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VOLUME XXV (1939)

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VOLUME XXV CONSISTS OF FOUR PARTS:

PART I: BOTANY AND FORESTRY

PART II: ZOÖLOGY

PART III: GEOGRAPHY AND GEOLOGY

PART IV: GENERAL SECTION

ANTHROPOLOGY
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PAPERS OF THE MICHIGAN ACADEMY OF SCIENCE ARTS AND LETTERS

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VOLUME XXV (1939)
IN FOUR PARTS

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

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GEOGRAPHY

A LAND TYPE MAP OF LIVINGSTON COUNTY, MICHIGAN

W. BRUCE DICK† AND STANTON J. WARE

IN ANY land-classification program it is important to recognize the interrelationships of qualities of the soil, slope, drainage, relief, and, to a certain extent, of the natural vegetation. These land qualities present a varying pattern from one locality to another. They form a basis for measuring differences in types of land. By observing in the field the complex of these qualities a unit of land or a type may be established. Combinations of elements which make up a land type are recognizable from one area to another, and the land types may be mapped as definite entities. Frequently the use of the land or the condition of farms reflects a fundamental relationship to land types, and tends to accentuate their importance.

In the summer of 1938 a land-type classification was developed for Livingston County (Fig. 1) and a quantitative measure applied to each land unit. The first step in field procedure consisted of extensive travel by automobile to become familiar with the local arrangements of land qualities and to identify various combinations of these for purposes of establishing land types. It was then possible to begin actual mapping.

Every road within the county was traversed. Positions on the map were calculated by measuring with an odometer the distance traveled. Thus, when it was decided that the limits of a land type had been reached, the boundary was drawn in.

The completed map (Fig. 2) shows twelve separate types. Seven had previously been recognized in adjacent Oakland County by J. O. Veatch and N. L. Partridge,[1] and the types and names used by them have been followed here. As in the method used in naming soils, local names were given to new land types. A brief summary of the characteristics of each of the twelve units is presented on pages 376-377. Three types, which are well contrasted, have been selected for further exposition: the Eau Claire, in the vicinity of Fowlerville; the Oronoko, in the southern part of the county; and the Beebe, to the east of the city of Howell.

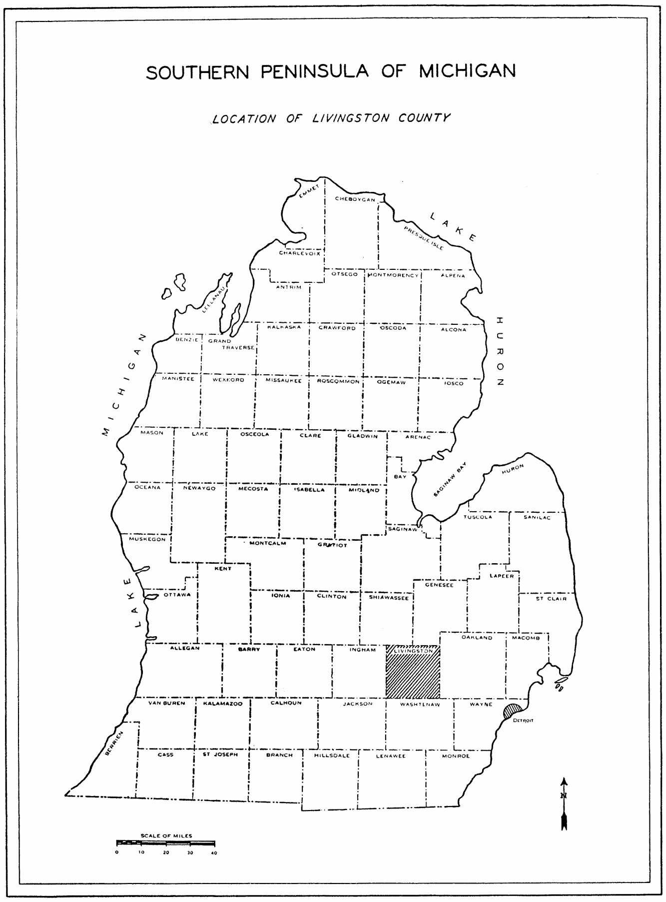

Fig. 1

EAU CLAIRE TYPE

The Eau Claire land type is characterized by gently rolling till or clay plains, with short slopes, usually less than 7 per cent, and heavy loam soils (Pl. I, Fig. 1). Swales and shallow depressions are not uncommon, and they frequently require artificial drainage for their full agricultural utilization. Farms in this land type are considered among the best in the county. The level land and friable soil lend themselves well to the use of power equipment in farming operations.

ORONOKO TYPE

In contrast to the Eau Claire type is the Oronoko, with its hilly knob-and-basin terrain (Pl. I, Fig. 2). Here are steep slopes, lakes, and swamps. The soils are mainly sandy barns. The slopes range chiefly from 7 to 25 per cent. Oronoko includes the roughest morainic country to be found within the county. Erosion presents a problem to the farmers in this land type, because the combinations of steep slopes and sandy loam soil lead to serious gullying and surface wash (Pl. II, Fig. 1). Much of the land is pastured, but under the dry conditions of midsummer it is difficult to maintain livestock in the usual numbers. Many of the hills are cropped, but the slopes and gullies prevent the use of power machinery and greatly restrict that of the plow. Under these conditions farmers have turned many of their fields into permanent sheep pastures.

BEEBE TYPE

The third illustration is the Beebe type. Flat swamp land made up of organic and poorly drained mineral soils characterize this low- land type (Pl. II, Fig. 2). Considerable portions are in tree cover, willow brush, and sedge. The forest floor is usually wet and soft, with occasional shallow pockets of standing water. The type is not very extensive in this county, and in the two areas where it does occur farmers utilize parts of it for summer pasture and allow their stock to browse and feed on the swamp grasses.

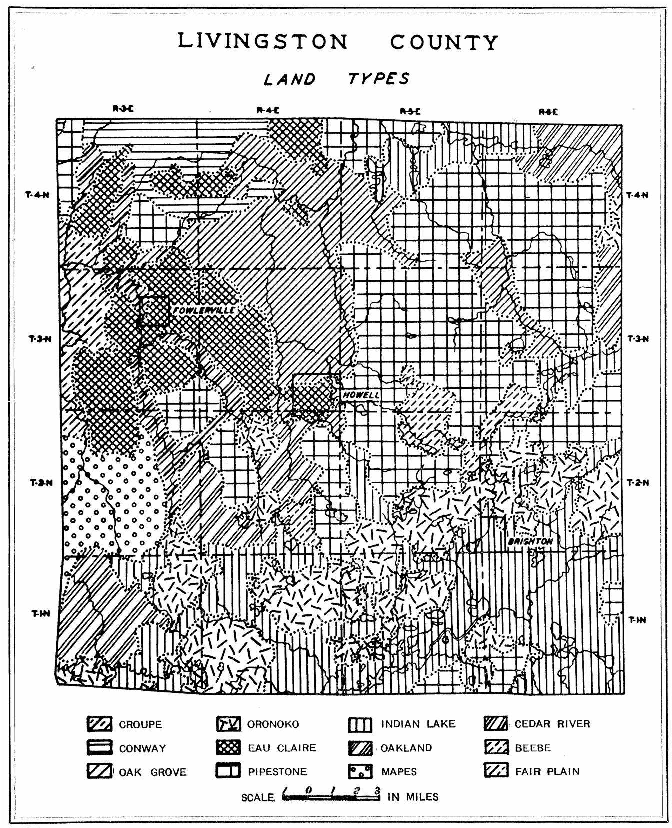

Fig. 2

SUMMARY OF THE LAND TYPES SHOWN IN FIGURE 2

Croupe. — Surface similar to that of the Eau Claire type, but broken by old river valleys, now cut to a considerable extent by artificial drainage ditches. Some swamp, but very little standing water. No lakes. Only small amount of wild land. Soils very heterogeneous, mainly of the lighter types. Patches of Hillsdale, Plainfield, and Fox with associated stream-bottom types of soil

Conway. — Surface smooth to gently rolling, with large areas of very flat, artificially drained land, which at one time had been wet. Idle and pasture land predominant. Dominant soils Fox series with muck. Artificially drained Carlisle muck, which has been cleared for agriculture

Oak Grove. — Rolling to hilly surface. Intermediate in relief between Oronoko and Eau Claire types. Considerable land in pasture. Soils dominantly Coloma loamy sand with Carlisle muck bordering the streams. Minor soils, Miami and Plainfield series. Sandier exposed hills subject to blowing in dry weather

Oronoko. — Hilly, knob-and-basin terrain. Slopes two to three times the area of level upland; high percentage of slopes, 15 to 25 or more; lake basins, dry depressions, and swamp basins. Dominant soils sandy loams mainly Bellefontaine and Hillsdale types, with smaller bodies of Coloma, Miami, and Fox or Fox-like soils

Eau Claire. — Gently rolling till or clay plains. Short slopes, few exceeding 7 to 15 per cent; swales and shallow basins. Dominantly Miami and Hillsdale loam types of soil. May be moderately stony

Pipestone. — Deeply rolling or broken, pitted or dissected clay land, till plains, or moraines. Slopes greater in area than level land; constructional swales and basins; generally considerable stream dissection. Dominant soils Hillsdale and Miami types. Some muck and peat

Indian Lake. — Sand plains, level surface but containing a large number of dry potholes, lake basins, muck and peat basins, swampy stream valleys, or chains of lakes. Slopes short, enclosing basins for the most part, but may include those up to 25 per cent or more. Dominant soils Fox and Bellefontaine. Some Plainfield and the organic soils

Oakland. — Intermediate in gradient and height of relief between Eau Claire and Pipestone on the one hand and Oronoko on the other; more Hillsdale and Miami soils than are found in Oronoko type. Slopes exceed area of level land; high percentage of slopes of 7 to 25 per cent gradient. Lakes and muck basins common. Dominant soil Hillsdale or sandy Miami; less Bellefontaine. May be stony

Mapes. — Level swampy land with interspersed higher areas having slopes generally less than 7 per cent. Dominant soils Carlisle muck and Hillsdale sandy loam. May include some Fox soils. Wild land predominant with patch cultivation on the interspersed highlands. Lower relief and fewer lakes than in the Indian Lake type

Cedar River. — Level, broad valley bottoms. Slow stream drainage with some artificial drainage. Similar to the Mapes type, but with little or no associated Hillsdale soil. Generally sinuous in outline. Soils mainly Carlisle muck. There may be small areas of Rifle peat. Surrounding upland chiefly Miami loam

Beebe. — Swamp land mainly Carlisle muck and Rifle peat, with small amounts of poorly drained mineral soils

Fair Plain. — Smooth sand plains, only slightly pitted or undulating. Few lakes and muck basins. Few slopes more than 10 per cent. Dominant soils Fox series

TABLE I

DATA ON QUANTITATIVE LAND TYPES

Land types	Date July 1938	Distance of traverse (in miles)	Percentage of total distance in slopes					No. of land components per mile of traverse						Percentage of total distance in soils							
			0–3% (Lowland)	0–3% (Upland)	3–7%	7–15%	15–25%	Streams	Catholes	Potholes	Swamps	Lakes	Swales	Well drained* 1	Well drained* 2	Well drained* 3	Poorly drained† 1	Poorly drained† 2	Poorly drained† 3	Poorly drained† 4	Poorly drained† 5
Oronoko ...	18	2.60	17.30	5.77	28.82	42.30	5.77	.77	.38	.38	.77	.38	0	0	76.9	0	0	0	0	0	23.1
	19	9.35	12.83	0	3.21	40.10	43.90	.54	1.71	1.82	.54	.75	0	0	85.0	1.6	0	0	3.2	0	10.2
	20	3.40	8.83	0	0	45.60	45.60	0	.59	.29	0	0	0	0	45.6	45.6	0	0	0	0	8.8
	21	1.60	34.40	0	0	65.60	0	.62	0	0	1.25	2.50	2.50	0	65.6	0	0	0	0	0	34.4
	Total	16.95	14.78	.87	6.20	44.00	34.20	.47	1.12	1.12	.53	.71	.24	0	74.0	10.0	0	0	1.8	0	14.2
Eau Claire .	18	4.60	0	100.00	0	0	0	.44	.22	0	0	0	.22	0	0	90.3	3.3	0	6.5	0	0
	20	.50	0	100.00	0	0	0	0	0	0	0	0	0	0	0	100.0	0	0	0	0	0
	21	8.20	1.83	95.70	2.44	0	0	.37	.12	0	.12	0	.73	0	0	98.2	0	0	0	1.8	0
	27	10.80	3.24	91.68	5.09	0	0	.28	.37	0	.09	.09	.37	0	0	96.6	0	0	3.4	0	0
	29	1.70	0	100.00	0	0	0	0	0	0	0	0	.59	0	0	100.0	0	0	0	0	0
	Total	25.85	1.94	95.10	2.90	0	0	.31	.23	0	.08	.04	.46	0	0	96.3	.6	0	2.5	.6	0
Pipestone ..	18	3.70	2.70	2.70	74.38	20.24	0	1.35	1.62	0	.81	.27	.27	0	0	97.3	0	0	0	2.7	0
	19	2.35	0	55.30	44.70	0	0	0	1.70	1.70	0	0	0	0	36.2	63.8	0	0	0	0	0
	20	19.40	10.07	2.84	71.40	15.71	0	.26	1.03	.46	.41	0	.21	.8	0	86.1	0	2.6	1.0	9.5	0
	21	4.55	0	13.20	86.80	0	0	.22	.88	0	.22	0	.22	0	0	100.0	0	0	0	0	0
	27	8.70	6.32	2.88	81.00	9.77	0	.23	.35	0	.58	0	1.15	4.6	0	89.0	0	0	4.6	1.7	0
	29	7.35	2.04	2.04	66.60	18.38	10.89	.27	.14	0	.68	.27	1.22	0	0	98.0	0	0	0	2.0	0
	Total	46.05	5.97	6.40	72.85	13.03	1.74	.33	.83	.28	.48	.07	.54	1.2	1.8	89.7	0	1.1	1.3	4.9	0
Fair Plain .	18	.80	0	0	100.00	0	0	0	3.76	18.80	0	0	0	0	0	0	0	100.0	0	0	0
Indian Lake	18	4.20	9.54	35.70	38.10	16.66	0	.71	.48	.24	.24	0	0	0	0	0	0	83.4	10.7	0	6.0
	19	10.25	7.32	27.29	42.44	22.92	0	.59	1.17	.49	.29	.49	0	0	92.6	0	0	0	0	2.0	5.4
	20	10.65	26.30	0	64.30	9.39	0	.85	.47	.47	.38	.19	0	0	74.6	12.2	0	0	0	2.8	10.3
	21	3.25	20.00	38.45	20.00	21.55	0	.31	1.23	0	1.54	0	.92	0	80.0	0	0	0	6.2	7.7	6.2
	27	3.80	0	0	100.00	0	0	0	1.58	0	.53	.79	1.32	0	82.9	17.1	0	0	0	0	0.
	29	3.95	5.06	0	45.60	49.40	0	.76	.51	0	.51	.25	2.52	6.3	88.6	0	0	0	0	0	5.1
	Total	36.10	13.30	15.36	52.75	18.55	0	.61	.86	.34	.47	.34	.50	.7	73.9	5.4	0	9.7	1.8	2.1	6.4
Oakland ...	18	1.00	0	40.00	30.00	30.00	0	1.00	0	0	0	0	0	0	0	80.0	0	0	0	20.0	0
	19	3.70	17.58	8.12	36.46	37.84	0	.54	1.08	0	.81	.27	0	0	51.4	28.4	0	14.9	5.4	0	0
	20	5.90	1.70	0	0	89.82	8.47	.17	0	.81	0	.34	0	0	80.5	17.8	0	0	0	1.7	0
	21	4.60	3.26	0	57.60	39.15	0	.43	.65	.22	.87	0	.87	0	78.2	18.5	0	0	0	0	3.3
	29	5.55	0	0	23.40	76.60	0	.90	.36	0	.54	.72	1.08	22.5	0	77.5	0	0	0	0	0
	Total	20.75	4.34	3.37	26.98	62.90	2.41	.53	.43	.28	.48	.34	.48	6.0	49.5	38.8	0	2.6	1.0	1.4	.7
Beebe	27	6.25	83.98	0	16.00	0	0	.64	.48	0	1.60	.64	.32	0	0	17.6	41.6	20.8	5.6	14.4	0
Mapes	21	4.20	58.40	0	41.60	0	0	.24	.71	0	.71	0	.24	0	51.2	7.1	0	0	0	41.7	0
Cedar River	20	.60	100.00	0	0	0	0	1.67	3.34	0	0	0	0	0	0	0	0	0	0	.6	0
	21	4.10	100.00	0	0	0	0	.49	.24	0	0	0	.24	0	4.9	19.5	0	12.2	12.2	51.2	0
	27	1.15	100.00	0	0	0	0	1.74	0	0	0	0	0	0	0	0	0	0	0	100.0	0
	Total	5.85	100.00	0	0	0	0	.86	.51	0	0	0	.17	0	3.4	13.7	0	8.5	8.5	65.8	0
Croupe	20	1.70	20.57	0	79.43	0	0	.59	1.77	0	0	0	1.77	0	11.8	67.6	0	0	5.9	14.7	0
	27	.45	100.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	100.0	0	0	0
	Total	2.15	37.18	0	62.80	0	0	.59	1.77	0	0	0	1.77	0	9.3	53.5	0	20.9	4.7	11.6	0
Conway ...	21	2.25	71.10	0	28.90	0	0	.89	.44	0	0	0	.44	0	53.3	20.0	0	0	0	26.6	0
	29	6.80	47.10	0	53.0	0	0	.59	1.47	0	.59	.15	1.47	0	58.1	11.0	0	9.6	0	21.4	0
	Total	9.05	53.00	0	47.00	0	0	.66	1.22	0	.44	.11	1.22	0	56.9	13.3	0	7.2	0	22.7	0
Oak Grove .	18	9.90	2.52	37.90	50.00	9.59	0	.73	.21	0	.10	0	.73	23.8	0	69.2	1.0	2.5	0	2.5	1.0
	20	10.60	11.79	5.66	67.90	14.62	0	.38	.47	.09	.47	.28	1.23	44.8	4.7	38.7	0	0	0	9.4	2.4
	27	2.00	37.50	0	35.00	27.50	0	.50	0	0	0	.50	0	35.0	27.5	0	0	30.0	7.5	0	0
	29	2.30	43.48	8.70	32.60	15.22	0	.87	.87	0	.43	.43	.87	39.2	0	15.2	0	34.8	10.9	0	0
	Total	24.80	13.10	18.33	54.85	13.70	0	.56	.36	.04	.28	.20	.89	35.1	4.2	45.6	.4	6.7	1.6	5.0	1.4

* Soils naturally well drained: (1) sands, 3 feet or more in thickness; (2) sandy loam surface or sands, underlain by clay at less than 3 feet; (3) loam to clay, underlain by clay.

† Soils naturally wet: (1) deep sands; (2) sandy loam and sands, underlain by clay; (3) loam to clay, underlain by clay; (4) muck, black, well decomposed; (5) peat, slightly decomposed.

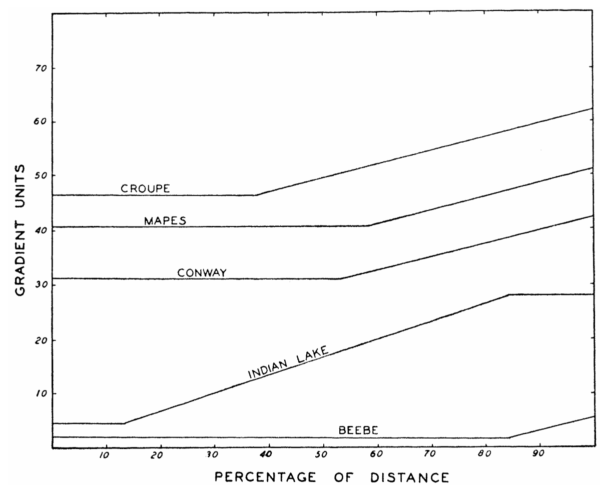

FIG. 3. Land-type slopes

CONCLUSIONS

After completion of the land-type map it seemed desirable to cheek the land divisions quantitatively. T he traverse method was employed for this purpose; three north-south and three east-west traverses of the county were made. Odometer readings in twentieths of a mile were recorded to measure distances in each percentage-of-slope category and in each soil division. At the same time streams, catholes, swales, lakes, and swamps were tallied as they were en- countered on the traverse. Slope and soil divisions were worked out on the basis of percentage of total distance in each land type, whereas the other land qualities were figured on the basis of number per mile. This provided a means for comparing these elements quantitatively.

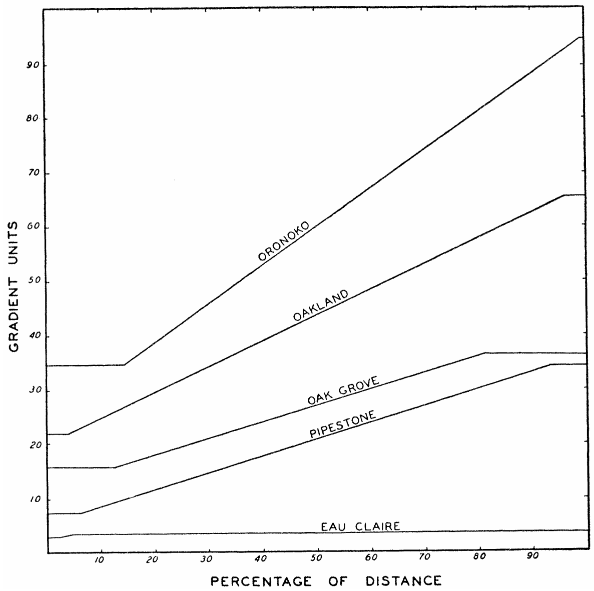

FIG. 4. Land-type slopes

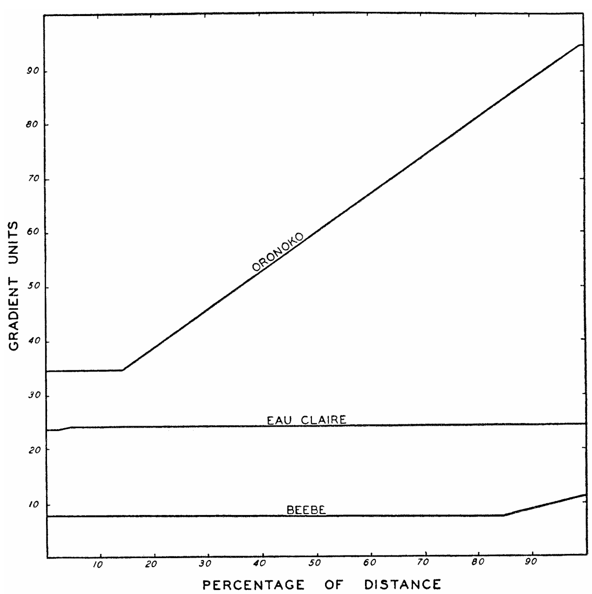

FIG. 5. Land-type slopes

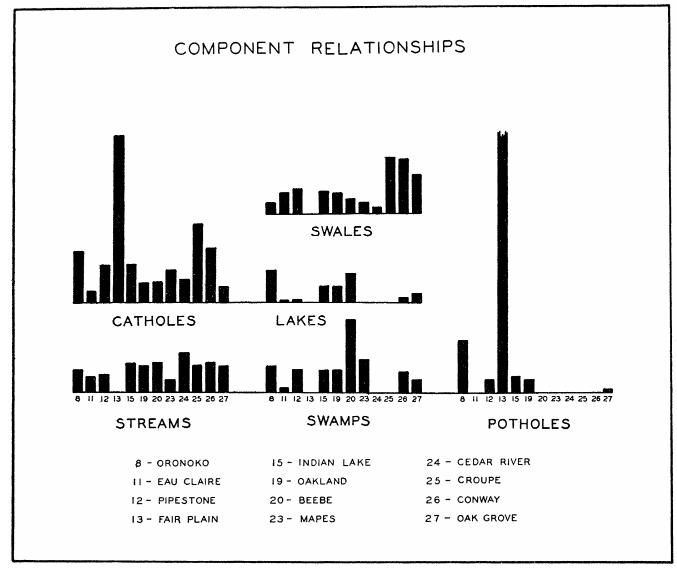

FIG. 6

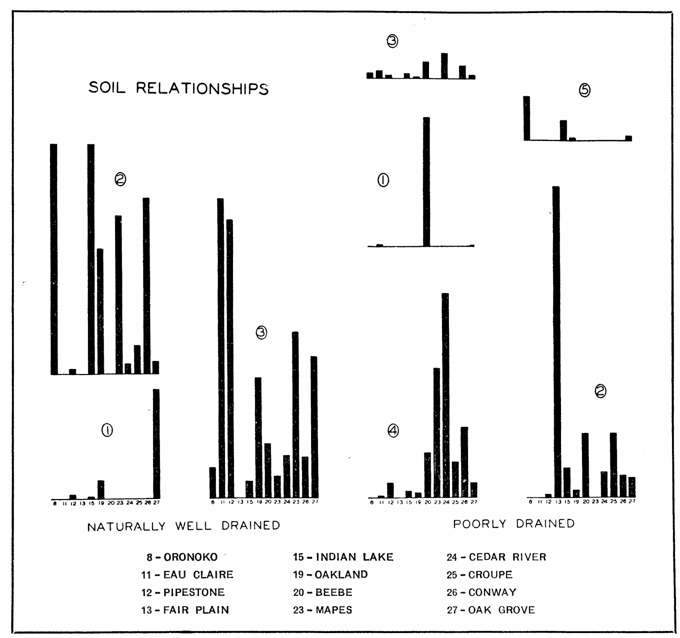

FIG. 7

The results of these calculations have been tabulated (Table I, pp. 378-379). The slope characteristics alone are considered in Figures 3-4. Graphs following the method suggested by J. O. Veatch have been drawn to show the relative proportions of slope, level upland, and level lowland in the types as well as to give an idea of the steepness of slope.[2] The flat part of each graph at the extreme left represents the proportion of lowland (0-3 percentage of slopes), and the flat part of the graphs at the extreme right shows the percentage of level upland. The slanting line indicates the character of the slope. Notice the predominance of steep slopes in the Oronoko in contrast to the short gentle slopes of the Eau Claire type (Fig. 5). Lowland is a little more extensive in the Oronoko, but nearly all the Eau Claire type is in level upland. The large amount of lowland in the Beebe type is one of its most important characteristics, together with the fact that there is no upland.

Although the slopes in these illustrations differ greatly, it should be remembered that land types are based not on slope alone but on combinations of slopes and other qualities. To make this clearer, graphs were constructed from the data of Table I. The bar graphs in Figure 6 demonstrate the variability of occurrence of such land elements as streams, catholes, and potholes. In like manner Figure 7 illustrates the soil differences.

Land typing is recommended as a method of land classification to which other data may be related. It offers practical application to agricultural and county rural zoning programs. Social and public administrative agencies are looking more and more for such convenient classifications for use in their work.

UNIVERSITY OF MICHIGAN

†EDITORS' NOTE—Mr. Dick died on October 28, 1939, of injuries received in an automobile accident. His death removes from the University campus an engaging personality as well as an enthusiastic young research worker.

[1] From an unpublished land-type map of Oakland County, Michigan, by J. O. Veatch and N. L. Partridge, Michigan State College, East Lansing, Michigan.

[2] Veatch, J. O., "Graphic and Quantitative Comparisons of Land Types," *Journ. Am. Soc. Agro*., 27 (No. 7): 505-510. 1935.

DICK AND WARE PLATE I

FIG. 1. A ploughed field in Eau Claire land type. Howell Township, Section 18

FIG. 2. Oronoko land type. Putnam Township, Section 33

DICK AND WARE PLATE II

FIG. 1. Compound gullies in Oronoko land type. Putnam Township, Section 28

FIG. 2. Beebe land type. Oceola Township, Section 34

KATAHDIN IRON WORKS, MAINE: A STUDY IN POPULATION DISTRIBUTION*

CLYDE F. KOHN

KATAHDIN IRON WORKS, once the scene of the active exploitation of a mineral resource, is today a deserted village in the forested area of central Maine. An unimproved dirt road is its only connection with Brownville Junction (Fig. 1), the nearest market center. The village, which was preceded by a brief unsuccessful agricultural settlement in the region earlier in the century, really came into being with the development of iron mining in 1843, and its population immediately declined in 1888, when this generative force proved no longer profitable.

Population curves may be constructed which, when read in the light of local history, help one to understand population distributions in small areas. The curve for Katahdin Iron Works (Fig. 2) shows four periods in its history, with a minor peak in 1850 and a major one in 1880. Each of these peaks is followed by a great decline of population — that of 1850 by a removal of all the people from the area and that of 1880 by a decline of 60.7 per cent. The closing of the mine in 1888 and the accompanying decrease in population cannot be ignored in a study of settlement in Maine. It is the purpose of this paper to analyze the development of iron mining at Katahdin Iron Works during the nineteenth century and to note its effect on the present distribution of population in the area.

The village is on the west branch of Pleasant River (Fig. 3), the narrow, steep-banked outlet of Silver Lake. In this part of Maine rejuvenated streams have dissected an old upland surface,[1] and a few intruded masses of igneous rock rise three hundred to four hundred feet above the general level of the region. Ore Mountain, lying to the west of the village, is one of these masses of rock. It is extraordinarily rich in pyrrhotite.

FIRST SETTLEMENT OF THE TOWNSHIP

In 1814 the intervals northwest of Silver Lake were cleared and settled (Fig. 4).[2] They were connected with the village of Sebec by a road through Barnard that has long been abandoned. The census for 1820 lists twelve persons as living in the township later known as the Katahdin Iron Works, but in the following year they exchanged their land for farms in Brownville. Since then no families have dwelt on these intervals. There was no one in the township in 1830 or 1840.

SETTLEMENT BASED ON MINING DEVELOPMENT

The second period in the history of Katahdin Iron Works began with the discovery of iron ore in the township by Moses Greenleaf,[3] onetime re manager and co-owner of Williamsburg, but now remembered as Maine's first map maker. He learned, through the translation of Indian words, that Mun-na-lam-mon-un-gun, the name for the west branch of Pleasant River, meant "very fine paint" or "place where [it] was found." This led him to the discovery of the iron deposit. His efforts to influence the legislature at Portland to develop the property in order to stimulate settlement in the interior of Maine were, however, futile.

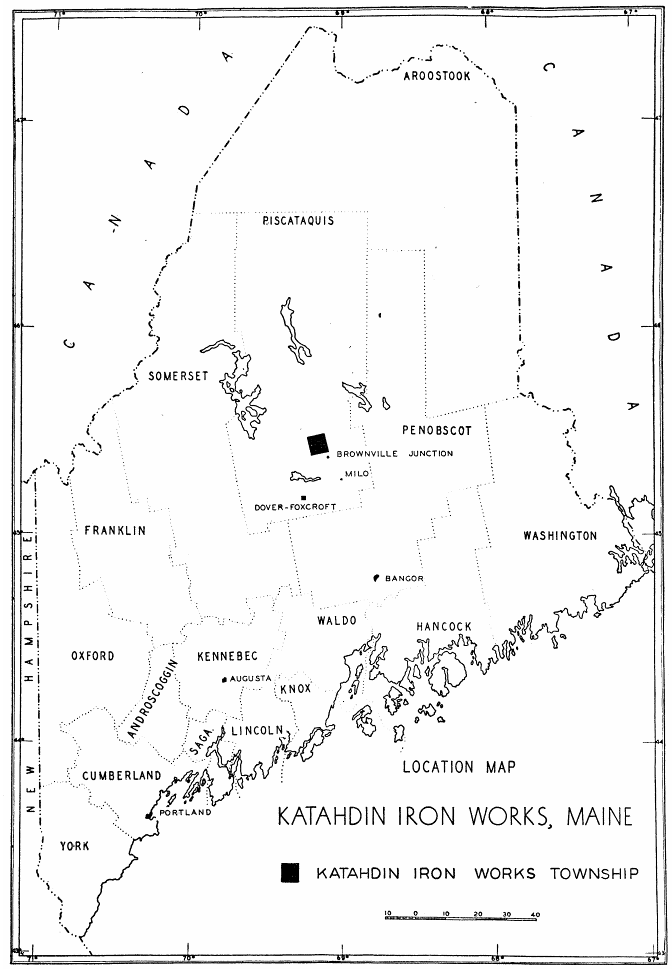

FIG. 1

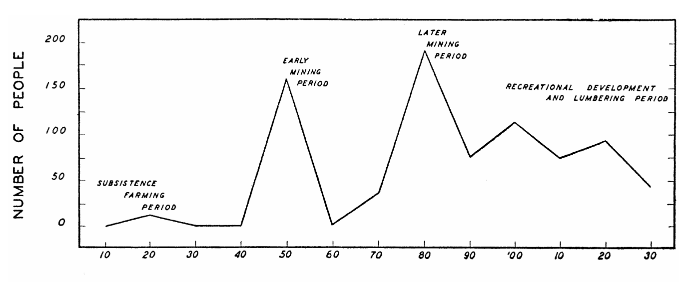

FIG. 2. Population graph of Katahdin Iron Works Township

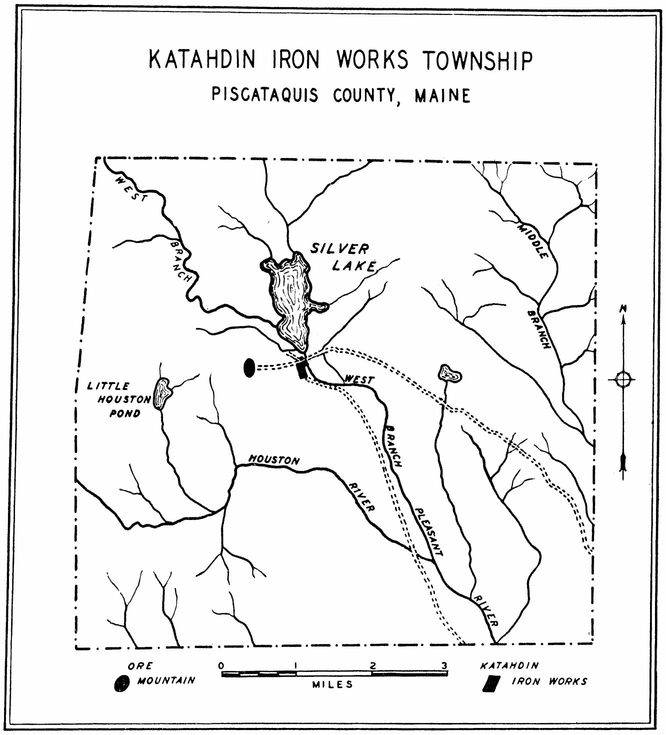

FIG. 3. Drainage map of Katahdin Iron Works Township. Pleasant River is a branch of the Piscataquis River, a western tributary of the Penobscot River

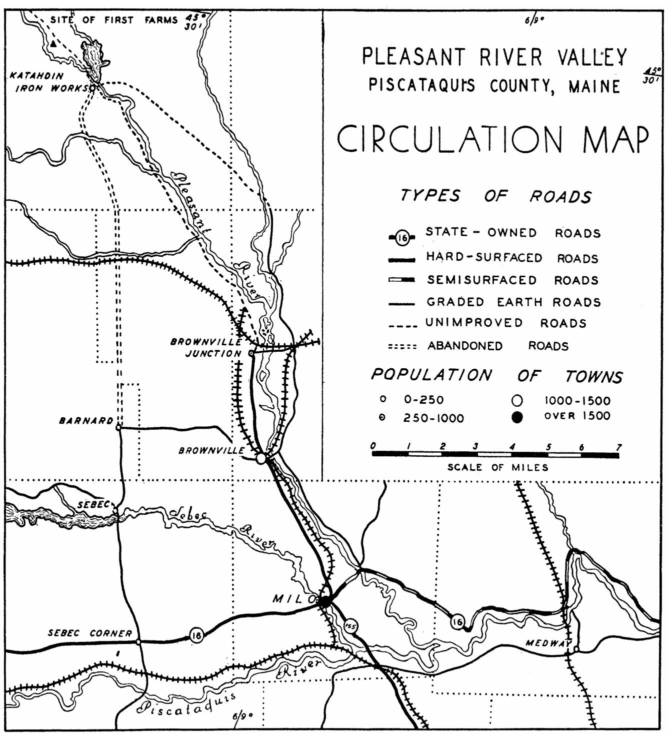

FIG. 4
Highway 16 connects Milo with Dover-Foxcroft to the west; Highway 155 connects Milo and Bangor

It was not until 1843 that the mining of ore was begun by Edward Smith, of Bangor.[4] In 1845 he sold the property to David Pingree and Company, of Salem, Massachusetts. This company carried on the work until 1856, when the hauling of the ore by ox team to Bangor, a distance of approximately sixty miles, proved too expensive, and the furnaces were abandoned. In this period a hotel and several houses were built to accommodate the workmen. For six or eight years all were vacant except one dwelling and the hotel, which was kept open to entertain lumbermen, explorers, and visitors. No inhabitants were recorded in 1860. With the closing of the mine the frontier of settlement had quickly retreated southward.

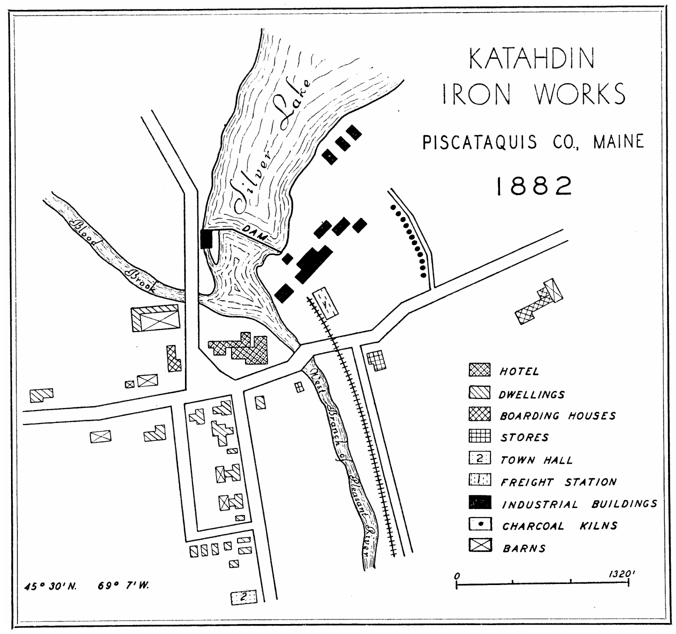

FIG. 5

Hinkley and Egerly, of Bangor, the creditors of Pingree and Company,[5] next undertook to extract the ore. Because of the demand for iron during the Civil War the output at Katahdin Iron Works increased steadily. In 1869 the Bangor and Piscataquis Railroad reached Milo, and the long, expensive haul by team to Bangor was no longer necessary. In 1882 (Fig. 5[6]), in order to improve further the transportation facilities, the Katahdin Iron Works branch of the railroad was built.[7]

About this time the Iron Works had become noted as the source of some of the best tool steel in America. About one hundred men were employed at the mine the year round. This number was increased to three hundred or more during the winter, when the year's supply of wood for making charcoal was cut and hauled to the furnace.

The village in the meantime had become a recreational center as well as a mining town. Located at the outlet of Silver Lake and among the hills in the woods of the central upland of Maine, it attracted a number of summer guests because of its scenery as well as the opportunities it afforded for hunting and fishing.

The rate of growth of the village was not, however, to be maintained. Near the end of the century several economic factors began to discourage further development. From 1843 to 1890 the property had been worked as an iron mine by utilizing the oxidized part or "gossan"[8] at the surface and also the pyritic ore deposited from spring waters issuing along the hillsides. These deposits were practically exhausted by 1890. The large body of pyrrhotite[9] that remained was of a low grade (42-50 per cent iron) and contained much sulphur (26-35 per cent). This made it necessary to put the ore through a special process of desulphurization before it could be smelted. Charcoal smelting also increased the costs of production. Furthermore, competition was encountered from Michigan and other parts of the West, where cheaper ore was available nearer the markets. The business at Katahdin consequently dwindled and was finally abandoned. The last iron was shipped about 1890.[10]

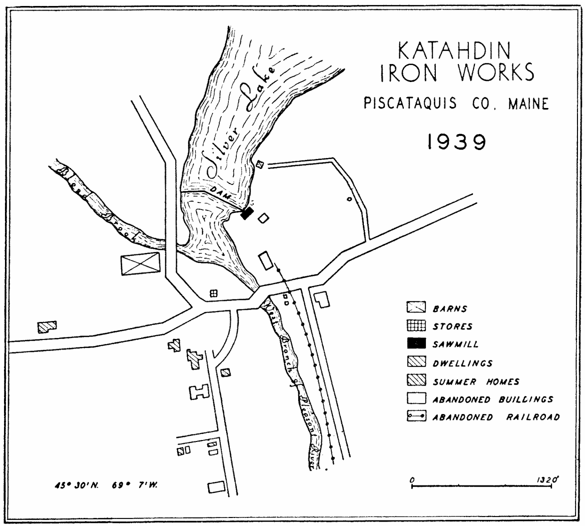

FIG. 6
Note the number of abandoned buildings

The closing of the mines in the township brought about an immediate decline in population. Houses were vacated (Fig. 6); the furnace was allowed to fall into disrepair; and the hotel, destroyed by fire, was never rebuilt. The Katahdin Iron Works branch of the Bangor and Aroostook Railroad was discontinued from Brownville Junction in June, 1922. In 1936 the tracks were taken up. Today the right-of-way is used as a private road into the Iron Works. Only the remnants of the iron furnace, a rock pile, and one large round-topped charcoal kiln are left to tell the story of the industry that had attracted so many inhabitants to the area.

The population curve (Fig. 2) indicates that the settlement entered another cycle in 1890. However, seasonal lumbering and recreational development rather than permanent settlement characterize this later period. Many of the old houses have been turned into summer homes, and new cabins have been built along the banks of Silver Lake, but in 1930 only forty-two persons resided in the township.

CONCLUSION

The four periods of settlement shown by the curve of population may be characterized as follows: the first, as a subsistence agricultural invasion of the wilderness from 1814 to 1821; the second, as an early mining development from 1843 to 1860; the third, as a more intensive mining development from 1860 to 1890; and the fourth, as a seasonal lumbering and recreational development lasting from 1890 to the present day. It was in the second and third periods that the greatest number of people lived in the area. After the mine was abandoned the population retreated to the more densely settled areas to the south. Every now and then there are rumors concerning resumption of work at the mine for the purpose of obtaining sulphuric acid. Should this take place, there would begin another period in the history of the settlement of the township, based on the same natural resource that caused its growth in the nineteenth century.

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* The field studies on which these observations are based were supported by a predoctoral fellowship from the Horace H. Rackham School of Graduate Studies, University of Michigan. The field work was done during the summer of 1938,

1 Toppan, F. W., "The Physiography of Maine," *Journal of Geology*, 43:81. 1935.

[2] Loring, Rev. A., *History of Piscataquis County, Maine* (Portland, Maine, 1880), pp. 220-222

[3] Smith, Edgar Crosby, *Moses Greenleaf, Maine's First Map-Maker*. Bangor, 1902.

[4] Loring, *op. cit*., p. 221.

[5] A box of records of this company that cover the affairs of the concern completely for the years 1845-63, with scattered items for 1832-69, are in the possession of Mr. George T. Carlisle, Jr., president of the Piscataquis Iron Company, Bangor. There are also complete treasurer's records for this period, a copy of the act of incorporation, and a record of the stockholders' meetings, 1846-50, but there is no record of individual holdings. The papers include the following: paid bills, bills of lading, accounts with haulers, vouchers, furnace records, checks, trustees' writs, letters between officials of the company and others addressed to David Pingree. There are an individual record of business done by one Coe and an account of transfer of stock in his favor. Inventories made in 1853 and 1857 and a survey made May 11, 1846, by Charles Jackson, are also available.

[6] Redrawn from *Atlas of Piscataquis County, Maine* (Houlton and Dover, Maine: George N. Colby and Company, 1882), p. 64.

[7] *The Twenty-first Anniversary of the Bangor and Aroostook Railroad*. Bangor, Maine, 1912.

[8] Bastin, E. S., "Large Pyrrhotite Deposits in Maine," *Engineering and Mining Journal*, 104 : 758-759. 1917.

[9] Philbrick, Shailer S., "The Contact Metamorphism of the Onawa Pluton, Piscataquis County, Maine," *American Journal of Science*, Fifth Series, 31 (1936): 9-10.

[10] Some of the information included here was given to the author by Mr. George Knowlton, Postmaster, Katahdin Iron Works, Maine.

A LAND-CLASSIFICATION SURVEY OF MAPLE RIVER TOWNSHIP, EMMET COUNTY, MICHIGAN

WILLIAM W. LEWIS

MAPLE RIVER TOWNSHIP, Emmet County, is an area with its main resource, timber, now depleted and many of its farms isolated and on unproductive soils (see Fig. 1). It is a part of the cutover, submarginal region of Michigan in which attempts need to be made to change the land use. The present uses are as follows: (1) for crops such as wheat, oats, and rye; (2) for forage crops such as hay and clover; (3) for pasture; (4) for timber; and (5) for sites of towns. In addition to these there are, of course, lands now idle (Fig. 2).

A qualitative land-use classification restricts the best area to Sections 11 and 12. Section 16 and Sections 19 and 30 together follow in a scale of decreasing value. In general, with these exceptions, the eastern and western parts of the township are ill suited to agriculture; a strip of the central sections, running north and south, is of fair quality.

On Frank Leverett's map showing the surface formations of the Southern Peninsula of Michigan[1] the western half of the township is shown as land-laid moraines having a soil varying from very stony material to a heavy clay with few stones, whereas the eastern half is represented as sandy lake beds with a light soil.

A detailed soil survey was made to break down this general classification. It is necessary to point out that designated qualities of soils hold true only for the northern part of the state. The best soils in Maple River Township might be rated differently farther south in the state. The soils range in quality from Selkirk Silt Loam and Bergland Clay Loam, good soils if well drained, to Rubicon Sand, one of excessive drainage, or Rifle Peat, a swamp soil (Fig. 3). There has been a complete agricultural utilization of the better soils, and because of their scarcity a considerable extension of substandard farming to the mediocre and even to the poorest soils has resulted.

Land types were determined by the combination of such elements as soils, slope, drainage, and vegetation. It is significant to note the concentrations of farms on the Kalkaska Bench type (compare Figs. 2 and 4). This flat area, which contains productive soil, is bounded on the east by the Rubicon Sand Plains and on the west by the Steep Slope Emmet, which forms a boundary of the westward farm expansion. The Rubicon Sand Plains have a nearly level surface, which is very sandy and excessively drained.

Lumbering has played an important part in the development of the area. Early in the 1870's pine was cut in the eastern sections of the township, floated to Cheboygan, and used for ship timber. Starting in the 'eighties, with the completion of the Pennsylvania railroad between Petoskey and Mackinaw City, lumbering operations were established within Maple River Township. Towns and mills sprang up along the railroad.

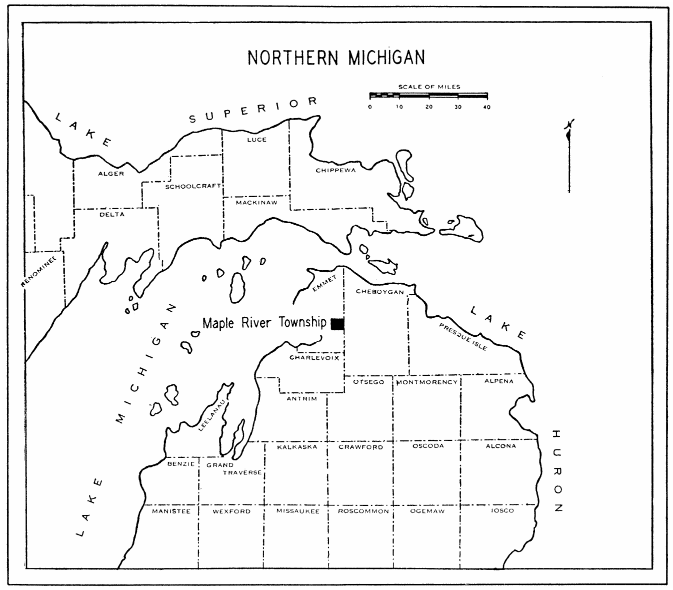

FIG. 1. Location of Maple River Township

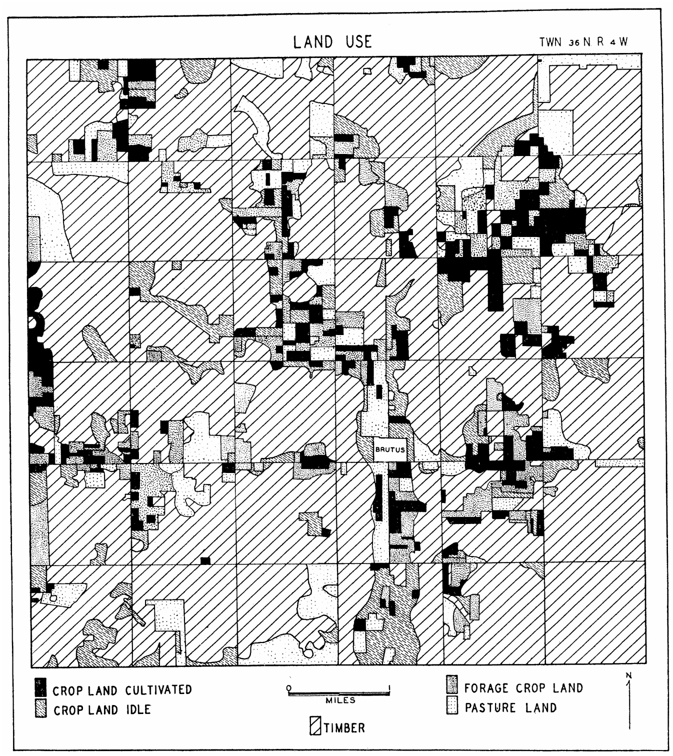

FIG. 2. Present land-use patterns

Agriculture was early developed in the central eastern part of the township, and thence followed the lumber expansion westward. When lumbering fell off after 1910 agriculture likewise declined, with abandoned land appearing first in the northeastern and south-eastern sections. Next to be deserted were lands near the mill towns Brutus and Pellston.[2] After that failure and abandonment spread throughout the township.[3] At the present time there are big tax-delinquent areas (Fig. 5).

A large number of these lands were bid to the state during the last tax sale (1938). Present conditions indicate that many of the remaining tax-delinquent lands will soon be owned by the state. This general situation is strong evidence that a new system of land use is necessary.

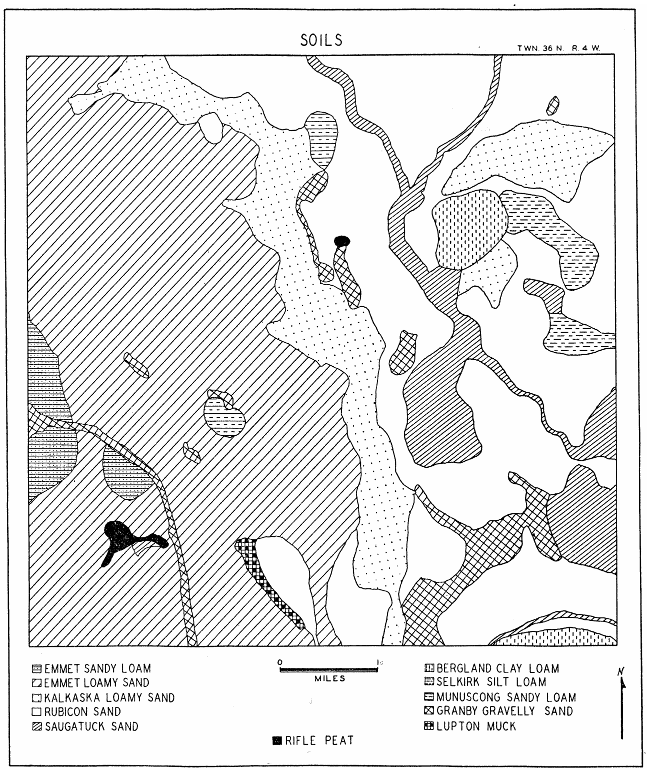

FIG. 3. Distribution of soils

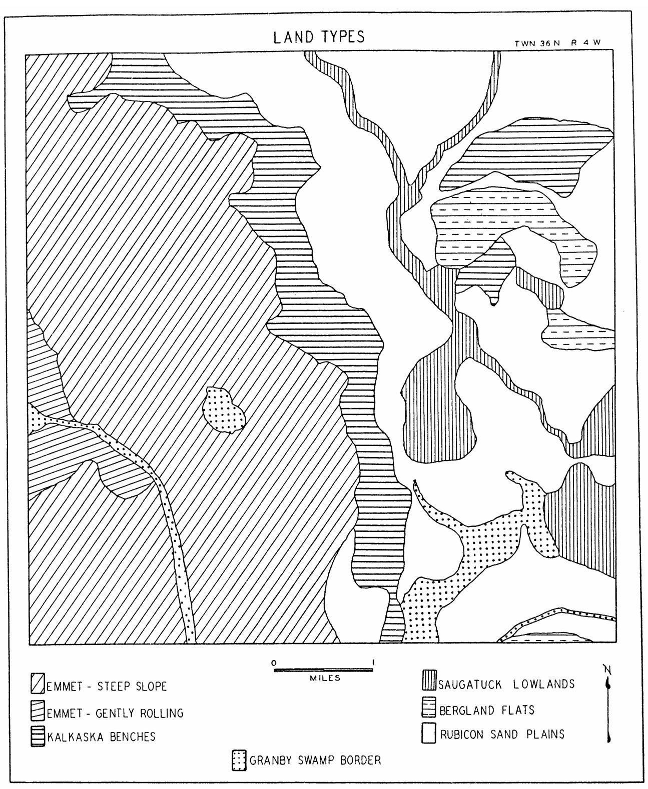

FIG. 4. Distribution of land types

In 1937 the Emmet County Agricultural Planning Committee constructed, under the direction of the county agricultural agent at Petoskey, a land-classification map of the area. The committee was composed of groups of men from each township in the county, who classified their own districts. Personal prejudice shows up but slightly on the completed map.

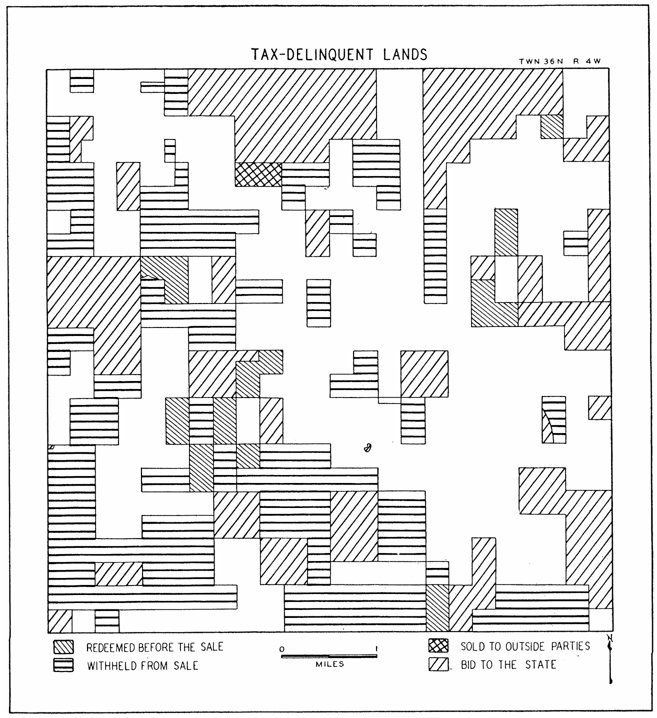

FIG. 5. Disposal of tax-delinquent lands

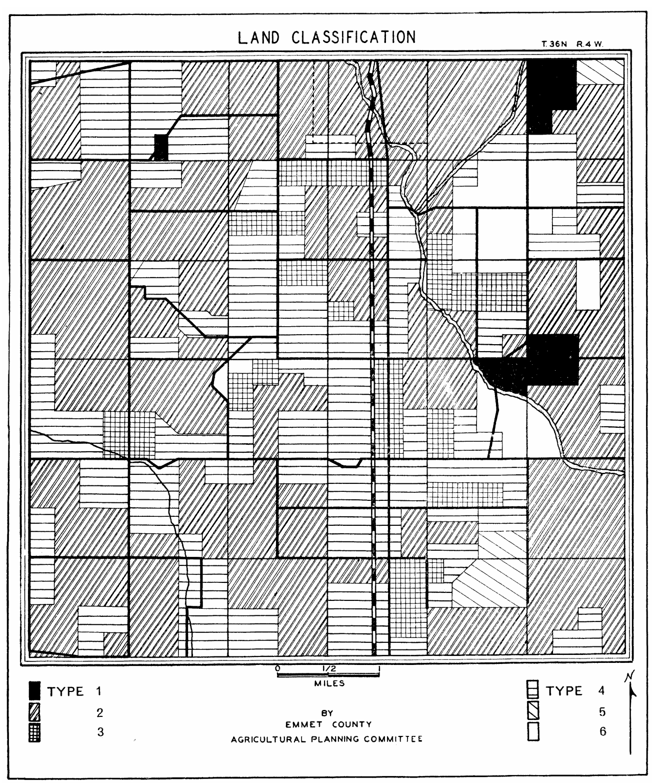

FIG. 6.

The value of the land for agricultural utilization is indicated by the shading, the black sections being the poorest farm land, the white, the best (the original order of the symbols is reversed here)

Six categories were used and are represented on the map (Fig. 6) by land ranging from black, or poor, to white, or the best. They are as follows: (1) areas which now contain farms, but which are not fit to farm and which should be put to some other use; (2) areas which are not now in farms and which should not be used for farms; (3) areas in which it is not certain that farming can be maintained; (4) areas which are not now in farms, but which may be suitable for agricultural development; (5) areas which are now in farms and are suited to farming, but in which important changes in types of farming or in sizes of farms are desirable; and (6) areas that are the best agriculturally and are now in farms.[4] A few of the criteria used in making the classification are: poorness of soil, steepness of slope, isolation of individual farms from settlements so that the cost of roads and schools per family is unduly large, lack of dependable sources of nonfarm work, effort and expense of drainage, and consideration of changes in the type of farming which might require excessive investment in land, buildings, equipment, and labor.

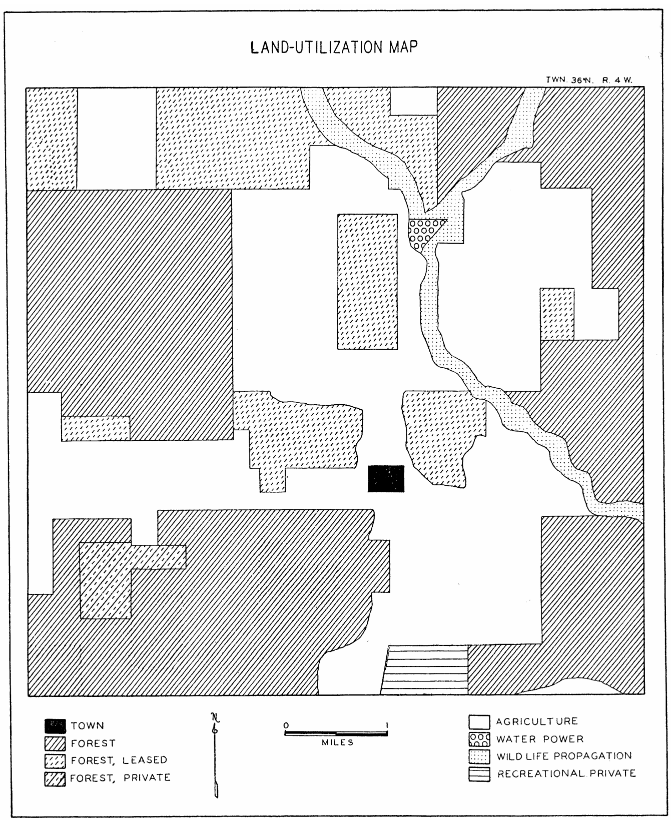

FIG. 7. Suggested land utilization

Because the county classification suggests no use for nonagricultural lands it has been necessary to make a classification which does (Fig. 7). In but a few places is there any strong disagreement between the maps concerning areas which should or should not be used for farming. In nearly every instance tax delinquency was one of the reasons for making a change.

The divisions of future use suggested here are: agriculture, forest, recreation, wildlife propagation, water-power development, and town. Their boundaries were established by a synthesis of maps showing cover and present use, soils, original vegetation, land types, tax assessments, ownership, tax-delinquent lands, house and road classification, and, finally, the county classification.

The forest land was divided into three groups: (1) larger tracts, a great part of them now state-owned, which are to be given blanket protection common for state forests; (2) smaller isolated tracts, now likewise almost completely state-owned, which are to be leased to individuals for their subsistence; (3) an area privately owned.

The wild-life propagation area is restricted to the Maple River and its banks. Possibly this stream might be developed for fishing.

The water-power development, which lies at the confluence of the eastern and western branches of the Maple River, consists of a dam and a hydroelectric plant. It is the property of the Michigan Public Service Company.

The small private recreational area is owned and used seasonally by a hunting and fishing club. The town of Brutus is indicated on the map because it seems likely to survive as the trading center of a small area.

The land-use changes suggested in this paper are designed to improve agricultural conditions in Maple River Township by concentrating farms on the more productive areas. At the same time the cost of maintaining unnecessary public facilities in isolated areas will be reduced, though the size of state-owned tracts will be increased by the combination of separate tracts into consolidated units. Such changes should result in better economic conditions.

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[1] Leverett, Frank, and Taylor, Frank B., "The Pleistocene of Indiana and Michigan and the History of the Great Lakes," *U. S. Geol. Surv., Mon. 53*. 1915.

[2] Pellston is directly north of Brutus on the southern boundary of the adjacent township

[3] Local information

[4] The six categories and criteria for making them were prepared jointly by the Resettlement Administration, the Agricultural Adjustment Administration, Extension, and the United States Department of Agriculture.

SURFACE GEOLOGY OF MONTMORENCY COUNTY, MICHIGAN

STANARD G. BERGQUIST

GENERAL CONSIDERATIONS

MONTMORENCY COUNTY is in the northeastern portion of the Lower Peninsula of Michigan. It forms a part of the physiographic unit commonly referred to as the northern upland and lies about twenty-five miles directly west of Thunder Bay (Fig. 1).

The area was covered by the Huron lobe of the Labrador ice sheet, which deployed over the region of the Great Lakes during the Pleistocene epoch. Upon retreating from the county the ice left in its wake a large amount of debris, which was spread out as a drift cover to bury completely the preglacial rock surface. The thickness of the glacial drift ranges from 100 feet in the northeastern corner of the county to over 800 feet in the southwestern portion (Fig. 2).

The surface expression of the county is characterized by a series of morainic ridges interspersed with trains of gravel and sand and occasional plains of till or boulder clay. The topography grades from rough and rolling in the morainal areas to smooth and level in the overwash plains. The general elevation of the terrain ranges from 1,300 feet in the high morainic uplands to slightly less than 800 feet in the valley of Thunder Bay River, where it leaves the eastern edge of the county near Hillman.

DRAINAGE

Montmorency County is a region of extremely youthful drainage. The large volume of melt water draining off from the ice front in its retreat was responsible for the development of a number of small and aimless streams. The haphazard character of the drainage is exemplified in the numerous swamps and lakes scattered over the surface.

Veatch[1] reports that swampy land occupies about 10 per cent of the total area of the county. Lakes are generously distributed through the county and occupy almost every type of environment available. It is reported that "the county contains 45 lakes of more than 50 acres in size and 3 more than 600 acres, in addition to a great number of small ponds and marshy bodies intermittently covered with water."[2]

Streams are poorly developed, and the drainage pattern is not at all systematic. To a large extent the smaller streams are concentrated in the valley trains between the morainal ridges and flow across floors of pervious sand and gravel, which permit downward percolation. In those areas where clay deposits form the valley bottoms or immediately underlie the gravel it shallow depths the streams are usually fringed with poorly drained swampy lowlands.

FIG. 1. Map showing Montmorency County, the area covered by the report, in black

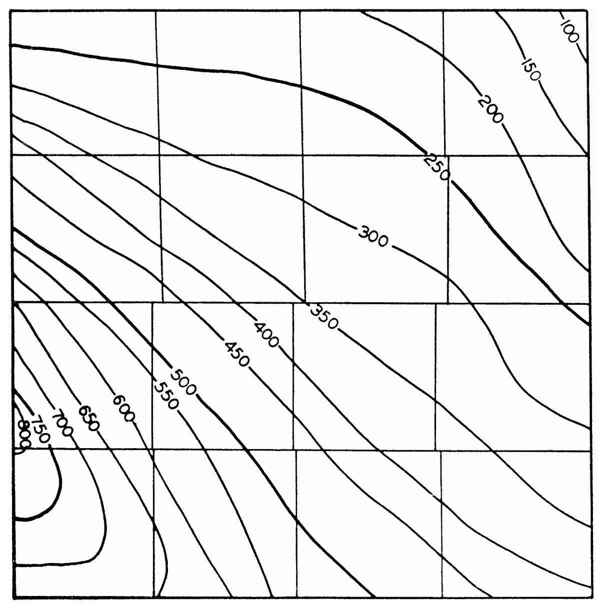

FIG. 2. Isopach map showing thickness of glacial drift in Montmorency County (after Michigan Geological Survey map compiled by James Akers)

After the final retreat of the ice from the county innumerable gullies have developed on the stronger slopes of the moraines. The higher uplands are being thoroughly cut up by rainwash dissection. By selective transportation the finer sediments are carried down slopes and the coarser sediments are being concentrated in the incipient valley ways.

ICE ACTIVITY

Moraines

The main ridge of the Port Huron morainic system cuts diagonally across the southwestern corner of Montmorency County. While this moraine was being constructed the ice front, in its last stand as a continuous mass, rested on the border of the ridge at its contact with the Lewiston outwash plain.

When the ice on the main ridge of the Port Huron system started to break up in the interlobate area directly north of Gaylord in Otsego County the Michigan lobe retired in a westerly direction. Simultaneously the ice in the Huron lobe began a retreat to the east. In its back stepping to the Lake Huron basin this lobe stopped at intervals to lay down a succession of five distinct more or less parallel finger-like morainic ridges trending north and south across Montmorency County.

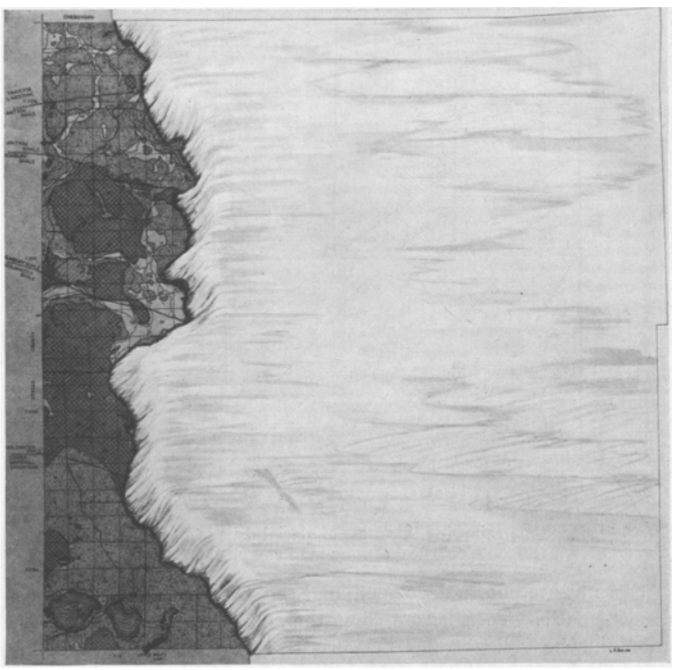

FIG. 3. The first stage of retreat of the Huron lobe in Montmorency County

At their southern ends these ridges are tied in directly with the main moraine of the Port Huron system. This confluent relationship would seem to indicate that the eastward-retreating ice front was pivoted in the ice mass which had been responsible for the development of this moraine. Thus it is logical to assume that the main axis of the Port Huron morainic system east of the interlobate area came out of the ice in piecemeal units. It developed, not as an extended and integrated ridge by northeastward retreat of the glacier, but rather in small segments controlled in development by the retirement of the Huron lobe to the east (Figs. 3-7).

FIG. 4. The second stage of retreat of the Huron lobe

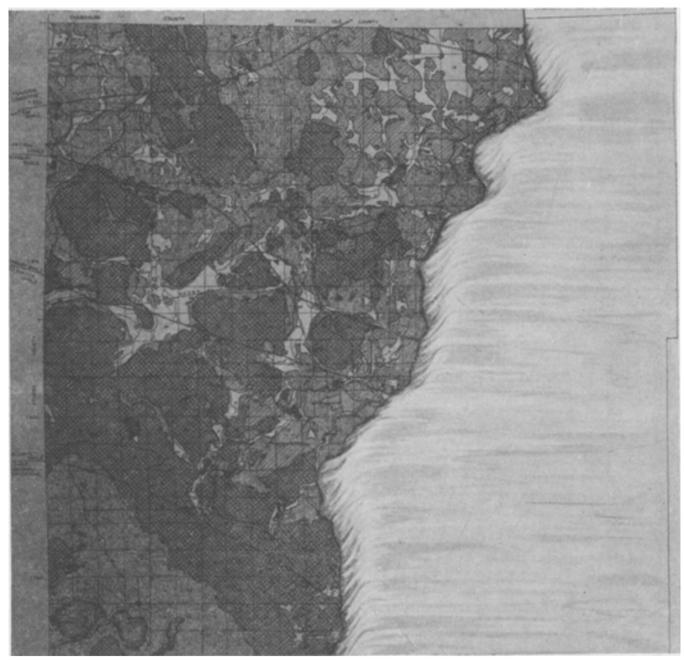

FIG. 5. The third stage of retreat of the Huron lobe

TILL PLAINS

Areas of till plains are not extensively developed iii Montmorency County. Such plains of boulder clay as were formed on the retreat of the ice from the position of one moraine to the next were in large measure buried under glaciofluvial and glaciolacustrine sediments carried out by melt waters from the receding ice front. Aside from the Hillman plain, which occupies some forty square miles in the northeastern section of the county, the till-plain areas occur merely in small isolated patches as outliers projecting through the glaciofluvial floors of the valley ways.

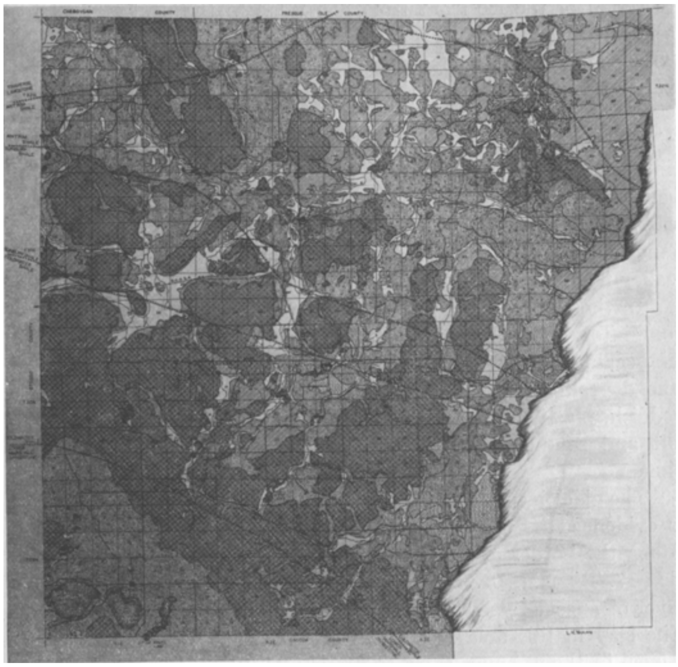

FIG. 6. The fourth or final stage of retreat of the Huron lobe

The Hillman plain comprises almost a complete unit within Montmorency County. It extends eastwardly very slightly into Alpena County. It is a relatively level plain of a fairly heavy till composed largely of boulder clay. A few small eskers and several kames are scattered through the plain, but they are features of minor importance.

MELT-WATER ACTIVITY

Border Drainage — Valley Trains

At each halt of the ice in its retreat eastward across the county melt-water activity was concentrated along the outer margin of the ice sheet. The intermorainic till plains, formed by the rapid recession of the ice front from one ridge to the next, were largely overwashed with gravel and sand deposited by the border streams. Thus there was developed between the morainic ridges a series of valley trains composed in the main of stratified gravel and sand.

The strong transverse ridge of the Port Huron moraine s r ed as a barrier to the southward expansion of the border drainage ways and caused considerable ponding of the excess melt water in the southern ends of the valleys. Into these ponded basins there was carried a great deal of sediment, which was banked up against the inner slopes of the moraines and distributed generally over the valley floors.

In those areas where the water was dammed back for relatively long intervals during the occupancy of the ice on the moraines much fine sediment in the form of stratified clay and silt was sorted out and deposited in the ponded waters. The clay in these deposits is reddish, plastic, and tight In many places it is interstratified with silt and sand and occasionally exhibits evidence of fine lamination.

The glaciolacustrine sediments vary considerably in thickness, as is evidenced by the records of several wells drilled in the county. Along the border of Hunt Creek in the northeastern corner of Section 17, T. 29 N., R. 3 E., a well 75 feet deep encountered a surface layer of 7 feet of yellow sand over a deposit of red clay 65 feet thick. The clay in this area rests on a brown stratified sand and gravel. A well in the swampy tract of Section 34, T. 32 N., R. 4 E. , is reported to have penetrated 114 feet of red lacustrine clay resting directly on gravel In the gravel plain two miles east of Atlanta in Section 8, T. 30 N., R. 3 E., a well 80 feet deep went through 79 feet of reddish lacustrine clay above a bed of gravel. The surface of the clay deposit in this area is covered with a thin veneer of fine-textured yellow sand. The Gilchrist No. 1 well, drilled in the lake plain area in the SE. ¼, SW. ¼, Section 12, T.29 N., R. 3 E., went down to bedrock through 335 feet of alternating beds of red clay and water sand. In the lake plain area on the Thunder Bay River at Hillman 90 feet of alternating beds of sand, red clay, and gravel were revealed in drilling.

From the thickness of these clay deposits it may well be inferred that ponded conditions prevailed in the valley ways for relatively long intervals of time. The amount of sedimentation reflected in the intermorainic valleys should possibly afford a clue to the relative length of time involved in the construction of the several recessional moraines.

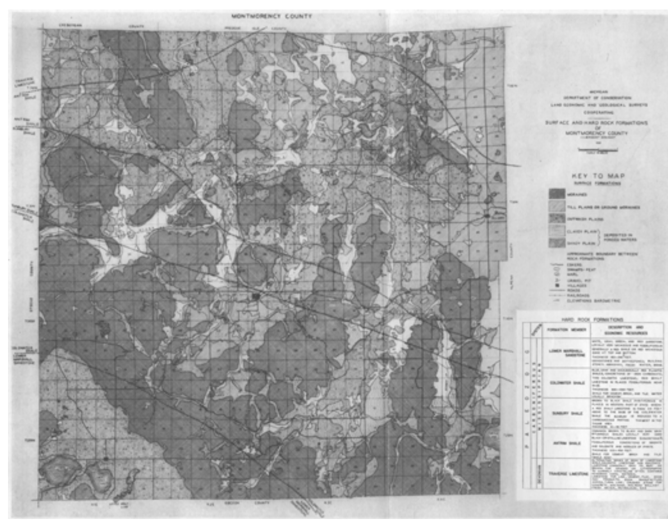

FIG. 7

Of unusual interest to the student of glacial geology is the small area of deeply pitted valley train in the region of Scotty Lake in T. 32 N., R. 2 E. The pits in this section are surface expressions of sink holes developed in the underlying Traverse limestone. They are lined up with the sinks in the Shoepac Lake country of Presque Isle County described by Poindexter.[3]

The caving of the limestone to form the Karst topography undoubtedly took place before the advent of Pleistocene glaciation. In the process of building up the valley train deposit either the melt waters were unable to carry in sufficient sediment to level up completely the surface before retreat of the ice sheet or some of the material was carried away by subterranean streams during or after deposition. The preglacial basins were thus left as partly filled pits when the ice finally disappeared.

OUTWASH PLAINS

Aside from the valley-train deposits distributed between the recessional moraines the only extensive piece of outwash in the county is the Lewiston plain in the southwestern corner. This outwash was laid down by melt waters draining out from the ice front during the construction of the main ridge of the Port Huron morainic system. It is merely a part of the extensive plain that continues into Oscoda and Wexford counties farther south.

In the Lewiston area the plain is composed of sorted and stratified gravel and coarse sand. The surface of the plain is relatively level, except in the pitted areas. Many of the pits are occupied by lakes such as East Twin, West Twin, Big Wolf, Little Wolf, Spectacle, and Crystal.

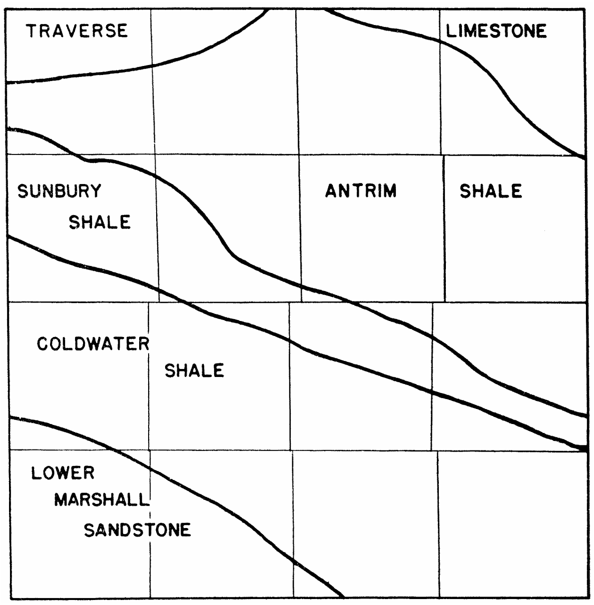

FIG. 8. Areal distribution of formations in Montmorency County (after the Centennial Geologic Map of the Michigan Geological Survey)

GAS SEEPS

Along the marshy borders and bottoms of several of the streamways, namely, Miller, Gilchrist, and Hunt creeks, and also the Thunder Bay River near Atlanta, there are numerous seeps of natural gas. In places the gas is emitted in volume sufficient to be ignited and may burn for many hours before becoming exhausted. In certain areas it boils up through the water under pressure so great that quantities of fine silt and clay are carried upward to form cones which measure five to six feet in height and up to eight and ten feet in diameter at the base. Many of the seeps are extremely active, and the gurgling gas churns the fine sediments into a milky white suspension.

The deposits in which the gas seeps occur are underlain by shale of the Antrim, Sunbury, and Coldwater formations (Fig. 8). These shales, especially the Antrim and the Sunbury, are usually dark and contain appreciable amounts of carbonaceous material, the decomposition of which is undoubtedly responsible for the production of the gas.[4] Eardley[5] contends that the gas has its origin in a middle gas horizon contained in the Antrim shale and that the largest seeps occur in those areas nearest the edge of the contact with the overlying formation.

CONCLUSION

A field study of surface features seems to bear out the view that the ice sheet responsible for the deposition of the main ridge of the Port Huron morainic system in Montmorency County retreated eastward in a series of short halts during the interval of its construction. This conclusion is emphasized in the north-south trend of the minor ridges which lie inside the main moraine in this area and also by the fact that they are attached directly to the axis of the principal moraine.

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ROUNDNESS OF GRAINS IN WESTERN MICHIGAN DUNE SANDS

JAMES LEWIS CALVER

MUCH has been written on the size and the shape of grains of sand. This study is an attempt to discover the amount and the rate of rounding that has taken place in the dune sands in relation to the distance the grains have been blown by the wind. Cressey suggested that the frosted appearance of such sands is "the distinguishing criterion of eolian action."[1] The amount of frosting was studied, but the investigation of this characteristic was later abandoned because it appeared to be very likely that frosting is part of the rounding process, since it was found in beach as well as dune sands. Although there is an increase in the number of frosted grains in dune sands in relation to the distance the sand has been moved by the wind, the frosting was evident only on grains having rounded surfaces.

During the fall of 1937 samples of sand were collected from three dunes on the east shore of Lake Michigan, in the vicinity of Grand Haven, Michigan. Dune I, the longest dune studied, is one mile north of the mouth of the Grand River. The length of this dune from the present lake shore to its apex, which rises about 140 feet above lake level, is 4,600 feet. Dune II, Rosy Mound, lies two and one-half miles south of Grand Haven; it is 4,200 feet in length, and its apex rises to a height of 240 feet. Dune III is eleven miles south of Grand Haven, just north of Port Sheldon. It is 2,800 feet long, with its apex 120 feet above lake level. These dunes were chosen for study because very little vegetation was growing on them.

Duplicate samples of sand were collected at measured intervals from the lake shore to the apex of each dune. Care was exercised to select only recently blown sand on the dune surface, and from a depth of not more than one-half inch. The distance between the stations at which samples were taken was measured by chaining with a hemp rope one hundred feet in length.

A petrographic analysis of sand occurring in the dune one mile north of Grand Haven showed the presence of the following minerals: quartz, orthoclase, microcline, magnetite, garnet, green hornblende, leucoxene, ilmenite, limonite, calcite, and epidote. Quartz, which is by far the most abundant, comprises over 93 per cent of the sand.

In determining the amount of roundness the qualitative method described by Russell and Taylor in their paper on Mississippi River sands[2] was employed. Although they found the method not so accurate as the quantitative one used by Wadell,[3] the results appear to be comparable; as for the visual-classification method, errors due to personal judgment are too small to affect the results seriously.

A mechanical analysis was made of all samples of sand used (about 220 grams in each), and the sand was separated into groups of the following diameters : > 1 mm., 1-½ mm., and < ½ mm. Ten grams of sand finer than ½ mm. in diameter were then separated into groups of ½-¼ and < ¼ mm. The sieves employed were made by the Central Scientific Company of Chicago, Illinois; they were shaken by hand. The results of the analysis are shown in Table I. Inasmuch as approximately 80 per cent of the sand falls into the ½-¼ group, only this sand was used in determining the amount of rounding.

On the average 467 grains were taken from this group for each sample studied and were examined under a binocular microscope. All opaque grains were separated and excluded from consideration; this procedure left about 420 grains to be classified, as follows: angular, subangular, subround, and round. The round and the angular grains were separated first, and the remainder of the sand was later divided into the subround and subangular groups.

The grains that showed no apparent wear and had sharp edges and sharp corners were called angular. Those in which the original form was evident and which appeared to have worn corners and edges were considered subangular. Those that had a rounded surface, with some of the original shape of the grain still visible, were regarded as subround. The ones that had no areas of the original grain distinguishable and possessed a smooth and, frequently, a completely frosted surface were called round. A few grains with freshly broken surfaces were arbitrarily placed in the angular group, even though the rest of the grain was subround or even round.

TABLE I

SIZE FREQUENCY OF DUNE SANDS EXPRESSED IN PERCENTAGES

Sample	Percentages of size groups				Total per cent
	> 1 mm.	1–½ mm.	½–¼ mm.	< ¼ mm.	
Dune I					
Beach	0.47	15.84	71.55	10.81	98.67
2,200 ft.	0.03	2.48	74.40	21.50	98.41
3,400 ft.	0.14	2.38	87.82	9.75	100.09
4,600 ft.	0.13	4.18	81.38	13.39	99.08
Dune II					
Beach	0.00	1.13	65.46	31.59	98.18
2,200 ft.	0.05	2.65	84.00	13.43	100.13
3,400 ft.	2.73	6.38	79.09	11.36	99.56
4,200 ft.	0.06	5.79	88.50	5.18	99.53
Dune III					
Beach	0.00	3.82	76.46	19.23	99.51
2,200 ft.	0.19	3.03	83.42	13.37	100.01
2,800 ft.	0.00	4.13	83.89	11.98	100.00

The method of securing the roundness values is the same as that used by Russell and Taylor.[4] The number is round by multiplying the frequency percentage of grains in each roundness group by an arbitrarily assigned number, as follows : angular, 1 ; subangular, 2; subround, 3 ; and round, 4. The products are then totaled and divided by 100. An example is given in Table II (p. 468). The roundness number obtained, 1.67, indicates that the mean degree of rounding of the sample is two thirds of the way between angular and subangular.

The accuracy of the data was tested in the following way: The grains from one sample were entirely reclassified three weeks after the first determination; the difference in the roundness values was 0.016. A complete test was run with a duplicate sample also. The mechanical analysis was essentially the same, and the roundness value was 0.012 less than the first number determined.

TABLE II

THE METHOD FOR FINDING ROUNDNESS VALUES OF SAND GRAINS AS ILLUSTRATED BY SAMPLE 1 FROM DUNE I

	No. of grains	*Percentage*
Angular	320	$55.6 \times 1 = 55.6$
Subangular	147	$25.5 \times 2 = 51.0$
Subround	86	$14.9 \times 3 = 44.7$
Round	23	$4.0 \times 4 = 16.0$
		$\frac{167.3}{100} = 1.67$

The roundness values found in this study are listed in Table III, and are also plotted on a graph in Figure 1. The first point of each curve represents sand taken from the beach where the waves were still working the material. The difference in these roundness values is explained by the fact that the samples were collected from different localities. Some local variation in the beach sand at Rosy Mound probably accounts for the low value of the first point in Dune II.

TABLE III

ROUNDNESS OF SAND GRAINS

1 = angular; 2 = subangular; 3 = subround; 4 = round

Distance from Lake Michigan	*Dune I*	*Dune II*	*Dune III*
Beach	1.67	1.53	1.84
2,200 ft.	1.71	1.69	1.90
2,800 ft.	....	....	1.92
3,400 ft.	1.77	1.73	....
4,200 ft.	....	1.77	....
4,600 ft.	1.84	....	....

When the roundness values are plotted on semilogarithmic graph paper it is apparent that the rate of rounding is nearly the same in each of the three dunes studied (see Fig. 2). It is evident that this rate in wind sands is an exponential function. In a recent paper Krumbein showed that several sedimentary problems could be studied mathematically.[5] The problems with which he worked were: pebble size on a beach, the thickness of a loess deposit, the profile of an alluvial fan, and the dispersion of glacial boulders in a boulder train. In each he found that an exponential function is involved.

The data used in this study of roundness of dune sands can be treated mathematically also. The distance in feet the sand grains have been blown by the wind is the independent variable, x, and the amount of rounding of the grains is the dependent variable, y. Since y increases geometrically as x increases arithmetically, the relation between the variables is called an exponential function and is ex pressed by the formula $y=mb^{ax}$. The constant m is the value of y when x equals 0; the constant b is the base of the exponential function, and e, the base of natural logarithms, is here chosen; the constant a is the coefficient of x.

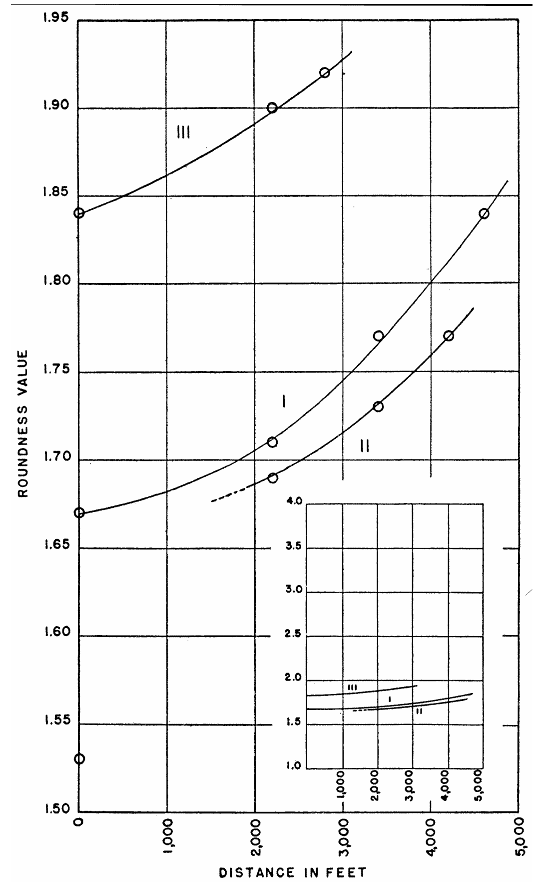

FIG. 1. Average roundness of dune sands near Grand Haven, Michigan

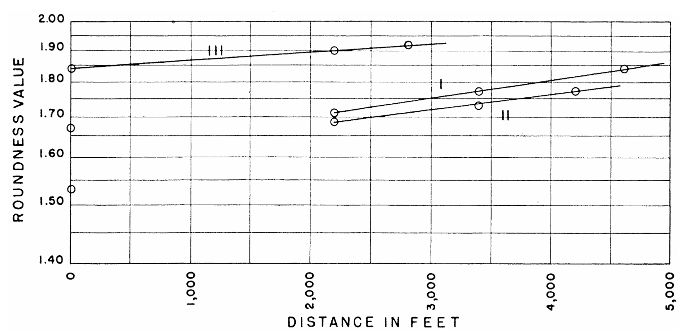

FIG. 2. Semilogarithmic graph of average roundness of dune sands near Grand Haven, Michigan

By substituting the values from Dune III in the equation and solving, the constant a is found to have the approximate value 15 · 106. This value is the *coefficient of roundness;* consequently the formula for the increase in rounding of wind sand in the dune is $y = 1.84e^{15\cdot(10^{-6})x}$. In Dunes I and II, by moving the y-axis to the 2,200-foot point and neglecting the points at the beach, and drawing straight lines through the points, the constant a has the following approximate values: for Dune I $a = 29.5 \cdot 10^{-6}$ and for Dune II $a = 21.5 \cdot 10^{-6}$. It would seem that the general law governing the rounding of sand grains in the area studied would be close to the average of these values, that is, $y = me^{22\cdot(10^{-6})x}$. If this average value is used for *a* the straight lines can be drawn through the points already determined (Fig. 3).

Several factors may affect the roundness of dune sands: the angle of the windward slope of the dune, the velocity of the wind, the amount of vegetation on the dune surface, the degree of inherited roundness, and others. In the sands of Dune III the apparent variation from the average rounding may be explained by one or more of these factors.

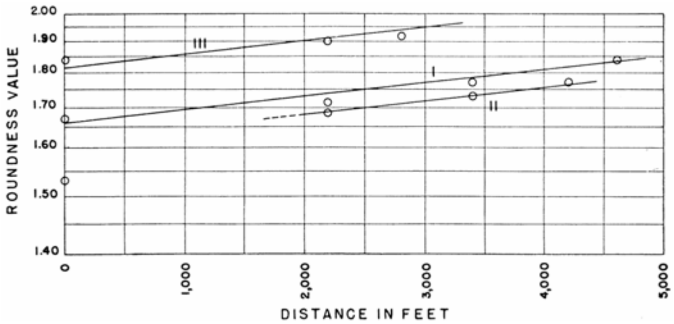

FIG. 3. Corrected semilogarithmic graph of average roundness of dune sands near Grand Haven, Michigan

CONCLUSIONS

More than 93 per cent of the sand in the dunes studied is quartz, and at least ten other minerals make up the remaining fraction.

About 80 per cent of the grains in the dune sands near Grand Haven, Michigan, have diameters between ½ and ¼ mm.

The rate of rounding of dune sand is an exponential function and was determined as: $y = me^{22\cdot(10^{-6})x}$. *y* is the amount of rounding expressed in an index number; *x* equals the distance in feet over which the sand has been blown; *m* is the value of *y* when *x* equals 0; and *e* is the base of the function.

Twenty per cent of the grains in dune sands which have traveled between 4,200 and 4,600 feet from the shore of the lake show some rounding which may be attributed to eolian activity. The increase in the average roundness produced during this transportation by the wind is so small, however, as compared with the inherited roundness, or the amount of roundness possible, that it cannot be used as a criterion to differentiate dune sand from beach sand.

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SOME EXAMPLES OF VENTIFACTS FROM SLEEPING BEAR POINT, LEELANAU COUNTY, MICHIGAN

KENNETH W. DOW

WIND-CUT pebbles occur, often in association with the perched dunes, at many points along the eastern shore of Lake Michigan. Some of the finest of these *Windkanter* may be found on the high wind-swept morainic plateau known as Sleeping Bear Point, in western Leelanau County, Michigan. The existence of ventifacts at this location was first noted by Winchell,[1] in 1886. With the exception of brief allusions, by Waterman[2] in 1926 and by the author[3] in 1937, no further mention of them has been made and no illustrations have ever been given. The purpose of the present paper is not only to illustrate the standard forms but also to describe briefly a few of the unusual wind-cut stones that have been found by the writer on Sleeping Bear Point.

Since the time of Blake,[4] who was one of the first to note the phenomenon, much has been written on the cutting of pebbles by wind action. As Woodworth[5] remarked after observing this process on Martha's Vineyard in 1894, "There can be no question that sands driven by the wind have the power to cut away the surface of rocks on which they impinge. Views at present differ only concerning the manner in which these planes were cut." Views still differ as to the exact method of formation; the work of the various authors has been admirably summed up by Bather[6] and, more recently, by Bryan.[7] The general consensus of opinion regarding small rocks tends to the belief that the shape is determined by the cutting of a surface at right angles to the wind rather than that individual facets are caused by a splitting or dividing of the wind as it passes over the rock. In this paper the classification of Bryan[8] is followed. He divides wind-faceted stones into four main types: (1) ridge-shaped, (2) triquetrous, (3) pyramidal, and (4) irregular. Examples of the first three types, which may be called standard forms, are commonly found on Sleeping Bear Point.

1. *Ridge-shaped type*

In Plate I, Figure 1, the pebble in the upper left-hand corner displays a single broad flat facet. The specimen in the upper right-hand corner is a more highly developed example of this type, in which two facets are inclined toward each other to form a ridge, with other facets existing at one or both ends.

2. *Triquetrous type*

At either end of the bottom row in Plate I, Figure 1, are stones which verge on the triquetrous or “Brazil-nut” shape, transition forms from the ridge type. This triquetrous shape, commonly found in small elongated pebbles, is the result of erosion around the base, with forward overturning of the pebble to expose a fresh surface to the wind.

3. *Pyramidal type*

A typical illustration of the pyramidal type is given in the bottom row, center, of the same figure. In this instance six facets converge toward a common point to form a rough pyramid. The small flat area in the middle may represent a remnant of the original top surface.

4. *Irregular type*

The ventifact in the top row, center, of Plate I, Figure 1, because of the peculiar hollowed facet, would be classed as “irregular.” The hollowing may have resulted from diffission or from the chipping off of a fragment. On the under side of the rock, however, is a distinct oval depression, and the hollowed facet on the upper surface is undoubtedly a reworking and polishing by the wind of a similar feature. It should be noted that the original form of the pebble often influences the shape of the wind-cut surface.

A most unusual ventifact of the irregular type is shown in Plate I, Figure 2. The outer portion of this rock, which is basaltic in character, appears to differ slightly from the core in hardness. The specimen seems to be not an example of a desert rind such as is described by Hobbs,[9] but, rather, the result of exfoliation — aided by a natural local variation in the constituents of the rock — with subsequent unequal cutting by the wind.

Plate II, Figure 1, shows another interesting product of wind action. Facets have been cut by the wind on a rather large glacial boulder without completely obliterating a series of crescentic cracks, or gouges, which have all the appearance of being a form of chatter mark. Chatter marks are usually found on a bedrock surface rather than on a loose boulder (see Chamberlin[10] or Russell[11]). If these cracks are chatter marks, however, the rock offers an unusual illustration of the results of the abrasion of a rock surface by two agents completely different in character — wind and ice. For comparison an example of genuine chatter marks from the Holland Quarry near Sylvania, Ohio, is given in the lower right-hand corner of Plate II, Figure 2.

Many forms of wind-cut rock in addition to the faceted types described are found on the plateau at Sleeping Bear Point. Typical of these wind-scoured, or wind-shaped, stones are the specimens shown in Plate II, Figure 2. The softer rocks are likely to exhibit pitting. Scouring along bedding planes occurs, and, as is evident in the illustration, fluting may be found in both the soft sandstones and the more resistant basaltic forms. There may also be undercutting, as in the largest specimen in this figure, a piece of red quartzite; or harder veins in a rock may be brought into relief, as in the specimen just to the left of the fragment showing chatter marks.

Excellent examples of unusual wind-worn stones as well as of standard types may still be found on Sleeping Bear Point, Leelanau County, Michigan. If, as is believed, the shape is determined primarily by the cutting of a surface at right angles to the wind, the general orientation of the wind-cut pebbles on Sleeping Bear Point would indicate winds Predominantly from the southwest. Owing to the growing Popularity of Sleeping Bear Point as a recreational area in recent years, however, and to its increased accessibility through the use of motor cars on the plateau surface, good wind-worn pebbles will soon become scarce. It is for this reason that a description of them is presented while they may yet be ob served in considerable variety.

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DOW PLATE I

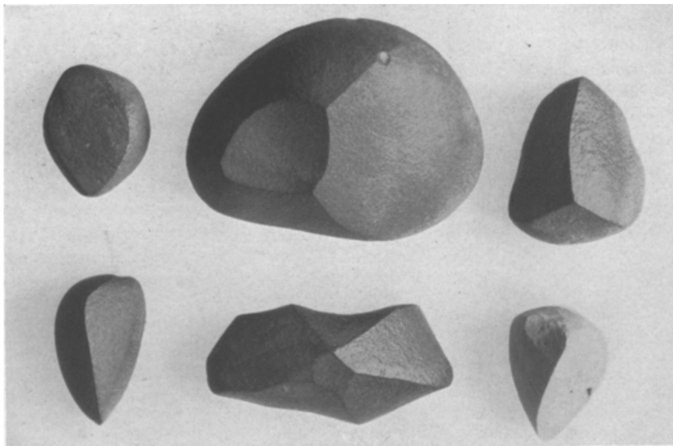

FIG. 1. Typical ventifacts from Sleeping Bear Point, Leelanau County, Michigan. About x ½

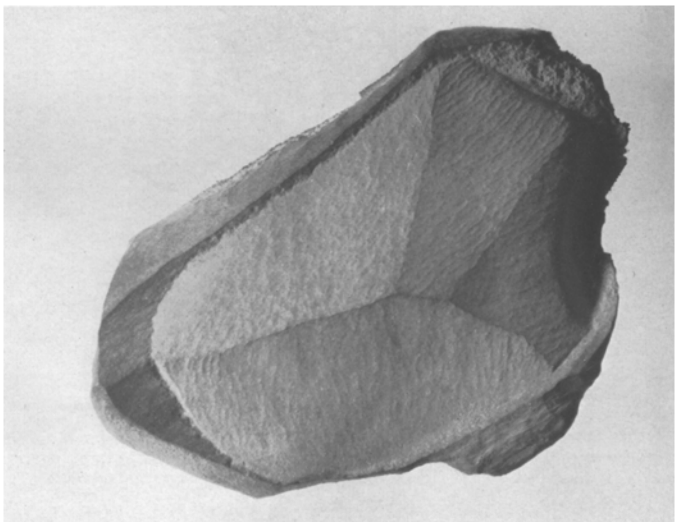

FIG. 2. Ventifact showing unequal cutting by the wind subsequent to exfoliation. About x ½

DOW PLATE II

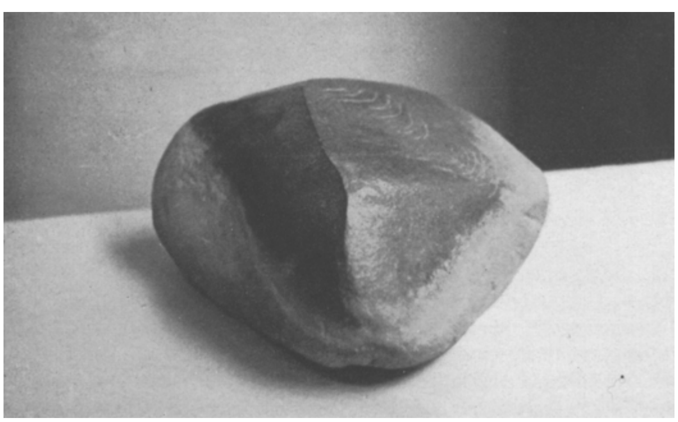

FIG. 1. Ventifact with crescentic gouges or chatter marks. X ¼

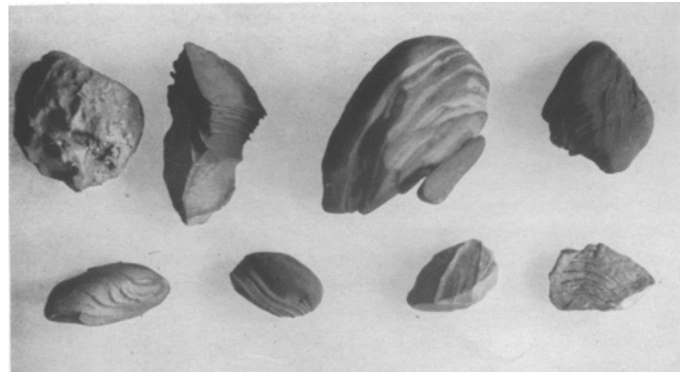

FIG. 2. Wind-scoured, or wind-shaped, stones from Sleeping Bear Point. Specimen showing chatter marks (lower right-hand corner) is from Holland Quarry near Sylvania, Ohio. All specimens about x ½

CONDITIONS AT THE FRONT OF A RETREATING ICE SHEET

WILLIAM H. HOBBS

EARLY studies of Pleistocene continental glaciers were under- taken before existing glaciers of this type had become known. The only glaciers known were mountain glaciers of the Alpine type, and the picture of conditions as regards climate and meteorology involving accretion and wastage of the ice, its movements, and the erosional and depositional conditions were all drawn from comparison with the same source — the small glaciers of the Alpine highland.

Both in Europe and in North America, where the Pleistocene glaciers were studied within the early period, the glaciers spread out for the most part over a flat terrane and within middle latitudes. Without knowledge of the autocirculation which characterizes the air above existing continental glaciers the Pleistocene glaciers were conceived to have had meteorological conditions much the same as do those of today within the same areas. Nourishment was thought to have been derived from invading surface air currents which were compelled to give up their moisture, much as do the moisture-laden clouds when they encounter elevated land areas. The shieldlike form of the glacier was explained throughout by a sort of viscous flow which obtained within the mass.

The Pleistocene ice sheets deposited materials — moraines and drumlins — which were left behind as the ice progressively wasted, and these naturally supply data which we are unable to derive from any existing glacier, where the bed is nowhere over any large area exposed for observation. The convexly festooned pattern of the moraines, with their intervening ground moraine and covering outwash, has been splendidly worked out, as has been also the history of the postglacial lakes.

As to conditions about the front of the glacier, that is quite another story, and here the existing continental glaciers permit us to correct the traditional picture. True, the existing ice sheets lie in very high latitudes and where they are best known are also in areas of high and rugged topography. They therefore throw even more light upon glaciation in New England than in the prairie areas.

Some of the facts which have been derived from their study are the following:

(1) The wind system above these glaciers is quite unlike the traditional one for Pleistocene ice sheets — a procession of cyclones which moved over them as over the area today. It is an autocirculation (glacial anticyclone) such that all strong surface winds blow downward and outward off the glacier and onto the surrounding territory.

(2) The nourishment of the glaciers by snow is not as formerly supposed — largely peripheral and due to upwardly directed air currents — but is more central to the mass and is explained by downwardly directed currents which bring moisture from higher to lower levels.

(3) The shaping of the mass is in part at least due to the centrifugal snow broom of the glacial anticyclone, which whenever in action is carrying snow outward toward the borders, so that the annual snow increment of the glacier thickens at an accelerating rate toward the margin, where it may even be piled up as marginal masses banked against the front.

(4) All relatively rapid internal movements of the glacier are restricted to the outer fifty miles, wherein the surface slope is sufficiently steep to induce movement.

(5) Melting and wastage of the ice and glacial and extraglacial water flow are restricted to the short summer season and respond quickly to the changes in air temperature from day to day. At such times huge blocks of ice from the glacier front are transported as bergs by the braided streams of the outwash, and these may support large boulders, which become either wholly or completely embedded in the sand plains outside the glacier front.

(6) At the end of the warm season the drainage ceases entirely, the extramarginal sand plains then quickly dry out, and the wind takes the place of water as a transporting agent. A glacial desert condition thus comes into existence, with the production of pebble pavements on most outwash surfaces. The sand which is lifted is carried to more sheltered areas, where it forms dunes, and the dust is laid down over broad areas farther out to form loess deposits covered with tundra vegetation.

The stranded and partially embedded boulders of the sand plains, unprotected as they are on their exposed surfaces, become deeply etched by the sandblast and are thus transformed into “anvil stones” wherever they have dikes, veins, or nodules of harder material.

(7) Wherever there are outlet tongues from the inland ice and these are held within high rock walls, they become channels or “bellows pipes” for the fierce and warm outward air currents, and are wasted by melting wherever rock dust has blown on to the surface. Since melting is promoted chiefly through contact and by radiation from rock surfaces, the glacier outlet is melted down in moats next to the rock walls, and these become channels for meltwater drainage, though much choked by sand, pebbles, and even boulders derived from the melting ice. Thus there arise “kame terraces” of the sort now recognized within areas of Pleistocene glaciation which have accented topography, such, for example, as New England.

(8) During the summer season the crevasses of the border zone of the glacier become the courses of drainage from the surface to the bed below, and they are in some cases so widened and extended as to separate sections of the glacier from the parent mass. This separated portion, being no longer fed by material arriving from higher levels, becomes stationary — stagnant. Examples of this were re ported by the British glacialists of both of Scott’s Antarctic expeditions — Ferrar of the first and Taylor of the second. The ice slabs of Ferrar, which later became the Blue, Garwood, Davis, Ward, Howchin, Miers, and Hobbs glaciers of the McMurdo Sound region in the Antarctic, all illustrate this. The great Taylor glacier, though still connected with the Ferrar glacier above it, is nonetheless stagnant. Glacialists such as Anderson, Flint, Goldthwait, and others have now tardily recognized this condition for different areas of Pleistocene ice sheets, and it is certain to assume much greater prominence in future studies.

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A CENSUS OF MASTODON REMAINS IN MICHIGAN

ARCHIE MACALPIN

TWO years after Michigan became a state James Henry Lanman (1839) reported the discovery of "the remains of a mammoth" in Van Buren County. They were probably mastodon bones; if so, they constitute the first known record of such a find in Michigan. For a hundred years everything from vague rumors to authenticated reports about similar finds has trickled into the literature and correspondence. Reports reaching the University of Michigan since 1908 have been carefully preserved by Dr. E. C. Case, and those sent to Michigan State College at East Lansing have been referred to him by Dr. W. A. Kelly. Many were investigated, and parts of thirty-two of the Michigan specimens were acquired for the University Museum. Incomplete lists of discoveries of mastodons in Michigan have been made by Hubbard (1840), Winchell (1861), Lane (1902, 1906), Dice (1920), and Hay (1923), whose publications are given at the end of this article.

The one hundred and seventeen specimens listed here probably represent considerably fewer than half of those found within the state since 1839. Many fossils have been destroyed or improperly recorded because the finder was ignorant of their worth or the methods of caring for them. Mastodon bones are extremely fragile on exposure to air, so that they require expert handling to be correctly exhumed and preserved. In spite of these difficulties enough have been found to give one a hint of the vast numbers of animals that once roamed the state.

The material for this census is taken from my "Survey of the Occurrence of Mastodon Remains in Michigan," submitted in February, 1939, to the Geology Department of the University of Michigan. This list is arranged by counties in alphabetical order. The data comprise (1) numbers corresponding with those on the map to designate the sites in each county (see Fig. 1); (2) towns near the places where remains were discovered, together with the section, township, and range; and (3) summary statements of the material found. Much more detailed information is available in the original survey, which contains, provided such information was obtainable, items (1) and (2) as just noted; (3) a complete list of the bones reported; (4) a description of the vertical section; (5) the name of the finder and the date of discovery; (6) the present location of the specimen; and (7) a bibliography of the literature, together with all the correspondence and clippings pertaining to the find that I could discover.

Though most of the finds are well authenticated, some are not traceable, and the records may be inaccurate. The Geology Department of the University of Michigan will greatly appreciate any corrections of the list and a detailed report of new discoveries. Only by the continual accumulation of accurate data can the time of these animals be defined and their habits become better understood.

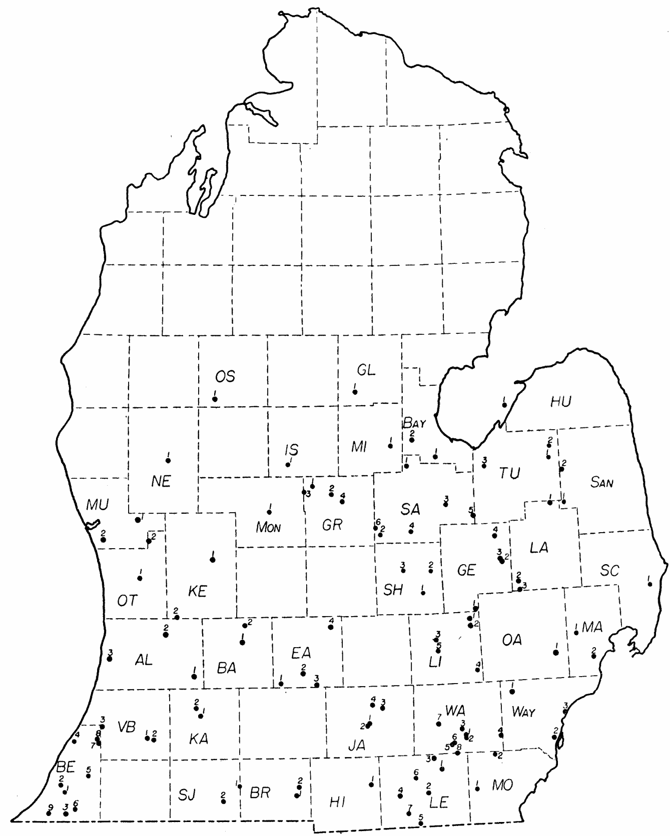

FIG. 1. Distribution of discoveries of mastodon remains in Michigan

KEY TO COUNTIES

AL — Allegan	HI — Hillsdale	MA — Macomb	SA — Saginaw
BA — Barry	HU — Huron	MI — Midland	SAN — Sanilac
BAY — Bay	IS — Isabella	MO — Monroe	SC — St. Clair
BE — Berrien	JA — Jackson	MON — Montcalm	SH — Shiawassee
BR — Branch	KA — Kalamazoo	MU — Muskegon	SJ — St. Joseph
EA — Eaton	KE — Kent	NE — Newago	TU — Tuscola
GE — Genesee	LA — Lapeer	OA — Oakland	VB — Van Buren
GL — Gladwin	LE — Lenawee	OS — Osceola	WA — Washtenaw
GR — Gratiot	LI — Livingston	OT — Ottawa	WAY — Wayne

No record of the embedding material or the depth of burial was available for 41 of the 117 fossils. Fifty-one specimens, or about two thirds of the remainder, were found in p or black, mucky soil; an additional four were enclosed partly in peat and partly in marl. These muck- or peat-buried remains were from a few inches to six feet below the surface. Many of them were lying directly on sand, till, marl, or clay. Of course, the preserving quality of peat accounts largely for our being able to recover so many remains; nevertheless such a preponderance of fossils on the sites of former lakes and swamps must indicate that these lowlands were a favorite habitat of the mastodon. The other finds were buried in sand, gravel, or silt of present streams, and marl of present or recently extinct lakes. A number of remains were at greater depths; bones in river deposits were from 7 to 15 feet deep, those in the lake marls about 20 feet, and a few in sand and gravel of undetermined origin from 1 to 30 feet. I have been unable to visit the sites of these discoveries, so that this information is based almost entirely upon the records available.

Except for three or four scattered localities in Canada (Hay 1923; Gilmore, 1908) the sites of discoveries of *Mastodon americanus* occur south of a line roughly following the forty-fourth parallel of latitude. In Michigan the localities are south of a line from Ludington, Mason County, to Standish, Arenac County. In New York all but one lie south of the location of the Rochester-Syracuse glacial-lake outlet. This distribution is so sharply marked that it has tempted me into much speculation regarding its cause.

The following modern forms of animal and plant life have been found associated with mastodon remains in Michigan: deer, wapiti, and fresh-water mollusks; and white spruce, black spruce, and tamarack. The only extinct form known to be thus associated is *Castoroides*, a giant beaver, reported by Hay from the town of Adrian, Lenawee County.

No evidence from fossils that proves the presence of mastodons prior to the advance of the Wisconsin glacier has been reported in Michigan. Their bones have been found elsewhere in earlier beds, but may be missing in Michigan because deposits containing such remains were disturbed by the last ice sheet.

I have located, by means of Leverett and Taylor's glacial map of the Southern Peninsula of Michigan (1915), the various types of deposits over which mastodon finds have been made. They are as follows:

	Percentage
Glacial drainage-channel material	26
Terminal moraines, mostly in peat	22
Ground moraines, mostly in peat	17
Sandy lake deposits	13
Glacial lake-bottom clays	10
Sandy drift, not definitely morainic	6
Other types	6

With one or two possible exceptions (MacCurdy, 1920) the remains occur above material of Wisconsin age, mainly in the muck and fillings of lakes and ponds.[1] This indicates that enough time had elapsed between the retreat of the ice and the invasion by the mastodons for plentiful vegetation to become established over a terrain very much like the present one. The fossils found over glacial-lake bottom clays show that the mastodons persisted in Michigan at least until the Great Lakes reached approximately their modern shore lines.

The abundance of mastodons found in Southern Ontario may serve to prove their existence during later glacial-lake times. If we may assume that a broad river can act as an effective barrier to the migration of mastodons, then, according to Leverett and Taylor's glacial-lake interpretations, there were three significant times when these animals might have migrated into Ontario: (1) during the Grassmere stage of Lake Lundy, when a mere shallow strait connected the Huron and the Erie divisions of the ancestral Great Lakes; (2) during the Kirkfield stage of Lake Algonquin, when discharge occurred at the Kirkfield outlet and the Port Huron outlet was dry; (3) during the early stage of the Nipissing Great Lakes, when discharge was through the Nipissing-Mattawa River previous to the final Port Huron outlet stage.

From the evidence at hand I conclude that the American mastodon arrived in Michigan after the ice had retreated from most of the Lower Peninsula, but before it had retired from the continent. Estimates of the length of time since the Wisconsin glacier left Michigan vary from 20,000 to 50,000 years, with the smaller figure more probable (Leverett and others).

Michigan seems to offer little or no evidence upon which an approximation of the time of the extinction of mastodons might be established. The shallow depths at which they are buried in bogs still actively accumulating peat point to a surprisingly recent date. Any estimates based on the rate of peat deposition are inconclusive because the rate of accumulation varies greatly owing to droughts, fires, and changes in local drainage.

Rather numerous accounts of mastodon fossils occurring with human artifacts and of Indian myths relating to elephant-like animals are reported from areas outside Michigan, but will not be reviewed here. The opinion of many writers, including myself, is that mastodons have only recently become extinct in North America and that they may have lived into historic times.

LOCATIONS OF FINDS OF MASTODON REMAINS

The abbreviations in parentheses after names of counties are those used on the map (Fig. 1). Numbers at beginnings of lines correspond with those employed on the map to indicate the sites of finds. Parentheses around such numbers signify that the sites are unknown,

Allegan County (Al)

1. Gun River, possibly in T. 1 N. , R. 11 W. One tooth.
2. Door, four miles west, approximately in T. 4 N., R. 13 W. Teeth and jawbone.
3. Fennville, four miles southwest, approximately in Sec. 11, T. 2 N., R. 16 W. One tusk.

Barry County (Ba)

1. Hastings, possibly in Sec. 16, T. 3 N., R. 8 W. One tusk.
2. Carlton, possibly in T. 4 N., R. 8 W. Teeth and bones.

Bay County (Bay)

1. Frankenlust, in the SW¼ Sec. 1, T. 13 N., R. 4 E. "Traces."
2. Auburn, in the SW¼ Sec. 3, T. 14 N., R. 3 E. Tusk, tooth, and bones.

Berrien County (Be)

1. Snow, in Sec. 36, T. 6 S., R. 19 W. One tooth.
2. Baroda, approximately in Sec. 23, T. 6 S., R. 19 W. Tusk, teeth, and bones.
3. Galien, approximately in Sec. 1, T. 8 S., R. 19 W. Tooth and some bones.

4. In the bed of the Paw Paw River. Exact location doubtful. Teeth and bones of possibly two specimens.

5. Eau Claire, in Sec. 32, T. 5 S., R. 17 W. Teeth and some bones.

6. Bakertown marsh, near Buchanan, in Sec. 3, T. 8 S., R. 17 W. Evidence of six mastodons.

7. Watervliet, three and one-half miles southeast, approximately in Sec. 1, T. 4 S., R. 17 W. One tusk.

8. Watervliet, two miles southeast, approximately in the SW¼ of T. 3 S., R. 17 W. One tusk (may be the same as 7).

9. Three Oaks, two miles east, approximately in Sec. 1, T. 8 S., R. 20 W. One poorly preserved skull, with teeth.

10. Baroda, in the NE¼ SE¼ Sec. 17, T. 6 S., R. 19 W. Four teeth.

Branch County (Br)

1. Archer's Lake, approximately in Sec. 5, T. 7 S., R. 5 W. Bone fragments.

2. Quincy, in a small marl lake, in T. 6 S., R. 5 W. One tooth.

Eaton County (Ea)

1. Bellevue, in Sec. 28, T. 1 N., R. 6 W. Tusk, teeth, and bones.

2. Olivet, four miles northeast, in the NW¼ Sec. 11, T. 1 N., R. 5 W. Eight teeth and many bones.

3. Narrow Lake, approximately in Sec. 33, T. 1 N., R. 4 W. Teeth and bones.

4. Millett, three miles northwest, in the SW¼ Sec. 21, T. 4 N., R. 3 W. About two thirds of a skeleton.

Genesee County (Ge)

1. Fenton, approximately in Sec. 36, T. 5 N., R. 7 E. "Remains."

2. Davison, in T. 7 N., R. 8 E. One femur.

3. Davison, in Sec. 4, T. 7 N., R. 8 E. Tusk, teeth, and bones.

4. Otisville, in Sec. 30, T. 9 N., R. 8 E. Two teeth.

Gladwin County (Gl)

1. Beavertown, possibly in T. 17 N., R. 1 or 2 W. Owner would not disclose exact locality. Tooth and bones.

Gratiot County (Gr)

1. Alma, in the S½ NW¼ Sec. 22, T. 12 N., R. 4 W. Teeth and bones.

2. Alma, in the NE¼ NE¼ Sec. 3, T. 11 N., R. 3 W. Parts of three specimens.

3. Riverdale, approximately in Sec. 31, T. 12 N., R. 4 W. Large number of bones and teeth.

4. Ithaca, four miles north, in the SW¼ Sec. 17, T. 11 N., R. 2 W. Skull and other bones.

Hillsdale County (Hi)

1. Church, approximately in Sec. 21, T. 6 S., R. 1 W. Most of a skeleton.

Huron County (Hu)

1. On an island in Saginaw Bay, near Sebewaing. Location indefinite. Pieces of bone.

Isabella County (Is)

1. Fremont, four miles southwest, in the SW¼ SW¼ Sec. 24, T. 13 N., R. 5 W. One tooth.

Jackson County (Ja)

1. Jackson(?), possibly T. 2 or 3 S., R. 1 W. Owner would not disclose exact locality. One tooth.

2. Jackson, about one thousand feet east of center of Sec. 9, T. 3 S., R. 1 W. Left ulna and radius.

3. Root State Prison Farm, in Sec. 8, T. 2 S., R. 1 E. Tusk, teeth, and bones.

4. Portage Creek, approximately in the N of T. 2 S., R. 1 W. Several bones.

Kalamazoo County (Ka)

1. Valley flat of Kalamazoo River, in T. 2 S., R. 11 W. One bone,

2. Kalamazoo, in Sec. 3, T. 2 S., R. 11 W. Tusk, teeth, and many bones.

Kent County (Ke)

1. Cannonsburg, approximately in Sec. 23, T. 8 N., R. 10 W. Lower left molar.

2. Ross, in Sec. 34, T. 5 N., R. 12 W. Parts of three tusks and one tooth.

Lapeer County (La)

1. Clifford(?), possibly in T. 10 N., R. 11 E. Owner would not disclose locality. Tooth.

2. Hadley, a village in Sec. 21, T. 6 N., R. 9 E. Tooth.

3. Big Fish Lake, in Sec. 33, T. 6 N., R. 9 E. Tooth.

Lenawee County (Le)

1. Tecumseh, in Sec. 33, T. 5 S., R. 4 E. Part of tusk, tooth, and bone fragments.

2. Adrian, in Sec. 2, T. 7 S., R. 3 E. Lower jaw.

3. Clinton, in Sec. 7, T. 5 S., R. 4 E. Foot bones.

4. Clayton, middle of the line between the SE¼ and the NE¼ SE¼ Sec. 7, T. 7 S., R. 2 E. Lower jaw.

5. Weston, two and one-half miles south, in Sec. 32, T. 8 S., R. 3 E. Three vertebrae and parts of leg bones.

6. Adrian, seven miles northeast, in Sec. 7, T. 6 S., R. 3 E. Tusks, teeth, and many bones.

7. Seneca, two and one-half miles northeast, approximately in Sec. 9, T. 8 S., R. 2 E. Tusks and bones.

Livingston County (Li)

1. Exact locality not known. T. 4 N., R. 6 E. A femur.

2. Tyrone, between Secs. 27 and 28, T. 4 N., R. 6 E. Tooth.

3. Shiawassee River, in T. 3 N., R. 4 E. Tooth and pelvis.

4. Green Oak, approximately in Sec. 11, T. 1 N., R. 6 E. Molar.

5. Howell, two miles southwest, approximately in Sec. 3, T. 2 N., R. 4 E. Tooth.

Macomb County (Ma)

1. Clinton River valley flat, in the E½ NE¼ Sec. 31, T. 3 N., R. 12 E. Teeth and jawbone.
2. Mt. Clemens, four miles south, approximately in Sec. 33, T. 2 N., R. 13 E. Teeth and many bones.

(3) Exact locality not known. Molar and bones.

Midland County (Mi)

1. Midland, in T. 14 N., R. 2 E. Exact location not given. Tooth.

Monroe County (Mo)

1. Petersburg, approximately in Sec. 3, T. 7 S., R. 6 E. "Remains."
2. Oakville, in Sec. 3, T. 5 S., R. 7 E. Tusk, teeth, and bones.

Montcalm County (Mon)

1. Stanton, in the NE¼ corner of T. 10 N., R. 7 W. Teeth.

Muskegon County (Mu)

1. Moorlands, two miles north, in the NE¼ NE¼ Sec. 16, T. 10 N., R. 14 W. Larger part of skeleton.
2. Exact locality not known. T. 9 N., R. 16 E. Tusk, teeth, and bones.

Newago County (Ne)

1. White Cloud, in northern part of T. 13 N., R. 12 E. "Tooth or jawbone."

Oakland County (Oa)

1. Birmingham, three miles northeast, approximately in Sec. 32, T. 2 N., R. 11 E. Tusk, teeth, and bones,

Osceola County (Os)

1. Hersey, in the NE¼ Sec. 24, T. 17 N., R. 10 W. Tooth.

Ottawa County (Ot)

1. Allendale, approximately in the SW¼ corner of Sec. 21, T. 7 N., R. 14 W. Many bones.
2. Conklin, two and one-half miles northwest, in the S½ NW¼ Sec. 19, T. 9 N., R. 13 W. About a hundred bones.

Saginaw County (Sa)

1. Saginaw, ten miles northwest, 0.25 mile N of S line of Sec. 20, T. 13 N., R. 3 E. Tusk fragment.
2. Exact locality not known. T. 9 N., R. 1 E. Tooth.
3. Bridgeport, three miles south, approximately in Sec. 33, T. 11 N., R. 5 E. Two teeth.
4. Chesaning, approximately in Sec. 9, T. 9 N., R. 3 E. Teeth and ribs,
5. Birch Run, four miles northeast, approximately in Sec. 24, T. 10 N., R. 6 E. Teeth and ribs.
6. Elsie, eight miles east of north, in the SE¼ SW¼ Sec. 4, T. 9 N., R. 1 E. Three teeth.

St. Clair County (SC)

1. St. Clair, five miles north, in Sec. 2, T. 5 N., R. 16 E. Two teeth.

(2) Exact locality not known. On shore of Lake Huron. Tooth.

(3) Port Huron, on the shore of Lake Huron. Tooth fragment.

St. Joseph County (SJ)

1. Colon, three miles southeast, in Sec. 24, T. 6 S., R. 9 E. Teeth and bones.
2. Prairie Lake, in the E½ of T. 7 S., R. 10 W. Two bones.

Sanilac County (San)

1. Marlette, in Sec. 5, T. 10 N., R. 12 E. Bone fragments.
2. Kingston, six miles northeast, in T. 12 N., close to the line of R. 11 and R. 12 E. Tusk.

(3) Exact locality not disclosed by informant. Tooth and bones.

Shiawassee County (Sb)

1. Bancroft, near the line between Sec. 36 and Sec. 25, T. 6 N., R. 3 E. Tusk, teeth, and bones.
2. Venice, near the center of Sec. 1, T. 7 N., R. 4 E. Tooth and part of tusk.
3. Owosso, approximately in Sec. 24, T. 7 N., R. 2 E. Tooth.

Tuscola County (Tu)

1. Cass City, four miles south, approximately in Sec. 21, T. 13 N., R. 11 E. Teeth and bones.
2. Cass City, in southern part of T. 14 N., R. 11 E. Numerous bones.

3, Gilford, in Sec. 26, T. 13 N., R. 7 E. Tusk, teeth, and bones.

Van Buren County (VB)

1. Paw Paw River valley flat, approximately in Sec. 26, T. 3 S., R. 14 W. Lower jaw and teeth.
2. Lawton, approximately in Sec. 31, T. 3 S., R. 13 W. Tooth.
3. Hartford, a few miles northwest, approximately in Sec. 6, T. 2 S., R. 16 W. Teeth and bones.

(4) Exact locality not known. Tusk, teeth, and bones.

(5) "Near Paw Paw Lake." Tooth.

Washtenaw County (Wa)

1. Saline, approximately in Sec. 36, T. 3 S., R. 5 E. "Some mastodon remains."
2. Saline, two or three miles south, approximately in Sec. 12, T. 4 S., R. 5 E. Tooth.
3. Lodi, in Sec. 23, T. 3 5., R. 5 E. Tusk, teeth, and many bones.
4. Ypsilanti, seven miles southeast, approximately in Sec. 1, T. 4 S., R. 7 E. Tusk, teeth, and bones.
5. Saline, about six miles west, approximately in Sec. 19, T. 4 S., R. 5 E. Teeth and part of skull.
6. Saline, about five miles southwest, approximately in Sec. 17, T. 4 S., R. 5 E. Tooth.

7. Rogers Corners, in Sec. 9, T. 3 S., R. 4 E. Tooth.

8. Macon, about three miles northeast, on the county line in the SW¼ SE¼ Sec. 33, T. 4 S., R. 5 E. "Remains"

Wayne County (Way)

1. Exact locality not given. T. 1 S., R. 8 E. Tusk and teeth.

2. Trenton, in the NW¼ NE¼ Sec. 12, T. 4 S., R. 10 E. Tusk and many bones.

3. Exact locality not known, possibly in T. 3 S., R. 11 E. Vertebra.

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[1] Hay's name, "Wabash beds" (1912), is preoccupied.

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THE NINETY-YEAR PRECIPITATION CYCLE

EDWIN L. MOSELEY

RAINFALL

IT IS possible to predict excessive or deficient rain for years in advance with considerable probability of the prediction coming true. Much of the interior of North America receives its moisture principally from the Gulf of Mexico. Throughout a large part of this territory there is a tendency for the rainfall in any particular region to be much like that of ninety years before. In the Ohio River valley, for example, there were excessive rains nearly every year in the period 1846-52, likewise ninety years earlier, 1756-62, and ninety years before that, 1666-72. Now, in 1939, ninety years later, this region is again getting heavy rains.

New York State has early weather records for many stations. After selecting periods of a few months' duration in which a majority of these stations showed excessive or deficient precipitation I wrote out twenty-seven "predictions" of the probable rainfall ninety years and four or five months later and then compared them with recent records. Sixteen of them agreed, four conflicted, and seven of the twenty-seven periods had precipitation which was about normal although I had predicted otherwise.

In the early years of most states records were kept at only a few places or not at all. Yet the records of a single station afford some criteria by which to judge the probable rainfall ninety years later. In Pennsylvania those at Lebanon go back as far as the years following 1828. From these early data I postulated that there would be less than normal precipitation in the five months from November, 1922, to March, 1923. The late records showed that in every one of these months rainfall was less than normal. For October, November, and December, 1930, I predicted precipitation below normal. The records showed it to be below, the deficit being very marked in October and November. From February to May, 1924, I expected more than average rain. March had less than usual, but in the period as a whole there was abundant rain. Of nine predictions which I made for Lebanon only two were poor; I had anticipated more rain than usual in April and May, 1921, but there occurred a deficit of nearly one third of an inch for the two months. I looked for less than the usual amount in June, July, and August, 1924; less fell in July and August, but June had heavy rain.

Ten predictions were made for Pittsburgh, Pennsylvania. Eight turned out well; the others were based on too small departures from normal in the period $90^2/_5$ years earlier. Similar results were obtained in predicting for Kentucky and Ohio, where there are five stations with records more than 90 years old. Farther west there are very few records equally early, but on the basis of these I made fairly successful predictions for Wisconsin, Iowa, Missouri, and Louisiana.

TREE RINGS

Before attempting to correlate recent weather records with those ninety years earlier I deemed it important to find out, as nearly as possible, the actual length of the cycle. Each year a living tree forms a new layer of wood just beneath the bark. This annual ring, as it is called, shows by its thickness whether the tree was getting more or less than the usual amount of moisture at the time it was formed.

A study of rings after a tree is cut down enables one to learn about the rainfall during its life. From the tops of stumps, the ends of logs, and cross sections taken from them I have made measurements representing more than four hundred large trees which grew in the region from southern Michigan to central Tennessee. A majority of them were between 180 and 370 years old; a few were still older, and so afforded information about the rainfall each year for the last four centuries.

In my earlier measurements I laid off zones in each of which were 46 rings, showing the growth of 46 years. In the summer of 1937 I concluded that I should use a 45-year period. In both periods, that is, the 45 and 46 years ending with 1890, I found that the trees grew more than in the following or the preceding period. Moreover, each even-numbered period proved to be a wet one, and with one exception each odd-numbered period a dry one. The study of individual rings, which was started later, has as yet been applied to only 120 trees, of which 81 were growing in the latter part of the eighteenth century, 46 in the seventeenth, and 12 in the sixteenth.

THE RECORDS

Dates of nearly all the years which show substantial agreement in their departure from the normal are given in Table I. Weather records go back a little more than a century; very few for the region west of New York State antedate 1835. They show that there was more than average rain when the trees made wide rings, and less than average when they made narrow ones. This correlation applies to the growing season, but not in all cases to the entire year.

As may be seen from the table, after an interval of 90 or 91 years each wet year was followed by another wet one; likewise each dry year by a dry one. If the precipitation cycle were as long as 90½ years, the 91-year interval would appear as often as the 90-year interval, but it does not. If the cycle were just 90⅓ years, then after three such intervals the difference would be 271 years, as it usually is, but sometimes it is 272 years, which implies that the cycle is a little more than 90⅓ years.

TABLE I

Years in Which a Majority of the Trees in the Region Extending from Southern Michigan to Tennessee Formed Wide or Narrow Rings

Wide rings				*Narrow rings*			
	1852	1761	1671	1936	1845	1755	1665
	1850	1760	1669	1934	1843	1753	1663
1939	1849	1759	1668	1932	1841	1751	1660
1938	1848	1758		1931			
1937	1847	1757		1930	1839	1749	1658
		1756				1748	
1928	1837	1747	1657	1925	1834	1744	1653
1927	1836					1743	1652
1922	1832	1741		1911	1821	1730	1640
				1910	1820	1729	1639
	1887	1797	1707	1907	1816	1726	1636
	1886	1796	1706	1904	1813	1723	1632
	1885	1795	1705	1901	1811	1721	1630
	1884	1794	1704	1900	1810	1720	1629
	1883	1793	1703	1899	1809	1718	1628
	1881	1791		1898	1808		
	1878	1788	1697(?)	1895	1804	1714	1624
	1877	1787	1696	1894	1803	1713	1623
	1876	1786	1695		1802	1712	1622
			1694	1891	1801	1711	1620
	1869	1779(?)	1688	1890	1800	1710	1619
	1859	1769	1678		1799	1709	1618
	1858	1768	1677	1874	1784	1693	1603
				1871	1781	1691	1600
				1870	1780	1690	1599
				1868	1778	1687	1597
				1867	1777	1686	1596(?)
				1864	1774	1683	1592
				1857	1767	1676	1585
				1856	1766	1675	1584

I made many attempts to correlate months of excessive or deficient rain, as shown by early weather records, with months between 90 and 91 years later. The best correlations were found after 90 years and five months; the next best after 90 years and four months. This result is in good agreement with the table of dates of wet and dry years indicated by the width of tree rings. Both methods lead to the conclusion that the length of the cycle is not far from $90^2/_5$ years.

AREAS AFFECTED

The period of $90^2/_5$ years used in making predictions for those parts of North America where rain is derived mainly from the Gulf of Mexico is four times the magnetic or double sunspot period, $22^3/_5$ years. It does not apply to eastern Massachusetts or to other parts of New England near the ocean. For them I made successful pre dictions for the years 1931-37 by using a period of 67 years and ten months, which is three times the sunspot period. Predictions based on 1867, a year of minimum sunspots, were not successful.

For New York City, Long Island, and the Hudson and Mohawk valleys predictions made on either basis were failures, presumably because part of their rain comes from the Gulf, part from the Atlantic Ocean. The same thing is true for Fortress Monroe, Virginia, and Charleston, South Carolina. Baltimore and Washington gave fair results with the period of $90^2/_5$ years.

LAKE LEVELS

The ninety-year cycle shows also in fluctuations of level of the the water in lakes and rivers. A few early records relating to Lake Ontario and some of the other Great Lakes arc now more than ninety years old. Recent records show that ninety years after these lakes were unusually high they were again unusually high. For Lake Erie we have data that are much older than the written records. On Cedar Point, Erie County, Ohio, may be seen a series of long parallel sand and gravel ridges which were piled up by the waves when there were great northeast storms. Only those storms which occurred at times of abnormally high water were able to build ridges that endured; the ridges that were formed at other times were not so far back on the land and, consequently, were de by later storms.

A study made early in this century enabled me to assign to each of these old ridges the approximate date of its formation. These dates, as well as the methods employed in determining them, can be found in my monograph "Formation of Sandusky Bay and Cedar Point," *Thirteenth Annual Report of the Ohio Academy of Science*, 1904, pages 223-236. Several intervals of ninety years and multiples of ninety occur between the dates of formation of these ridges, the earliest of which was made about 1429 and the latest about 1879. This leads to the conclusion that the ninety-year cycle has affected the region of the Great Lakes during the last five centuries.

FLOODS

Most of the settlements which were made west of the Allegheny Mountains before the beginning of the nineteenth century were located near the Ohio River or its tributaries. We have records of a few great floods of this river between 1762 and 1832; each of them was followed by a great flood about ninety or ninety-one years later, the water in some of them attaining about the same height as in the corresponding early floods. Fortunately for our study the precipitation at six places along the river was measured and recorded long before the United States Weather Bureau was established. These records show that rainfall was excessive about ninety years and five months prior to every great flood from 1913 to the present.[1]

FORECAST

There follows a brief forecast of what may be expected regarding precipitation for nearly forty years to come. It applies to the populous area that extends from Missouri and Iowa to Pennsylvania and New York State; this is an area for which we have more early data regarding rainfall than we have for the states situated farther west or north or south. Much of the forecast will also apply beyond these limits — to southern Minnesota, eastern Kansas, parts of the Gulf States, and parts of Virginia and New England that are not near the coast.

As in the past, we may expect wet and dry seasons. The dry ones will be less numerous than they were in the forty-five-year period from 1891 to 1935. Average precipitation will be greater than it was then, and much greater than it was during the twenty years beginning with 1917.

After the middle of 1943 the precipitation for nearly five years may not average above normal; in fact, a drought may be expected in many states from the latter part of 1946 until late in 1947.

In 1948 and 1949 much more rain than usual will fall; after that about the normal amount may be expected most of the time until 1957, except for a dry period in the latter part of 1954.

Late in 1957 and throughout most of 1958 a drought will affect a large area. Abundant rain will fall again in 1959 and the first part of 1960.

In several states farther west than New York and Pennsylvania the rainfall will average below normal during a period of more than four years beginning in the fall of 1960, especially in the first half of this period.

After 1964 precipitation will exceed the normal nearly every year for more than a decade.

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[1] Moseley, E. L., "Long Time Forecasts of Ohio River Floods," *Ohio Journal of Science*, 39 : 220-231. 1939.