Lake Michigan.

With the uncovering of the North Bay Outlet the waters receded to the early stage of Lake Nipissing, which was likewise below the present lake level. At this time the Herring embayment was dry, except for the area occupied by Upper Herring Lake. The uplift of the North Bay Outlet caused a repetition of the Algonquin conditions and resulted in a rise in the level of the Nipissing lakes to the Port Huron Outlet, which at that time was fifteen feet above the Lake Michigan level. Therefore, the embayment was again flooded.

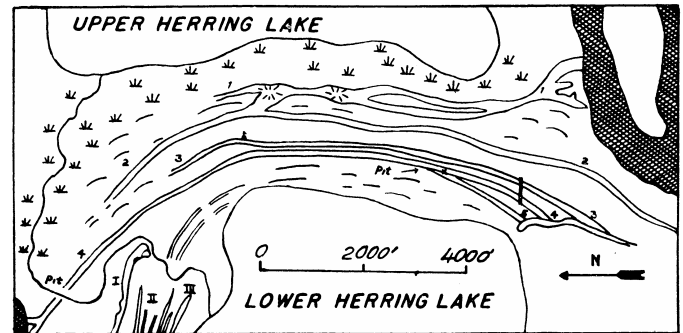
Since Nipissing time the outlet at Port Huron has been cut down fifteen feet, with one possible halt at the Algoma stage. Under present conditions there has been a more or less periodic fluctuation in level amounting to more than five feet.³ Thus we note four distinct periods or levels (late Algonquin, late Nipissing, Algoma, and present) at which shore adjustments could have been formed and preserved.

In this resume it is pointed out that, during the later stages of Lake Algonquin, the Herring Lake embayment consisted of a rather long depression between the moraines, with a broad opening into the large lake, and was flooded. Therefore, one would expect to find evidences of an Algonquin level along the eastern and adjacent shores of present Upper Herring Lake. However, no shore features could be definitely recognized at the locations where this level should exist. The lake is practically surrounded by the moraine, which presents a very uneven front, with numerous indentations and low spurs running out almost to the lake. Evidences of shore activity on the morainic border during Algonquin time could easily have been destroyed in the building of the road which runs around the lake along the edge of the moraine.

It is possible that the main road in front of the W. D. Salsgiver resort on the north side of the lake is located on an Algonquin shore inasmuch as it stands about eleven feet above Upper Herring Lake. This would be approximately correct for the Algonquin level, since the present level of Upper Herring Lake is about thirteen feet above that of Lower Herring. Farther along, to the northeast, the road runs very close to the lake on top of the moraine, a spur of which juts out at this point and has been truncated by the waves. Along the exposed face of the morainic bluff is a poorly developed bench about ten feet above the Upper Herring Lake level, which, again, may represent the Algonquin level. From these meager shore features it seems evident that the wave activity in the bay head was very slight during this time.

To the west, separating Upper from Lower Herring Lake, is a rather wide strip of ground consisting of an interesting series of ridges separated by shallow troughs (Map 41). These features are roughly parallel and are oriented in a general north-south direction. They are all

curved, with their concave sides toward the west, indicating activity from the main lake. With the exception of the easternmost these ridges have smooth, gentle slopes and are composed of coarse, well-rounded fragments.



MAP 41. Series of mid-bay bars between Upper and Lower Herring lakes

The first, or easternmost, ridge starts from the moraine to the south and continues in a northerly direction about halfway across the depression before it dies out. Although there are many variations in height, it is a well-defined ridge throughout its extent; it drops away sharply to the low swampy area at the east. To the south it is low and branches to join the moraine. Continuing north these forks or branches merge into one ridge, then divide into two ridges with a low swale between, and eventually merge again. It is composed of sandy material to a depth of at least four feet. The average elevation is eleven feet above Upper Herring Lake, which would place it at about twenty-four feet above Lake Michigan. The crest of the ridge is uneven and in two places rises to twice its usual height. These elevations have steep slopes to the east, approaching the angle of repose. This ridge is interpreted to have been a first unsuccessful attempt at the formation of a mid-bay bar from the south side of the indentation. Its irregularities of contour and surface are due to subsequent modification by wind action, although it is possible that the two highest points may have been islands.

Bar 2 is longer and slightly lower than the sandy ridge first described. It starts as a low ridge farther to the southwest and becomes higher and better defined to the north, where it intersects and merges with an offshoot from Bar 1, and continues for some distance before dying out. To the north and east the land is rolling, with no definite bar arrangement that can be traced. This gently rolling area merges gradually into the swampy tract bordering the creek.

The southern end of Bar 3 is no longer visible, since it and also the ends of Bars 4 and 5 disappear under the long dune ridge farthest back from the shore, which has been blown up over the ends of these bars. Bar 3 runs parallel to Bar 2, but is not quite so long and is somewhat lower. To the north it becomes confused and dies out.

Bar 4 is the only one of the group which is well defined throughout its extent and continues all the way across the embayment, except where it is cut by Heron Creek, to the moraine on the northern side, which it joins in a fork. (It will be recalled that a similar forked or branched effect at the juncture of the bar with the moraine also occurred in the case of Bar 1.) Bar 4, therefore, represents the first completely successful closing off of a portion of the embayment. The top of this bar, which is the highest of the group, is at an elevation of approximately twenty-five feet above Lower Herring Lake. At the time these studies were made the outlet of Lower Herring Lake into Lake Michigan was not dammed, and both lakes stood at about the same level. There is a gravel pit in Bar 4 at the point of junction with Bar 5. The material exposed ranges from sand to gravel to small cobbles about a yard below the surface. It is well stratified and is indicative of strong wave action. The beds are nearly horizontal, but dip gently to the west and southwest. In the northern part of Bar 4 a small pit has been dug, in which the same type of material can be seen. Bar 5, which is lower than Bar 4, is relatively local. It can be traced from the sandy ridge to the south and runs northeast until it joins Bar 4.

The southern parts of Bars 3 and 4 are crossed nearly at right angles by a narrow ridge of earth. This is an artificial grade constructed for the old railroad which was built along the southern shores of the lake during the time of the lumbering operations in this region. It is listed merely that it may not be confused with the bars.

From their material, general appearance, and elevation the last four ridges in the series described above have all the characteristics of mid-bay bars formed during periods of intense wave and current action in the waning stages of Lake Algonquin. They were built up from the south, they differ slightly from one another in height, and are incomplete, with the exception of the fourth bar, which entirely crosses the embayment. In accordance with Johnson's classification⁴ the term "mid-bay bar" is used, since they reduce the length of the depression by about one half. These bars probably came into existence because the embayment was so shallow that the waves broke before they had a chance to reach the shore. The depth here, approximately ten feet, would presuppose the existence of waves ten feet high along the Algonquin shore.⁵ This height is not improbable since waves have often been observed on Lake Superior which were accurately determined to be from twenty to twenty-five feet in height.⁶ No measurements of waves on Lake Michigan are known to the writers, but it is believed that they are somewhat near the same magnitude.

This premature breaking of the waves, which resulted in the building up of the bars, accounts for there being little or no evidence of a well-developed Algonquin level along the eastern shores of Upper Herring Lake, and also for the lack of dunes in that area.

After Lake Algonquin the deciphering of the history of the embayment is based upon the interpretation of the dune

ridges, and some discussion of the principles involved is here undertaken. The relative age of dunes has been determined by: (1) position or location; (2) extension or direction; (3) development — (a) simple ridges, (b) deformed ridges, (c) size; (4) soil profile. Regarding position or location, the dunes farthest back from the shore were the first to be formed and therefore are the oldest. This principle is based upon the assumption that there has been no dune migration. By "migration" is meant the progression of a dune in response to winds subsequent to its detachment from its place of origin. This assumption is correct for most of the dune areas about Lake Michigan, but should be checked in each instance. "Extension" or "direction" refers to the direction in which the dunes run, which sometimes, furnishes a clue to the time and the manner of their formation. The development of a series of simple undeformed ridges which run approximately parallel to one another indicates a prograding condition of the shore, whereas deformed ridges indicate retrograding or oscillating conditions.⁷ On a retrograding shore sand is largely removed by wave and current action. Thus the dunes became deformed without notable additions of material and are therefore of moderate size. On the other hand, exceptionally large deformed dunes (150-250 feet high) are the result of the alternating addition and abstraction of sand along the shore of a lake whose level oscillates. "Oscillation" in this sense refers to the normal short-period fluctuations such as occur under present conditions. As stated above, dunes of this type are to be expected at the flood stages of both Algonquin and Nipissing, Algoma possibly, and the present.

The work of Scott and of Stevenson⁸ in other portions of the Lake Michigan basin has shown consistently that the largest dunes are of Nipissing age. The apparent chaotic appearance of the dunes is in reality an orderly arrangement. Between the Algonquin and the present Great Lakes the total drop in level was but twenty-five feet, and the several stages persisted long enough for the shore to be cut back to nearly the same locality at each stage. Under these conditions were formed a series of greatly deformed ridges piled up within a narrow zone, the later on the earlier, to heights which rival those of any others so far discovered. These deformed dunes are particularly well represented in the areas south of Frankfort.

In this study soil profiles were utilized sparingly within the area for correlating the dunes with one another as to approximate age. No attempt was made to compare them with the profiles of dunes in other areas, the method employed farther to the south. Owing to differences in climate and degree of leaching, results obtained from the use of this method in this more northern region are not considered reliable except in comparisons within a local area. With this brief discussion in mind the dune area of the depression will be considered.

Along this western side of Michigan the Herring Lake embayment seems to be the only example of two fairly

large lakes, distinctly different in age, that occupy the same depression. A great series of dunes have been piled up within the embayment, but none have formed at the bases of the high headlands to the north and south where they come out at right angles to the beach, since it is the material eroded from these exposed morainic ridges that has in large part provided sand for the formation of dunes along the less exposed portions of the shore.

Starting with the group of dunes to the north of Lower Herring Lake (Map 42), the first form encountered in front of Bar 4 is a single, relatively low, sandy ridge (I). The upper portion of the soil profile is deep orange, with much ortstein and some podsolization, and is the darkest found in the dunes of this area. The course of Heron Creek has been deflected to the south in order to get around the southern end of this dune ridge, which stops abruptly at the creek and does not continue beyond that point. At the southern end the ridge has been deformed somewhat by the wind, but continues in a general northwest direction until it disappears under the main dune complex. Beyond this point it cannot be traced.



MAP 42. Dune area north of Lower Herring Lake

Because of its distinctive soil profile it is considered to be the oldest dune form found, and the location in front of Bar 4 would indicate that it belonged to very late Algonquin time. It may represent a foredune ridge imperfectly developed before, or as, the water level receded to that of the early Nipissing stage. It is the only ridge in this area that may be said to belong to the transition between late Algonquin and early Nipissing.

Between the ridge described above and the shore of Lower Herring Lake are a series of several rather discontinuous, low sandy ridges or bars (II), two of which also seem to continue south of the creek. These indistinct ridges are lower than either the Algonquin or the Nipissing levels and may be interpreted as offshore features of an age contemporary with that of the dune ridge (I).

During early Nipissing the area now occupied by Lower Herring Lake must have been practically dry, except for Heron Creek, with a greater western extent than at present. However, with the return of the waters to a higher level at the Port Huron Outlet, shore activity in this locality was renewed and resulted in the formation of a great series of dunes.

In front of the group of ridges just described (I, II) is a ridge (III) that starts near the creek, travels northwest, and then curves back to the north and slightly northeast and joins with a ridge (IVA) that goes northeast and disappears under the higher portion of the main dune complex. However, it reappears (IVB) farther on and continues in a long curve. Ridge III is approximately fifteen feet above Lower Herring Lake. Inasmuch as this is a dune and not a bar, the elevation of the crest does not represent the Nipissing level, although the ridge itself would seem to be of that age, having been formed after the readvance of the water level. This conclusion is reached partly from the location of the ridge and also because the soil profile is distinctly lighter than that of Ridge I, and is free from ortstein.

To the northeast of this ridge are morainic hills and spurs, some of which contain much sandy material, but also quantities of rather large boulders, so that there is little danger of confusing any of these hills with the dune ridges in this particular location, a few of which appear to have been blown up or perched upon the gently sloping flanks of the moraine. The series of seven roughly parallel ridges to the north are entirely morainic.

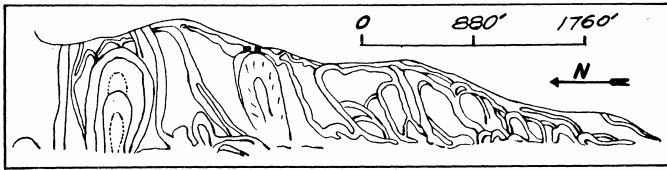
Ridge IVB and the series of lower dune ridges farthest back from the shore to the north and east seem, on the basis of their position, soil profiles, and deformation, to have been formed during the Port Huron Outlet stage of Lake Nipissing. With their formation along the front of the moraine the opening of the depression toward the lake was greatly narrowed.

To the south, in front of Ridge III, running in a general east-west direction, are two sand ridges (V), one of which merges at its eastern extremity with Ridge III. They are slightly lower, and must have been formed subsequent to Ridge III. That these two ridges were formed when the depression was open on the Lake Michigan side and before the existence of the wide bay-mouth bar enclosing Lower Herring Lake is shown by the fact that at their western ends they merge and curve to the north before they disappear under the deformed dunes, instead of curving south toward the bay-mouth bar, as they would have done if they had been ridges formed along the shores of the present Lower Herring Lake.

Obviously, the high ridges (VI) in this northern area were blown up at a somewhat later date than those farthest from the shore, since the highest of the group buries a portion of Ridge IV. These high dunes are probably of late Nipissing age, although most of them have a surface coating of modern material. All the lower ridges to the west of this series of high dunes are thought to be post-Nipissing.

It seems probable that the bay-mouth bar came into existence at, or immediately following, the end of the Nipissing. The entrance to the embayment must have been closed when the deformed ridges (VII) nearer the shore were formed, since their soil profile is very similar to the soil profile of the sand out on the northern part of

the bay-mouth bar, indicating that this group of dunes must all be of very nearly the same age. They may possibly belong to the Algoma (?). It will be noted that some of the dunes in this series cover the western ends of the little ridges (V) previously described.



MAP 43. Dunes on bay-mouth bar north of outlet

The dunes nearest the shore are modern (VIII), and there is one large, recent, compound horseshoe blow that extends back a considerable distance. With the exception of this and several minor blows the entire area is quite thickly covered with second-growth timber, and the dunes are fixed in character.

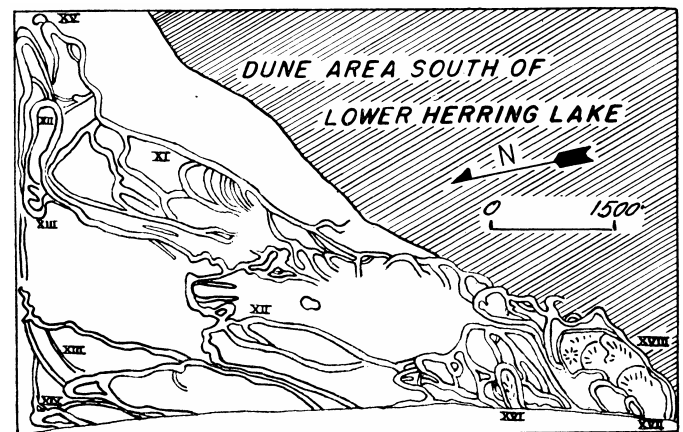
The dunes out on the bay-mouth bar north of the outlet (Map 43; Pl. LII, Fig. 1) are probably all modern, although parts of them may be of Algoma (?) age. By "modern" it is not meant necessarily that they have been blown up within the past hundred years or so, but that they have formed at some time since the withdrawal of the Nipissing Great Lakes. The soil profile of these dunes is not that of the light-colored sand such as is found on the beach today, but is of a moderately yellow shade, verging on an orange-brown color.

In the northern part of this bay-mouth bar the back slopes of some of the series of horseshoe dunes (IX) have been truncated, and are still in the process of being worn away by the action of the waves in Lower Herring Lake. These are good examples of longitudinal dunes in a humid region, formed on a bay-mouth bar.

In the northwest corner of the lake is a small lagoon (X) separated from it by a low bar approximately six and one-half feet in height. The bar was formed by Lower Herring Lake after the formation of the bay-mouth bar, since it curves to the south to join the bay-mouth bar. This little bar may be composed of material from the truncated dunes to the west. However, since it is slightly higher in the eastern portion, it may have been built down from the east, although the eastern shore of the lake is quite pebbly, and it does not seem as though there would have been available much fine material which could have been carried by the waves. Also, Heron Creek does not set up any strong current in Lower Herring Lake. The crest of the bar is above any known historical level of the lake and might be correlated with the Algoma (?). However, it seems doubtful whether such a transitory form as a shallow lagoon would persist from that time until the present day, even though the bar is so much lower at the western end that a rise of approximately four and one-half feet in lake level would have kept the lagoon filled with water. Because of this conflicting evidence the age of the bar has not been definitely determined other than to say that it is post-Nipissing.

Of the dunes to the south of the depression (Pl. LII, Fig. 2) it is difficult to determine their age accurately, since the geologic record is not so clearly portrayed here as on the northern side, where the bars and other key features are well preserved.

For the most part the dune pattern is complex (Map 44), but is characterized, unlike the section to the north, by long festoon ridges somewhat parallel to the present shore of Lake Michigan, though angling in toward the embayment; and by small horseshoes and apices blown up upon these ridges. These horseshoes are oriented with a general northeast-southwest tendency, indicating an effective southwest wind, a rather noteworthy orientation. As for the long ridges, they have a more easterly trend than does the present shore line and therefore are beveled at their southern ends, which precludes a definite determination of their age. One must therefore rely upon the soil profiles and the character of the ridges in comparison with the dunes of other parts of the area, for a rather inconclusive correlation. In general, the appearance of these dunes is quite different from those to the north, and the ridges are not so high. Those in the far southern part of the area owe their apparent great elevation to the fact that they are perched on the moraine, which at this point is over 300 feet in height.⁹

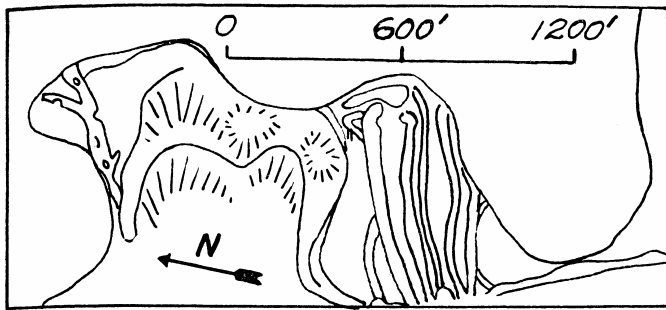


MAP 44. Dune area south of Lower Herring Lake

The series farthest to the east (XI) have a rather dark profile, with much ortstein and podsolization, and inasmuch as they cover the ends of Algonquin Bars 3, 4, and 5 they are considered tentatively to have been formed during the Nipissing.

The age of those nearer the shore, including the ones along the shore of the present Lower Herring Lake (XII), is not known, except that they must be somewhat younger. As for the latter series, the curving effect of most of the ridges (XIII) away from the south bar would indicate that they were formed previous to the existence of Herring Lake. However, the small group (XIV) nearest Lake Michigan has a soil profile identical with that of the dunes on the southern part of the bay-mouth bar, and was connected with them at one time, before the ridge was cut away to give ready access to a large dock on the shore, the remains of which may still be seen. The

dunes of the southern part of the bay-mouth bar (Map 45) are mainly longitudinal and fragmentary, with the exception of a large active amphitheater blow which rises to a height of eighty feet and whose back slopes are being truncated by Herring Lake.



MAP 45. Dunes on bay-mouth bar south of outlet

The old lumber town of Watervale stretches along the southern shore of Lower Herring Lake, and consequently the elevations of the low ridges near the shore cannot be relied upon, since they must have been greatly modified.

To the east there is a question whether or not the old ridge farthest back from the shore ever joined with the series along the small lake. An old logging road runs through the place (XV) where the juncture of the ridges could have occurred. However, from the general appearance of the place it does not seem as though the ridge could ever have been very high at this point, and the loggers probably found it convenient to use this low spot in the ridge as an entrance for their road. If such was the case, it would bear out the theory advanced, that the dunes along the south shore of Herring Lake were formed somewhat later than those composing the series under which the Algonquin bars disappear.

As to the age of the perched dunes to the south, it is difficult to say much. Their foundations are undoubtedly of Nipissing age, but a great amount of more recent material has been piled up on top of them. There are two modern blows, known as "Razor Back" (XVI), at a height of approximately 127 feet, and "Baldy" (XVII), at 330 feet (Pl. LII, Fig. 2). The openings of both are oriented N. 60° E. The ridge forming the south arm of "Baldy" (XVIII), which is now being actively cut into by the wind, displays a foundation of medium yellow sand capped with a mantle of lighter-colored sand, indicating that there were two distinct periods in the building up of this ridge.

In conclusion, it may be added that a well-developed foredune ridge stretches across the entire embayment, but ends abruptly at the morainic ridges where they come out to the shore.

SUMMARY

The Herring Lake embayment lies within a U-shaped moraine open to the west.

The embayment was first occupied by water in late Lake Algonquin time, during which stage Upper Herring Lake was isolated by a series of mid-bay bars. Dune formation during this stage is represented by a single ridge on the north side of the embayment.

The embayment, except for Upper Herring Lake, was drained during the early stage of Lake Nipissing.

At the time of late Lake Nipissing the embayment was again flooded and remained open to Lake Michigan. During this stage not only the series of low dune ridges along the northern shore of Lower Herring Lake, but also the largest parabolic dunes of the area were formed.

The embayment was finally closed by the present bay-mouth bar in post-Nipissing time. Upon this bar and adjoining shores lower dunes of recent origin have formed.

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² George Stanley, personal communication.

³ Profile of lake levels. United States Lake Survey.

⁴ Johnson, D. W., *Shore Processes and Shoreline Development*, pp. 303-304. 1919.

⁵ Johnson, *op. cit.*, pp. 16-18.

⁶ Gaillard, D. D., "Wave Action in Relation to Engineering Structures," *Corps of Engineers U. S. Army, Prof. Pap.* 31, p. 82. 1904.

⁷ Solger, F., *Düneribuch-Werden und Wandern der Dünen*, pp. 40-45. 1910.

⁸ Stevenson, E. B., "The Dunes of the Manistique Area," *Pap. Mich. Acad. Sci., Arts and Letters*, 14 (1930): 485. 1931.

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PLATE LII



FIG. 1. View looking south, showing Lower Herring Lake to left, truncated dunes on north bay-mouth bar, Lake Michigan to right, and small lagoon in center foreground

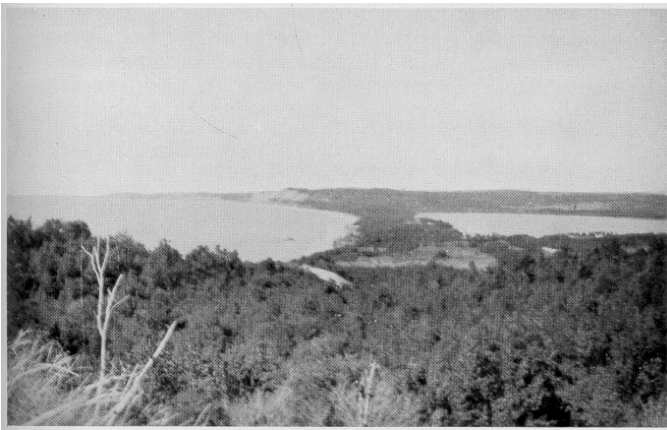


FIG. 2. View looking north from "Baldy," showing Lower Herring Lake to right, southern dune area, and Lake Michigan to left